



EMERGING SCIENTIFIC TRENDS IN NEW PLANT BREEDING TECHNIQUES

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ABSTRACT

Biotechnology is emerging as a millennium tool in Agriculture. The trends for adoption of emerged scientific revolutions in biotechnology needs to be focused for effective development, dissemination and utilization of technologies pertaining to biotechnology. Market feasibility, market stability, cost, profit consistency, compatibility, visibility, trial ability and demonstrability have to be considered while developing the appropriate technologies. Capacity building, skill development, effective communication skills, training, human resource development, effective programme planning needs to be strengthened among the biotechnology professionals by utilizing the seven orchestrated, concerted comprehensive Narayana's wheel model.

KEYWORDS: New plant breeding techniques, biotechnology adoption, Narayana's wheel model.

INTRODUCTION

The nineteenth century as an era of industrial revolution, 20th century is golden age of electronics and 21st century emerged as biotechnological revolution. However, five Scientific Revolutions have emerged in the world during this millennium like (1) Genetic Engineering and ability to use this understanding to develop new process and products in biotechnology. (2) Eco-technology and blending of best traditional knowledge with frontier technologies in biotechnology. (3) Information technology and its rapid growth in the systematic assimilation and timely dissemination to the concerned professional. (4) Motivation techniques for efficient utilization of available biotechnology innovations by ultimate users. (5) Need for appropriate policies to biotechnology development, technology dissemination and technology utilization. Hence, it is desirable to know the details of trends for adoption of emerged scientific revolutions in biotechnology.

(1) Appropriate Technology Development Through New Plant Breeding Techniques As A Trend

Techniques for introduction of novel traits more precisely in plants often without introduction of foreign genetic materials known as new plant breeding techniques is also not properly addressed by the biotechnology plant scientists. However, the several research and evaluation studies conducted in India revealed that utilization of new plant breeding techniques in plant science is far from satisfactory in different parts of the country. However,

Narayana's Innovation Attributes Lotus Model (Fig.1) explains four attributes with seven sub components under each for appropriateness of new plant breeding techniques in plant science to adopt like Relative advantage, Compatibility, Practibility and Complexity for livelihood security in the emerging global order. (A) Relative Advantage: Is the degree to which an innovation of new plant breeding techniques is superior to the idea it supersedes. It can be explained with seven sub items like. (1) Market feasibility: as the extent of market demand for the product derived out of new plant breeding techniques innovation and also the extent of scope for marketing product. (2) Market stability: as the consistency of market price and demand of product derived out of new plant breeding techniques Innovation. (3) Cost: is of two types, initial cost and continuing cost. Initial cost represents the capital investment required for adoption of new plant breeding techniques innovation. Further, the cash or inputs required for subsequent years use of new plant breeding techniques innovation is termed as continuing cost. (4) Net Profit: as the quantum of monetary benefit obtained by an individual through adoption of new plant breeding techniques innovation. (5) Profit consistency: denotes the regularity of net returns obtained by an individual or group of individuals over a period of time by adoption of a new plant breeding techniques innovation. (6) Utility potential: as the degree to which the multiple use potential of a new plant breeding techniques innovation to an individual or group of individuals through adoption of new plant breeding

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techniques innovations. (7) Time saving: Indicates the best efficiency of a new plant breeding techniques innovation in terms of saving time in different aspects. (B) Compatibility: a new plant breeding techniques innovation is consistent with past experiences, existing values, and future plans of the adopters of plant science technologies. Compatibility is divided into seven sub groups like (1) Cultural compatibility: a new plant breeding techniques innovation is consistent with the values and norms of the society. (2) Social compatibility: denotes prestige gain or esteem by individual in the society through adoption of a new plant breeding techniques innovation. (3) Physical compatibility: a new plant breeding techniques innovation is consistent and should fit into the needs and interests of the adopters. (4) Psychological compatibility: New plant breeding techniques innovation usefulness as perceived by the members of social system. (5) Situational compatibility: denotes consistency and harmony of the new plant breeding techniques innovation with previous practices followed by adopters. (6) Relational compatibility: a new plant breeding techniques innovation can be adopted independently by the adopters just like other practices. (7) Anticipated compatibility: A new plant breeding techniques innovation should be consistent with the future ideas of the adopter over a period of time. (C) Practibility: a new plant breeding techniques innovation of plant science can be easily communicated, tested, demonstrated and practiced. (1) Point of origin: Indicates the credibility of the source from where the new plant breeding techniques innovation originated. (2) Access to advice: For implementation of new plant breeding techniques innovation, its extent of availability of original and detailed information for guidance and clearing doubts that arise while implementing it. (3) Visibility: the results of a new plant breeding techniques innovation are visible. (4) Trialability: The degree to which new plant breeding techniques innovation can be tried on a small scale. (5) Mastery: The practice of a new plant breeding techniques innovation could be learned or mastered in a short period of time. (6) Demonstrability: a new plant breeding techniques innovation can be demonstrated to members of social system easily. (7) Communicability: The information about the new plant breeding techniques innovation can be diffused to members of the social system easily and speedily. (D) Complexity: a new plant breeding techniques innovation of plant science is relatively difficult to understand and use. (1) Failure probability: a new plant breeding techniques innovation chances of failure and uncertainty of results after its adoption. (2)

Discomfort saving: Represents avoidance of physical discomfort may be derived by adoption of a new plant breeding techniques innovation. (3) Resource complexity: difficulty in getting the necessary inputs and other resources for the application of a new plant breeding techniques innovation. (4) Reversibility: degree of ease with which the new plant breeding techniques innovation can be replaced in case of its failure. (5) Work efficiency: the adoption of new plant breeding techniques innovation saves labour or increase the available labour efficiency. (6) Cognitive complexity: an extent of relative difficulty in understanding a new plant breeding techniques innovation. (7) Application complexity: relative difficulty of a new plant breeding techniques innovations use and application on the farm.

(2) Capacity Building among Biotechnology Professionals as a Trend:

Capacity building among biotechnology plant scientists is too complex phenomenon to be explained by a single factor. However, Narayana's Wheel Model (Fig.2) explains combination of seven components for capacity building among biotechnology plant scientists viz. Innovativeness, Decision making ability, Achievement motivation, Information seeking ability, Risk taking ability, Coordinating ability and Leadership ability. The combined contribution of the above seven factors to an individual behavior is being expressed in terms of capacity building among biotechnology professionals, so far attention given is limited.

(1) Innovativeness: Considered as socio-psychological orientation of a biotechnology plant scientists closely associated with change, adopting new ideas and practices. An individual biotechnology plant scientist adopts new ideas relatively earlier than others in his/her organization. However, innovativeness in professionals is very essential to motivate others for adoption of new plant breeding techniques in plant science. (2) Decision making ability: Considered as the nature of decision making either individually or consulting with others while performing new plant breeding techniques in plant science activities. It is the degree to which an individual justifies his selection of most efficient means from among the available alternatives on the basis of scientific criteria for achieving maximum profits. Hence, decision making ability is very important among biotechnology plant scientists to motivate professional for adoption of new plant breeding techniques in plant science. (3) Achievement motivation:

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Every biotechnology plant scientist has a desire to achieve certain things in life. Achievement motivation is considered as the extent to which an individual is oriented towards maximizing profits. Achievement motivation as a social value that emphasizes a desire for excellence in order for biotechnology plant scientists to attain a sense of personal accomplishment. So achievement motivation increases efficiency of biotechnology professionals in use of new plant breeding techniques in plant science. (4) Information seeking ability: It refers to the frequency of contact by biotechnology plant scientist with various information sources. This is the pattern by which a biotechnology plant scientist gets his/ her information either on his/her own seeking or as a consequence of his/her being a part of the network. This component is important for use of new plant breeding techniques in plant science by professionals. (5) Risk taking ability: Some biotechnology plant scientists take more risk, some others take moderate risk and many biotechnology plant scientists hesitate to take risk. Risk taking ability considered as individual orientation towards risk and uncertainty in adopting new ideas and courage to face the problems. Use of new plant breeding techniques in plant science demands ability to take risk by professionals. (6) Coordinating ability: In order to complete the required work in stipulated period, a biotechnology plant scientist has to harmonize and synchronize the various activities for better profit. It is an individual co-ordinates action in a time dimension. This ability helps to increase the efficiency of professional in motivating biotechnology plant scientists for adoption of new plant breeding techniques in plant science. (7) Leadership ability: To get things done properly, a plant scientist has to initiate the action, motivate the followers and decision should be taken. It is an individual initiates or motivates the action of the other fellows. Hence, leadership ability is an important component in biotechnology professional to motivate plant scientists for adoption of new plant breeding techniques in plant science.

(3) Skill Development among Biotechnology Professionals as a Trend

To meet the requirement of emerged scientific revolutions the biotechnology plant scientists concerned should be trained properly. To train biotechnology plant scientists specific skills are required for conducting an effective training. The skill as ability to do things, to effectively apply knowledge and personal aptitudes and attitudes in work situation. However, the concept of skill

concerns the ability to use ones knowledge effectively and rapidly in execution of performance and more generally it is an acquired power of doing something competently. Further, skills notably professional skills are becoming increasingly important. Biotechnology today calls for professional skills in its application. Seven skills are identified for effectiveness among biotechnology plant scientists. However, Narayana's Wheel Model (Fig.3) describes seven orchestrated, concerted comprehensible skills required among biotechnology plant scientists for efficiency like (1) Technical Skill is the ability of the biotechnology plant scientist to use any technique or method or equipment or product or process as a tool in the context of new plant breeding techniques in plant science. (2) Human Skill is the ability of biotechnology plant scientists in motivating other professional involved in new plant breeding techniques in plant science with thorough understanding while working with them as a team. (3) Conceptual Skill is the ability of biotechnology plant scientists coordinating and integrating all the activities of new plant breeding techniques with visionary outlook. (4) Managerial Skill is the ability of biotechnology plant scientists in planning, organizing, directing, leading, reporting and budgeting and reviewing the work of other professional involved in new plant breeding techniques in plant science. (5) Design Skill is the ability of biotechnology plant scientists in finding out a workable solution to problems through new plant breeding techniques requires deliberate efforts to develop solution. (6) Creative Skill is the ability of biotechnology plant scientists in generating new ideas or in doing things already done in a new way through new plant breeding techniques in plant science. (7) Communicative Skill is the ability of the biotechnology plant scientists to adopt technologies at different levels using series of new plant breeding techniques over a period of time.

(4) Effective Communication among Biotechnology Professionals as A Trend

Good communication does not consist merely of giving orders but of creating understanding. It does not consist merely of imparting of knowledge but to help biotechnology plant scientists to gain a clear view of the meaning of knowledge. It is therefore, the responsibility of professionals involved in generation of new plant breeding techniques in plant science to familiarize themselves to become effective communicators. However, Narayana's Wheel Model (Fig.4) explains seven orchestrated concerted comprehensible in the system for

effective communication. (1) Credibility: Climate of belief, earnest desire of new plant breeding techniques in plant science. (2) Context: Realities of the situation must provide for participation and playback for new plant breeding techniques in plant science. (3) Content: The new plant breeding techniques message must have meaning for the biotechnology plant Scientist and the content determines the plant scientist. (Vice-versa). (4) Clarity: The new plant breeding techniques message must be put in simple term, words must mean the same thing to the biotechnology plant scientist as they do to the other professional. (5) Channels: Established channels of communication which biotechnology plant scientists respects must be used for promotion of new plant breeding techniques in plant science. (6) Consistency: Communication is an unending process for biotechnology plant scientists. However, it requires repetition of new plant breeding techniques in plant science to achieve penetration, it should be consistent. (7) Capability: This refers to availability, habit, ability and Knowledge of biotechnology plant scientist. Much misunderstanding results from faulty communication. Too many biotechnology plant scientists saying the wrong things at the wrong time, in the wrong ways, to the wrong professional slows progress. What is needed is more biotechnology plant scientists saying right things, at the right time, in the right ways to the right professional. This is a formula for good and effective communication. The new plant breeding techniques in plant science promoter is actually a motivator, needs devotion and full identification with the biotechnology plant scientists, which are pre-requisites for success.

(5) Training of Biotechnology Professional as a Trend

Training is a planned and systematic effort to increase biotechnology professional competency. Further, to enable the biotechnology plant scientists to increase knowledge, to improve skills, to inculcate appropriate attitude and develop appropriate attributes to serve better. Several training models are used by the organizations to influence the biotechnology professional to make desirable changes in their behaviour to achieve the objectives of the organization. Further, observed that training is a building process, to reflect this, a good course is organized in ascending order of complexity. However, understanding of modern biotechnology and deliver it to users in a usable form along with monitoring of activities needed to implement and evaluate its usefulness are urgently needed. The information has to be integrated with

available communication methods to suit the resource positions of institutions and time following the integration. Further, good linkages have to be established with inter and intra system of biotechnology plant scientists in organizations. However, experience gained in training so far indicates that mere development of conceptual understanding and an operational plan based on it may not be adequate. Training has to be made to work. This can happen only when all the three parties involved in training like organization, trainer and trainee – join in their effort and make it to work. An important issue facing us is commitment to training. This is required and it is seldom well realized. Hence, there is a need for knowledge of training models to train biotechnology professionals in plant science. The Narayana's Model of training process (Fig.5) for training biotechnology plant scientists, explains training process may be a temporary system but the trainer and trainee both learn through various opportunities available for checking their effectiveness. This also explains training as an interdependent and interrelated process. Here lot of opportunity is given for independent and intervening variables to become dependent variables. Hence, this model helps to increase the efficiency of biotechnology professionals in plant science and to develop competency among biotechnology plant scientists. The process of training must start by questioning the basic assumption which has governed our training approach. So an analysis of SWOT i.e., Strength Weakness and Other Things called for to enable as to have new conceptualization. The training of biotechnology plant scientists during the millennium must take in to account the needs of broad based plant science to introduce greater professional competence.

(6) Human Resource Development among Biotechnology Professional as a Trend

During the last five decades of development, growth of developing countries is directly related to their human resource bases. The countries which have given good performance are the countries which have made significant investments in Human Resource Development (HRD) of biotechnology professional. There is an overwhelming evidence that human capital is one of the key factors for adoption of new plant breeding techniques in plant science in Developed countries. Further, HRD is widely regarded as the single most important resource for faster adoption being attempted in the developing countries. Hence, there is need for training to develop human resource at various levels in biotechnology

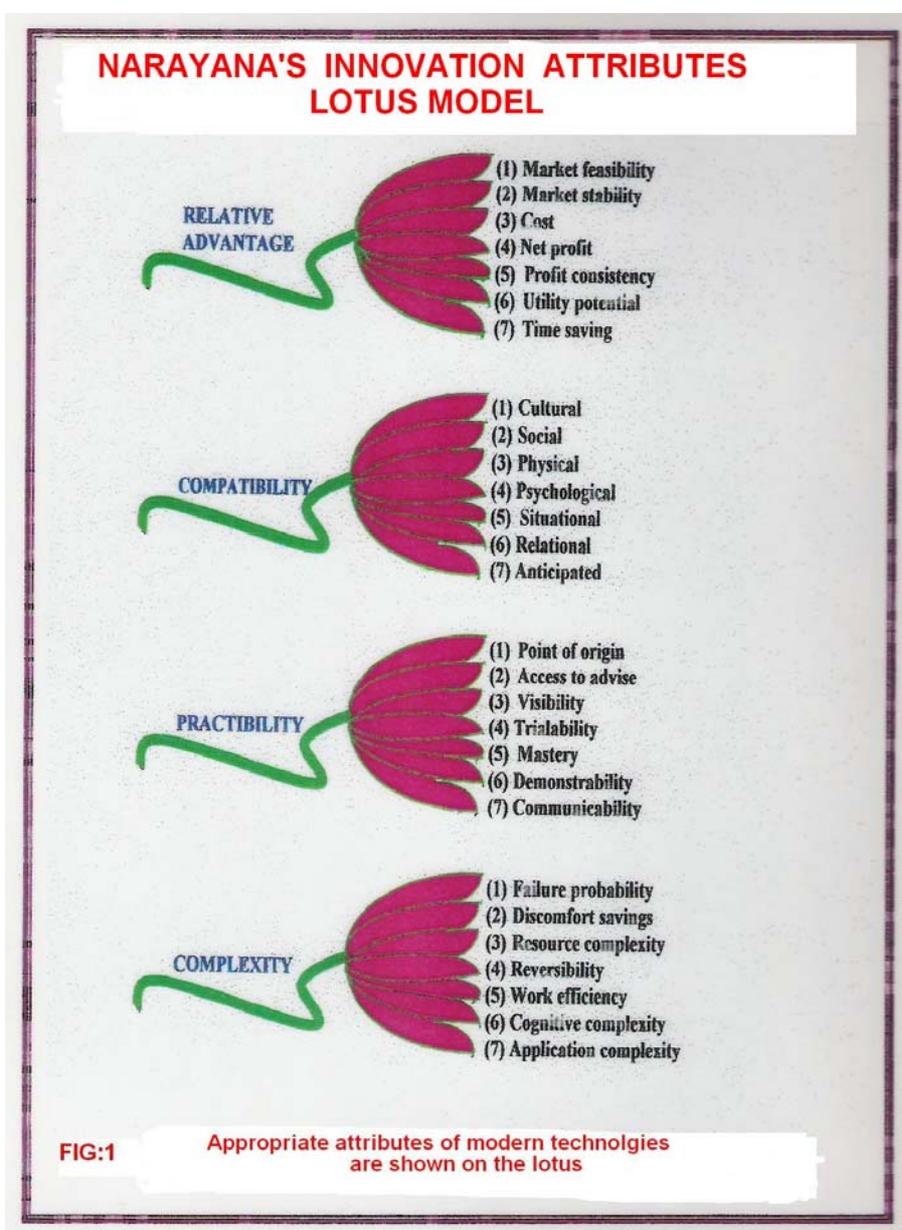
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institutions for efficient use of new plant breeding techniques in plant science. Hence, Human resources are assuming increasing significance during the millennium. However, experience in the past has indicated that HRD among biotechnology professional is lacking in our country as revealed by large number of research and evaluation studies. How it should be done is explained in Narayana's Algebraic Model of HRD (Fig. 6) among professionals. $HRD = HRS + HRT + HRU$ i.e., $HRD = HR(S+T+U)$ i.e., Selection of Human Resource, Training of Human Resource and using of Human Resource profitably are urgently needed for adoption of emerging

new plant breeding techniques. This is a challenge that needs to be tackled immediately.

(7) Effective Programme Planning For New Plant Breeding Techniques in Biotechnology as a Trend

Biotechnology plant scientists should have effective programme planning and execution for adoption of emerging new plant breeding techniques in plant science. However, Narayana's Wheel Model (Fig.7) explains seven important steps in programme planning through (1) Analyzing the situation, (2) Identifying problems, (3) Finding solutions, (4) Deciding objectives, (5) Plan of work, (6) Execution of plan and (7) Evaluate the



NARAYANA’S WHEEL MODEL FOR



Fig. 2. Seven Orchestrated, Concerted, Comprehensible shown on the Wheel

NARAYANA’S WHEEL MODEL FOR EFFECTIVE COMMUNICATION

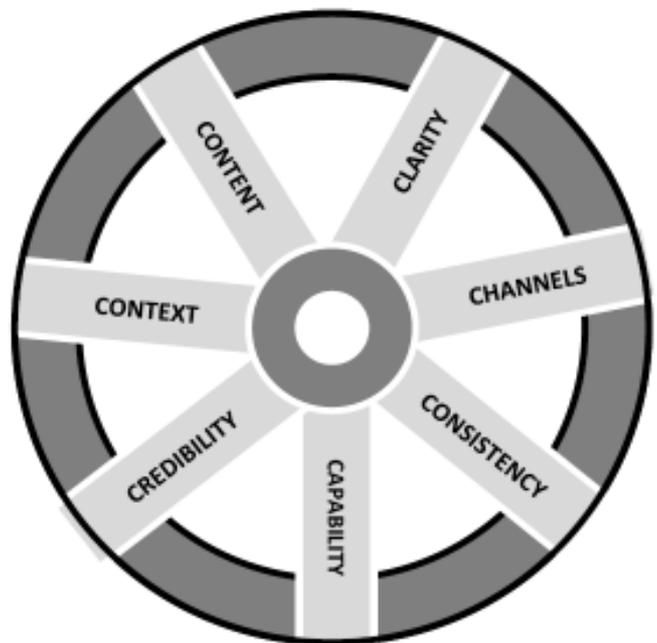


Fig. 4. Seven Orchestrated, Concerted, Comprehensible shown on the Wheel

NARAYANA’S WHEEL MODEL FOR SKILL DEVELOPMENT

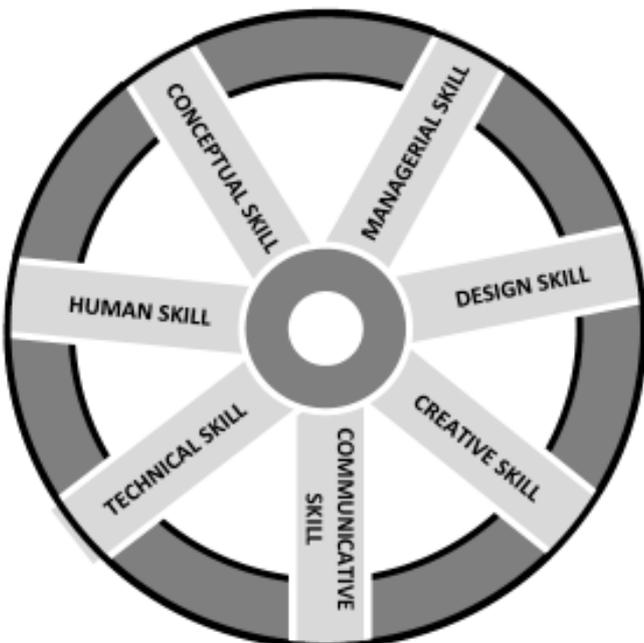


Fig. 3. Seven Orchestrated, Concerted, Comprehensible shown on the Wheel

effectiveness of new plant breeding techniques in plant science programmes concurrently at the end of a year. The strong and weak points identified may be considered in revising the subsequent programmes to promote new plant breeding techniques in plant science. The evaluation report prepared must reach large number of biotechnology plant scientists and organizations in the locality and in similar outside locations. However, the experience in the past has revealed that for effectiveness it should answer to local plant scientist needs. To achieve this aim a process of extensive consultation with the concerned target group of biotechnology plant scientists is required.

CONCLUSION

A dynamic trend needs to be provided to cater the needs of different categories of biotechnology plant scientists. The country needs to be mapped out for immediate growth potential areas in new plant breeding techniques and future growth potential areas in biotechnologies. Governmental system need to be reoriented with proper POSDCORB (Planning, Organizing, Staffing, Directing, Coordinating, Reporting And Budgeting) individual biotechnology plant scientist need to be educated to use the available technology in a planned way for maximization of profit.

NARAYANA'S MODEL OF CONTINUOUS TRAINING PROCESS FOR PLANT SCIENTISTS

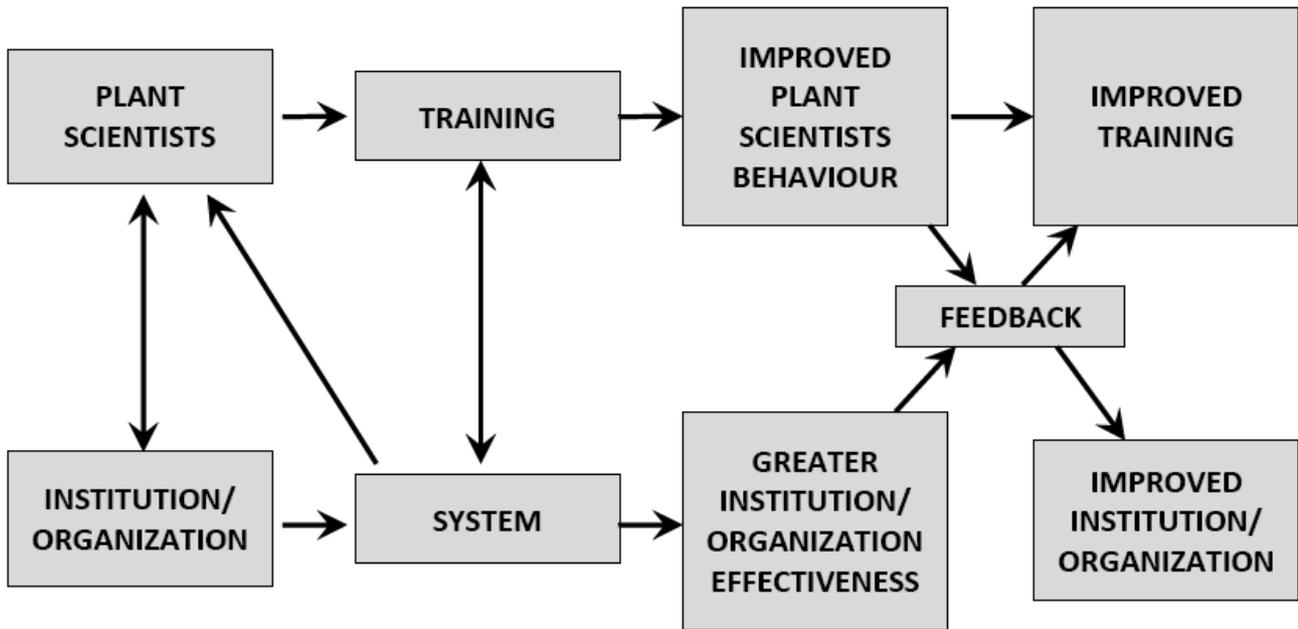
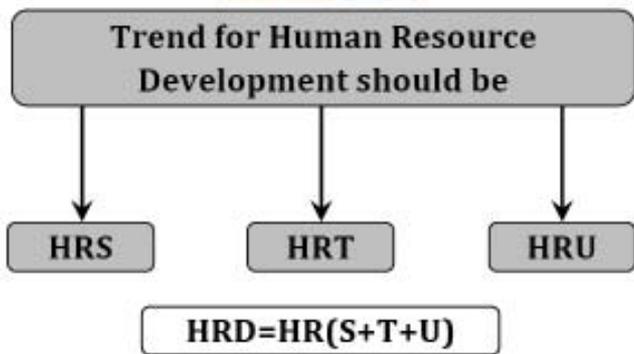


Fig. 5. Training process model

NARAYANA'S ALGEBRAIC MODEL OF HUMAN RESOURCE DEVELOPMENT



HRD = Human Resource Development
HRS = Selection of Human Resource
HRT = Training of Human Resource

Fig. 6. HRU = Using of Human Resource Profitability

NARAYANA'S WHEEL MODEL FOR SKILL DEVELOPMENT

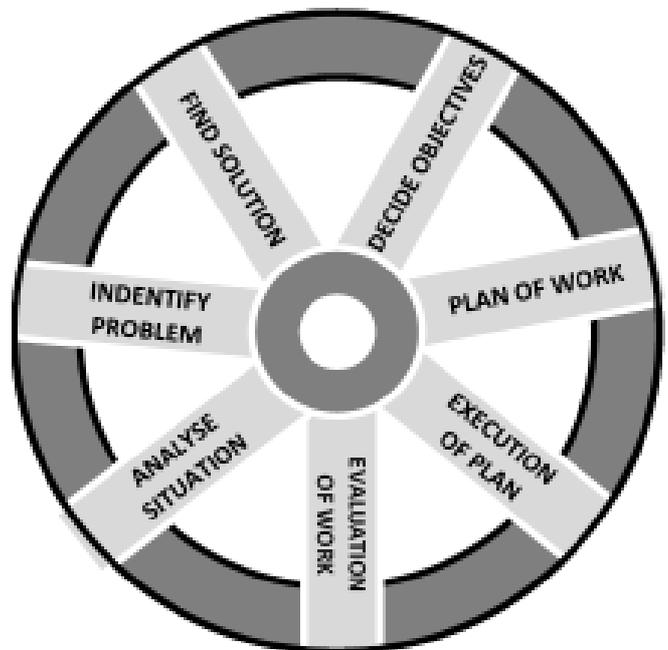


Fig. 7. Seven Orchestrated, Concerted, Comprehensive shown on the Wheel



STATISTICAL DESIGNS AND REGRESSION ANALYSIS IN AGRICULTURAL SCIENCES

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ABSTRACT

Statistics is important in the field of agriculture, because it provides tools to analyze collected data. Many modern statistical techniques were first developed for use in agricultural research, and many basic statistical tools are still important for such research. Good experimental design, following the basic principles of experimental designs, allows the control of anticipated environmental variation and the estimation of treatment effects in the presence of such variation. ANOVA provides a wide-ranging approach to the analysis of data from designed experiments, aiding the interpretation of the results of complex experiments. Regression analysis can be used to explore the relationships between a quantitative response variable and one or more quantitative explanatory variables.

KEYWORDS: ANOVA, Experimental design, GLM, Hypothesis testing, Regression, p-value, Variability

INTRODUCTION

Statistical education for agriculturists tries to give them a solid foundation in statistics. A wide use of statistical methods in order to allow the students to apply these techniques in many fields of agricultural sciences like field crop production, livestock, veterinary medicine, agricultural mechanization, water resources, agricultural economics and other fields. The use of statistical techniques in agriculture goes back many years and in fact, many of the modern statistical techniques were first developed for use in agricultural research. Early developments, due to R.A. Fisher at Rothamsted Experimental Station in the United Kingdom in 1920s included the basic principles of experimental design – replication, randomization and local control – and the analysis of variance (ANOVA), and these techniques, in common with many statistical methods, were developed to cope with the inherent variability associated with experimentation using biological material. In fact, it is the need to explain or allow for the extensive variation often found in experimental biological data that has driven, and still drives, the development of statistical techniques. By using the correct statistical tools, we can separate the signal from the noise within our data – if we do not handle the experimental variability properly we run the danger of being unable to draw any useful conclusions from our data.

DESIGN OF EXPERIMENTS AND ANALYSIS OF VARIANCE

In the design of experiments, the grouping or blocking of experimental units can be used to eliminate the effects of systematic changes in environmental conditions (the experimental units within a block are assumed to be as similar as possible). The randomization of treatments to units can protect against unknown variability, replication provides the basis for the comparison of treatments, allowing the assessment of whether the differences between treatments are large relative to the variation between replicate observations on each treatment. The most commonly used experimental design is the “randomized complete block design”, with a complete replicate of the set of treatments appearing in each block of experimental conditions. These include incomplete block designs, row-and-column designs (e.g. Latin squares) and split plot designs. The analysis of variance technique separates the variation in observed results into that due to the applied treatments and that due to the experimental environment, and hence allows the assessment of whether observed treatment differences are important relative to the underlying variation between experimental units. The ANOVA technique for analyzing data from designed experiments is readily available in most statistical computing packages.

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REGRESSION ANALYSIS

Where applied treatments are quantitative, it is often of more interest to determine the form of relationship between the response variable and these explanatory variables using regression analysis. Simple linear regression is concerned with fitting the simplest of relationships, a straight line, between the response variable and a single explanatory variable, with the parameters of the line (slope, intercept) determined to minimize the variance in the response variable about the fitted line. It is important to realize that the adjective linear in simple linear regression refers not to the fitting of a straight line, but to the relationship between the response variable and parameters being linear.

Extensions of this linear regression approach include multiple linear regression (more than one explanatory variable), linear regression with groups (including a qualitative treatment factor and allowing parameters to vary with different levels of this factor) and polynomial regression (quadratic, cubic... etc., relationships between response variable and explanatory variables). Many real biological relationships, however, are not well described by the range of models that can be constructed within the linear regression framework, but require the use of models where the response variable is related to the parameters in a non-linear fashion. Advances in computer power now make the fitting of such non-linear regression models relatively simple, and many standard non-linear response functions are readily available in most statistical computing packages. These include models based on the exponential function (for example, to describe the decay of pesticides in soil or unconstrained growth), sigmoid functions, such as the logistic and Gompertz curves (to describe constrained growth or for dose-response studies), and rational functions, including inverse polynomials (used to describe the relationship between crop yield and applied nutrient levels).

The ANOVA and regression analysis methods that are mentioned above have an underlying assumption that the response variable is continuous and normally distributed. However, much of the data collected in agricultural research, particularly in relation to crop protection research, are in the forms of discrete counts (numbers of weeds, insects, disease lesions) or proportions based on counts (numbers of diseased fruit per tree, or of insects killed by some treatment), and therefore do not satisfy these assumptions. For example, count data may

follow a Poisson distribution and proportions based on counts may follow a Binomial distribution. In this situation two approaches are possible – to find some transformation of the data that allows this assumption to be satisfied or to use an alternative form of analysis that takes account of the distributional form of data. The development of General Linear Models (GLMs) by McCullagh provided a solution to the latter approach, allowing the analysis of data for a range of non-normal distributions, within the same basic structure as for analysis of variance and regression analysis. Of particular interest within this framework are log-linear models for count data and probit/logit models for proportions based on counts, these latter approaches being particularly important for the analysis of bioassay experiments.

There are a number of areas where future development of statistical methodology will be important in agriculture. One is the analysis of spatial data. Whilst spatial statistical methods have been developed and used for many years, particularly geo-statistical methods in the mining industry and hydrology, there has been relatively little use of such methods in agriculture. Interest in the spatial distributions of plants, pests, diseases, nutrients, and pesticides, however, is now becoming important both in understanding the biological processes behind agricultural production and particularly in the development of precision agriculture approaches to apply, for example, pesticides or fertilizers to match the requirements of small areas of crop. Another area where development of statistical methodology is needed is for on farm experimentation, involving the assessment of experimental methods when scaled-up from small experimental plots to whole field (or even whole farm) experiments.

STATISTICAL ERROR IN HYPOTHESIS TESTING

There are two types of error or incorrect conclusions possible in hypothesis testing and possibilities in which the statistical test falsely indicates that significant differences exists between the two or more groups and also analogously to a wrong positive results. Rejection of null hypothesis (H_0) when it is true is called Type-I error and acceptance of null hypothesis (H_0) when it is false and it is known as Type-II error and Type-II error is more harmful than Type-I error (Keppel, 1978; Gupta and Kapoor, 1970).

The probability of Type-I error is known as level of significance (α) and the probability of type II error is known as the power of the test $\hat{\alpha}$ or $(1-\hat{\alpha})$ (Keppel, 1978; Gupta and Kapoor, 1970). By convention, statistical significance is generally accepted if the probability of making Type-I error is less than 0.05, which is commonly denoted as $p < 0.05$ (Elenbaas *et al.*, 1983). The probability of Type-II error is more difficult to derive than probability of type-I error, actually it is not one single probability value. The probability of type-II error ($\hat{\alpha}$) is often ignored by researcher (Freeman *et al.*, 1978). The probability of type-I error (α) and probability of type-II error ($\hat{\alpha}$) are inter-related. As α arbitrarily decreased, $\hat{\alpha}$ is increased. Similarly, α is increased, $\hat{\alpha}$ is decreased (Hopkins and Glass, 1978; Keppel, 1978).

P-VALUE

The p value is the probability to observe effects as big as those seen in the study if there is really no difference between the groups or treatments. The reasoning of hypothesis testing and p values is convoluted. The p values helps to answering whether this apparent effect is likely to be actual or could just by chance or sampling fluctuation. The p values give the magnitude of difference present between populations. In calculation of p values, first assume that no true difference between the two groups/treatments. The p values allow the assessment of findings that are significantly different or not. If the p value is small, the findings are unlikely to have arisen by chance or sampling fluctuations, reject the null hypothesis. If the p is large, the observed difference is plausibly chance finding, we do not reject the null hypothesis. By convention, p value of less than 5 per cent is considered small or significant. Sometimes p value is less than 1 per cent or 0.01, called as highly significant (Gupta and Kapoor, 1970; Rao, 1985).

CONCLUSIONS

Many modern statistical techniques were first developed for the use in agricultural research, and many basic statistical tools are still important for such research. Good experimental design, following the basic principles of replication, randomization and local control, allows the control of anticipated environmental variation and the estimation of treatment effects in the presence of such variation. ANVOA provides a wide-ranging approach to the analysis of data from designed experiments, aiding the interpretation of the results of complex experiments. Regression analysis can be used to explore the relationships between a quantitative response variable and one or more quantitative explanatory variables. Linear regression

techniques primarily provide an explanatory approach, whilst non-linear regression techniques allow the modeling of responses using biologically realistic relationships. Generalized linear models (GLM) provide an important tool for working with the non-normally distributed data that is common in the crop protection experimentation that frequently occurs in agricultural research, with log-linear models (for count data) and probit or logit models (for counts as proportions) being important specific cases. Future developments of statistical methodology will be important in three areas of agricultural research – the analysis of spatial data, the development of precision agriculture techniques, and on-farm experimentation. In this paper, the role of statistical research design and regression application of basic techniques in agricultural research, have been emphasized scientifically.

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PRODUCTIVITY OF SOYBEAN INFLUENCED BY SOWING DATES AND PLANT DENSITIES

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ABSTRACT

A field experiment was conducted during *kharif*, 2014 to study the influence of different sowing dates and plant densities on productivity of soybean. It was comprised of nine treatments with three sowing dates (June 28, July 14 and July 29) and three row spacing's (30 cm × 10 cm, 45 cm × 10 cm and 60 cm × 10 cm) and replicated thrice. Plant height, drymatter production, leaf area index (LAI), days to 50 per cent flowering, numbers of pods plant⁻¹ (44.7), number of seeds per pod⁻¹ (2.2), seed yield (1487 kg ha⁻¹), haulm yield (2496 kg ha⁻¹), harvest index (39.1%) and test weight (9.9 g) increased with early sowing on June 28 than later. Productivity of soybean was inconsistent with different row spacing's. The highest plant height, drymatter production, leaf area index (LAI), seed yield (1396 kg ha⁻¹), haulm yield (2386kg ha⁻¹) and harvest index (39.2%), were recorded at a spacing of 30 cm × 10 cm. More number of days to 50 per cent flowering, highest number of pods plant⁻¹ (48.1), number of seeds pod⁻¹ (2.1) and test weight (9.9 g) were recorded at a spacing of 60 × 10 cm. The interaction between sowing dates and row spacing's was significant with all the growth parameters and yield attributes except number of seeds pod⁻¹ and test weight.

KEYWORDS: Growth, Plant densities, Sowing dates, Soybean, Yield attributes and Yield.

INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is an important oilseed crop, which plays an important role in Indian economy. Soybean has now established as number one crop, among oilseeds and contributes more than 50 per cent of oilseed production and 30 per cent of vegetable oil production. In India, it is mainly grown in Madhya Pradesh, Maharashtra and Rajasthan (AICRPS, 2008). It occupied an area of 12 mha and production of 12.8 mt and with productivity of 1079 kg ha⁻¹. It is a good source of protein (40%), oil (20%), unsaturated fatty acids and minerals like Ca and P including vitamin A, B, C, D which can meet different nutritional needs of human and animals (Mondal *et al.*, 2002). Besides, its main use for oil extraction, it can be used for dal, soya milk, *tofu* etc. The productivity of soybean is low due to various constraints. Time of sowing has a considerable influence on growth and yield of soybean. Early sowing in the season may encourage higher vegetative growth which may invite various diseases and insects pests. However, delayed sowing may shrink the vegetative phase, which in turn reduces dry matter accumulation leading to poor realization of the potential yield. In addition to sowing time, planting density is one of the main factors that has

an important role on the growth and yield of soybean. The optimum plant density and time of sowing for higher yield may differ from location to location. Therefore, an experiment was initiated to study the optimum sowing time and optimum plant density.

MATERIAL AND METHODS

A field experiment was conducted during *kharif*, 2014 at college farm, Agricultural College, Mahanandi, ANGRAU. The soil of the experimental site was sandy loam and it was slightly alkaline in reaction with a pH of 7.98, EC of 0.06 dSm⁻¹ and low in organic carbon (0.46%) and available nitrogen (266 kg ha⁻¹), high in available phosphorous (145 kg P₂O₅ ha⁻¹) and high in available potassium (774 kg K₂O ha⁻¹). The experiment was laid out in factorial randomized block design and replicated thrice. The treatments consisted of three sowing dates *viz.*, D₁ (June 28), D₂ (July 14) and D₃ (July 29) and three plant densities, *viz.*, S₁: 30 × 10 cm (3.33 lakh plants ha⁻¹), S₂: 45 × 10 cm (2.22 lakh plants ha⁻¹) and S₃: 60 × 10 cm (1.66 lakh plants ha⁻¹). Variety JS-335 which matures in 80-85 days was tested in the experiment. Recommended fertilizer dose of 60kg P₂O₅ and 40kg of K₂O through Single Super Phosphate and muriate of potash respectively was applied as basal at the time of sowing. Whereas

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nitrogen @ 30kg was applied through urea in two equal splits, one at the time of sowing and another at 30 days after sowing (DAS). No serious attack of pests and diseases was observed. However, minor incidence of tobacco caterpillar (*Spodoptera litura* (Fab.) was observed at flowering. Monocrotophos @ 2 ml L⁻¹ and Acephate (0.08%) @ 2g L⁻¹ were used for effective control of pest. Weeding was done at 15 and 30 DAS for each sowing date to keep the plots weed free. When crop was subjected to prolonged dry spell irrigation was given to protect the crop. The total rainfall received during crop growth was 515.2 mm in 28 rainy days. Five plants were randomly selected in the net plot area and tagged. The biological data was collected from the tagged plants at 30 days interval up to harvest, where as the yield attributes and yield were recorded at harvest.

RESULTS AND DISCUSSION

Effect of Sowing Dates

Growth Parameters

The differences in plant height, total drymatter production, leaf area index and days to 50 per cent flowering were significant due to different sowing dates. Sowing of soybean on June 28 recorded significantly higher plant height, total drymatter production and leaf area index over rest of the sowing dates *i.e.* July 14 and July 29 (Table 1). The increase in growth parameters in early sowing date might be due to favorable environment enjoyed by early sown crop than that sown at later dates even after receiving similar inputs resulting in more plant height and vigorous vegetative growth. The less number of nodes and reduced inter nodal distances caused by non-optimal sowing time could be also the reason for reduction in plant height under delayed sowing. Sowing of soybean on July 29 resulted in early flowering followed by July 14 sowing. The reduction in total duration from sowing to 50 percent flowering might be due to photosensitivity of soybean.

Yield Attributes and Yield

Yield attributes such as number of pods plant⁻¹, number of seeds pod⁻¹, test weight and yield significantly influenced by different sowing dates. The higher number of pods plant⁻¹ (44.7), number of seeds pod⁻¹ (2.2) and test weight (9.9 g) were recorded with sowing at June 28 over other two sowings (Table 2). This might be due to adequate and increased availability of nutrients for development of

more number of pods plant⁻¹ and better seed filling with maintenance of better source-sink relationship. Similar results have been reported by Halvankar *et al.* (2001) .

Significantly highest seed yield (1487 kg ha⁻¹), haulm yield (2496 kg ha⁻¹) and harvest index (39.1) were recorded with early sowing of June 28 over other sowings and this might be due to partition of higher proportions of its total drymatter into component parts of the plant. Added to the above, better growth and development of crop sown at June 28 date when compared to other dates of sowing in all aspects might have reflected in better yield expression. Billore *et al.* (2000) also reported higher yield in early sowing which was ascribed to higher values of harvest index. The seed yield and haulm yield were decreased from June 28 to July 29 sowing. Delayed sowings on July 29 produced the lowest seed yield and haulm yield. This might be due to best performance of early sown crop due to prevailing high temperature and moisture during crop growth period that resulted in increased drymatter and which in turn reflected in higher seed yield. Similar results were also reported by Amarajyothi and Pullarao (2002).

Effect of Plant Densities

With regard to spacing's, narrow row spacing 30 cm × 10 cm recorded significantly highest plant height, total drymatter production, leaf area index and reduced number of days to 50 per cent flowering followed by medium row spacing (45 cm × 10 cm). The positive relationship of closer spacing on growth attributes might be attributed to the cumulative effect of more number of plants unit area⁻¹, high inter-plant competition which caused internodal elongation, higher leaf area index and more light interception as reported by Halvankar *et al.* (1993). With regard to row spacing narrow row spacing 30 cm × 10 cm resulted in early 50 per cent flowering than 45 cm × 10 cm and 60 cm × 10 cm spacing's. The reduction in days to 50 per cent flowering might be due to intra plant competition in dense planting. This was also observed by Hariram *et al.* (2010).

Yield Attributes and Yield

With regard to row spacings, the number of pods plant⁻¹, number of seeds pod⁻¹ and test weight were increased significantly with increasing row spacing from 30 cm × 10 cm, 45 cm × 10 cm to 60 cm × 10 cm spacings. Significantly highest number of pods plant⁻¹ (48.1), seeds pod⁻¹ (2.1) and test weight (9.9 g) were recorded with the spacing of 60 cm × 10 cm than other row spacing's. Less

Influence of soybean productivity by sowing dates and population

Table 1. Growth parameters of soybean as influenced by sowing dates and plant densities

Treatment	Plant height (cm)	Drymatter production (kg ha ⁻¹)	Leaf area index	Days to 50 per cent flowering
Sowing dates				
June 28	38.1	3762	3.7	54
July 14	37.8	3389	3.32	46
July 29	37.1	3051	2.6	36
C.D (P=0.05)	0.01	51.57	0.16	0.38
Plant densities				
30 cm × 10 cm	40.7	3532	4.2	43
45 cm × 10 cm	37.8	3379	3.4	45
60 cm × 10 cm	34.4	3292	1.8	48
C.D (P=0.05)	0.01	51.57	0.16	0.38
D X S				
SEm±	0.01	30.0	0.09	0.2
C.D (P=0.05)	0.03	116.9	0.37	0.87

Table 2. Yields attributes and yield of soybean as influenced by sowing dates and plant densities

Treatment	Number of pods plant ⁻¹	Number of seeds pod ⁻¹	Grain yield (kg ha ⁻¹)	Haulm yield (kg ha ⁻¹)	Test weight (g)	Harvest index (%)
Sowing dates						
June 28	44.7	2.2	1487	2496	9.9	39.1
July 14	42.6	2.1	1289	2177	9.6	37.9
July 29	40.6	1.8	1036	1911	9.3	33.8
C.D (P=0.05)	0.02	0.12	6.12	31.02	0.17	1.99
Plant densities						
30 cm × 10 cm	36.7	1.9	1396	2386	9.3	39.2
45 cm × 10 cm	43.2	2.0	1274	2170	9.5	37.3
60 cm × 10 cm	48.1	2.1	1143	2027	9.9	34.4
C.D (P=0.05)	0.02	0.12	6.12	31.02	0.17	1.99
D X S						
SEm±	0.01	0.07	4.0	18.0	0.1	1.1
C.D (P=0.05)	0.05	NS	13.90	70.37	NS	4.51

NS: Non significant

competition in wider spacing and ample availability of light, moisture, better source sink relationship and nutrients might had resulted in more number of branches plant⁻¹ which in turn might have increased more number of pods plant⁻¹, more number of seeds pod⁻¹ and also increased test weight. Increase in number of pods plant⁻¹, number of seeds pod⁻¹ and test weight with wider row spacing was also reported by Masum Akond *et al.* (2012).

Among different row spacing significantly highest seed yield, haulm yield and harvest index were recorded with narrow row spacing of 30 cm × 10 cm over other two spacings. Though all the yield attributing characters were higher at wider spacings, these improvements were not sufficient to compensate the yields that were obtained due to higher plant population per unit area from closer spacing. Similar increase in seed yield, haulm yield and harvest index at closer spacing was also reported by Manjappa *et al.* (2002).

Interaction Effect

The interaction between sowing dates and row spacings had significant influence on growth parameters, yield parameters and yield of soybean.

Sowing of soybean on June 28 with the spacing of 30 cm × 10 cm attained maximum plant height, total drymatter production and leaf area index over other combinations of sowing dates and row spacing. Sowing of soybean on July 29 with a spacing 30 cm × 10 cm resulted in early flowering. Sowing of soybean on June 28 with the spacing of 60 cm × 10 cm attained the maximum number of pods plant⁻¹ over other combinations of sowing dates and row spacing's. The interaction between date of sowing and row spacing was not significant with regard to number of seeds pod⁻¹ and test weight. Sowing of soybean on June 28 with the spacing level of 30 cm × 10 cm attained the maximum seed yield, haulm yield and harvest index over other combinations of sowing dates and row spacings.

From above investigation, it can be concluded that sowing of soybean on June 28 with the spacing of 30 cm × 10 cm row spacing was more beneficial for getting higher seed yield in soybean on sandy loam soils of scarces rainfall zone of Andhra Pradesh.

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POTASSIUM DYNAMICS IN RELATION WITH SOIL PROPERTIES IN RICE GROWING SOILS OF KURNOOL DISTRICT, ANDHRA PRADESH

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ABSTRACT

An investigation was carried out to study the different forms of potassium and their relationship with soil properties in rice growing soils of Kurnool district. The mean values of water soluble K, available K, exchangeable K, Non-exchangeable K and fixed K were of 20.42, 189.60, 169.18, 329.63 and 519.23 mg kg⁻¹, respectively. Non-exchangeable K had significant positive relationship with other K fractions indicating that equilibrium exists between different forms of potassium in the soil. The order of dominance of different forms of potassium was Fixed K > Non-exchangeable K > Available K > Exchangeable K > Water soluble K. Among the different soil properties pH, CEC, organic carbon and percentage of clay showed positive correlation with all forms of potassium, indicating that soil properties are more influence on the exist of different forms of potassium.

KEYWORDS: Available K, Exchangeable K, Non-Exchangeable K, Water soluble K, Soil properties.

INTRODUCTION

Potassium is the major nutrient and also a most abundant in soils but the K content of the soil varies from place to place based on physico-chemical properties of soil. Potassium exist in soil in different forms *viz.*, water soluble, exchangeable, non-exchangeable (fixed), mineral, lattice and total. But these forms were not homogeneously distributed in soils. Its amount in soil depends on the parent material, degree of weathering, K gains through manures and fertilizers and losses due to crop removal, erosion and leaching. Usually the amounts of non-exchangeable and total K present in the soil were high as compared to water soluble and exchangeable K. The dynamics of potassium in soil depends on the magnitude of equilibrium among various forms and mainly governed by the physico-chemical properties of soil (Lalitha and Dakshinamoorthy, 2014). The present investigation was carried out to study the different forms of potassium in relation with the soil properties in rice growing soils of Kurnool district in Andhra Pradesh.

MATERIAL AND METHODS

The surface samples collected from different locations in rice growing soils of Kurnool district were processed and analyzed for various soil properties such as particle size analysis by Bouyoucous hydrometer method. The pH and EC were determined in 1:2 soil: water

suspension by using pH meter and EC meter, respectively. The organic carbon content, CEC and CaCO₃ were determined as per standard procedures outlined by Jackson (1973).

Water soluble potassium was determined in 1:5 soil: water extract, after 5 minutes shaking (Kanwar and Grewal, 1966). The available potassium was determined by 1N NH₄OAC (pH 7.0) extract with 1:5 soil extract after 5 minutes shaking as described by Jackson (1973). The exchangeable potassium was obtained as a difference of the available and water soluble potassium. The fixed form of potassium was determined by boiling for 10 min with 1 N HNO₃ (1:10 soil: acid ratio), (Wood and Turk, 1941). The Non-exchangeable potassium was obtained by deducting the available potassium from fixed potassium contents.

RESULTS AND DISCUSSION

Physico-chemical properties of soil

Relative proportion of sand, silt and clay fractions of soils ranged from 42.56 to 76.56 per cent (with a mean of 55.49 percent), 0.36 to 19.36 per cent (with a mean of 11.91 per cent) and 16.08 to 43.08 (with a mean of 32.60 per cent), respectively (Table 1). The texture of studied soils varied from moderately coarse to fine. The pH ranges from 7.2 to 8.52 with a mean value of 7.99, indicating

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that soils were neutral to slightly alkaline in reaction. The Electrical Conductivity ranges from 0.14 to 1.52 dS m⁻¹ with a mean value of 0.52 dS m⁻¹ (Table 2).

The CEC ranged from 11.21 to 26.91 c mol (p+) kg⁻¹ with a mean value of 18.21 c mol (p+) kg⁻¹. The organic carbon varied from 0.26 per cent to 0.94 per cent with a mean of 0.67 per cent (Table 2) indicating that most of the soils are belong to medium in organic carbon content.

Different forms of potassium in the selected soils

The water soluble potassium varied from 10.5 to 39.5 mg kg⁻¹ with a mean value of 20.42 mg kg⁻¹. The available potassium varied from 69 to 431 mg kg⁻¹ with a mean value of 189.60 mg kg⁻¹. The exchangeable potassium content varied from 48.5 to 393.5 mg kg⁻¹ with a mean value of 169.18 mg kg⁻¹ where as non-exchangeable potassium ranged between 190.5 to 711 mg kg⁻¹ with a mean value of 329.63 mg kg⁻¹. The fixed potassium in the selected soils varied from 261 to 1142 mg kg⁻¹ with a mean amount of 519.23 mg kg⁻¹ (Table 3). The order of dominance of different forms of potassium was Fixed K > Non-exchangeable K > Available K > Exchangeable K > Water soluble K.

Correlation coefficients (r) among the forms of potassium:

Water soluble K showed positive and significant correlation with available K ($r = 0.468^{**}$), exchangeable K ($r = 0.386^*$), non-exchangeable K ($r = 0.526^{**}$) and fixed K ($r = 0.533^{**}$) whereas available K showed positive and significant correlation with exchangeable K ($r = 0.996^{**}$), non-exchangeable K ($r = 0.754^{**}$) and fixed K ($r = 0.924^{**}$) (Table 4). Similar results were reported by Singh *et al.* (2010). Exchangeable K showed a positive and significant correlation with non-exchangeable K ($r = 0.733^{**}$) and fixed K ($r = 0.910^{**}$). These results were in conformity with the findings of Islam *et al.* (1994), Das *et al.* (2000) and Subhash and Ali (2011). Non-exchangeable K had positive relationship with other K fraction indicating the existence of equilibrium among the forms of K and a depletion of one form will replenishes the other forms of K (Prasad, 2010).

Correlation coefficients between different forms of potassium and soil characteristics

Coefficients of correlations were worked out to assess the influence of soil properties on various forms of K (Table 5).

Among the different soil properties pH, CEC, organic carbon and clay showed the positive correlation with all forms whereas EC, CaCO₃ and sand showed negative correlation. Similar reports were made by Taleb *et al.* (2010). Available K showed positive correlation with CEC ($r = 0.119$), indicating that clay humus complex formed from increased organic matter provides more exchangeable sites and access to K (Basumatary and Borodoloi, 1992).

Exchangeable K showed positive relationship with clay ($r = 0.273$) but negative with EC ($r = -0.096$) and CaCO₃ ($r = -0.112$). High amount of clay ($r = 0.273$) played an important role in increasing the exchangeable K level by holding more potassium in the exchange sites thereby preventing it from leaching.

CONCLUSIONS

The study brings out the importance of potassic forms in the soil and positive correlations among themselves indicates the dynamic equilibrium among the forms of K and majority of potassium is found in fixed form which replenishes soil solution potassium. Hence, if potassium not adequately supplied during plant growth, fixed K depletes and helps in attaining sustainability on a long term basis. Among the different soil properties pH, CEC, organic carbon and clay per cent showed positive correlation with all forms of potassium, it indicating that soil properties are more influence on the exist of different forms of potassium.

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Potassium dynamics in relation with soil properties

Table 1. Particle size analysis and textural classes of the soils

S. No.	Village Name	Clay %	Silt %	Sand %	Texture
1	Nandipalli	16.08	7.36	76.56	Sandy loam
2	Kambalapalli	41.00	10.36	48.64	Sandy clay
3	Chennuru	33.08	15.36	51.56	Sandy clay loam
4	Yerraguntla	34.08	11.36	54.56	Sandy clay loam
5	Abdullapuram	35.08	2.36	62.56	Sandy clay
6	Bathunuru	37.08	9.36	53.56	Sandy clay
7	Bachapuram	33.18	12.36	54.46	Sandy clay loam
8	Gadivemula	34.08	11.36	54.56	Sandy clay loam
9	Nallagatla	39.08	16.36	44.56	Sandy clay
10	RARS,Nandyal	43.08	14.36	42.56	Clay
11	Padakandla	36.08	17.36	46.56	Sandy clay loam
12	Nagulavaram	31.08	0.36	68.56	Clay loam
13	Mandalluru	25.08	14.36	60.56	Sandy clay loam
14	M.C.Farm, College	19.00	12.36	68.64	Sandy loam
15	Rollapadu	37.08	13.36	49.56	Sandy clay
16	Korrapoluru	36.08	6.36	57.56	Sandy clay
17	Midthur	39.08	12.36	48.56	Sandy clay
18	Alaganuru	39.08	12.36	48.56	Sandy clay
19	Bollavaram	31.08	12.36	56.56	Sandy clay
20	Bereli	31.08	4.36	64.56	Sandy clay loam
21	Thellapuri	39.08	16.36	44.56	Sandy clay
22	Gorukallu	35.08	6.36	58.56	Sandy clay
23	Brahmanapalli	31.08	16.36	52.56	Sandy clay loam
24	AyyavariKoduru	31.08	4.36	64.56	Sandy clay loam
25	Pamulapadu	19.00	14.36	66.64	Sandy loam
26	Nehrunagar	34.08	11.36	54.56	Sandy clay loam
27	Parnapalle	29.78	15.96	54.26	Sandy clay loam
28	Machenipalle	25.08	18.36	56.56	Sandy clay loam
29	BandiAtmakuru	30.08	19.36	50.56	Sandy clay loam
30	Krishnaraopeta	33.08	18.36	48.56	Sandy clay loam
Mean		32.60	11.91	55.49	
Range		16.08-43.08	0.36-19.36	42.56-76.56	

Table 2. Physico-chemical properties of soils under investigation

S. No.	Village Name	pH	EC (dS m ⁻¹)	Organic Carbon (%)	CaCO ₃ (%)	C.E.C C mol (p ⁺) kg ⁻¹
1	Nandipalli	7.25	0.59	0.26	1.90	14.65
2	Kambalapalli	7.84	0.25	0.36	1.10	19.82
3	Chennuru	7.87	0.83	0.78	1.80	16.92
4	Yerraguntla	8.10	0.41	0.69	2.70	18.31
5	Abdullapuram	7.87	0.22	0.61	3.80	22.69
6	Bathunuru	8.07	1.52	0.46	2.50	17.31
7	Bachapuram	7.80	0.51	0.55	2.20	14.41
8	Gadivemula	8.26	0.87	0.90	4.20	20.76
9	Nallagatla	7.85	0.84	0.82	2.20	16.42
10	RARS,Nandyala	8.14	0.26	0.76	2.76	22.76
11	Padakandla	8.23	0.35	0.85	1.90	23.65
12	Nagulavaram	8.18	0.24	0.76	4.90	25.61
13	Mandalluru	7.97	0.79	0.45	2.90	14.43
14	M.C.Farm, College	7.77	0.19	0.46	1.13	11.53
15	Rollapadu	8.14	0.28	0.76	3.70	17.32
16	Korrapoluru	8.52	0.62	0.83	3.50	19.43
17	Midthur	8.29	0.61	0.49	3.60	18.29
18	Alaganuru	8.06	0.31	0.78	1.60	17.43
19	Bollavaram	8.12	0.67	0.91	3.80	26.91
20	Bereli	8.08	0.38	0.81	1.10	15.32
21	Thellapuri	8.17	0.31	0.86	3.85	23.41
22	Gorukallu	7.99	0.42	0.94	4.94	24.81
23	Brahmanapalli	7.78	1.01	0.69	1.97	18.21
24	AyyavariKoduru	7.90	0.47	0.64	1.41	14.21
25	Pamulapadu	7.20	0.14	0.53	2.90	15.31
26	Nehrunagar	8.05	0.51	0.93	1.70	15.91
27	Parnapalle	7.30	0.37	0.44	3.10	14.91
28	Machenipalle	8.22	0.75	0.51	2.10	12.48
29	BandiAtmakuru	8.50	0.25	0.62	3.50	11.21
30	krishnaraopeta	8.11	0.51	0.71	3.90	21.91
	Mean	7.99	0.52	0.67	2.76	18.21
	Range	7.2-8.52	0.14-1.52	0.26-0.94	1.1-4.94	11.21-26.91

Potassium dynamics in relation with soil properties

Table 3. Different forms of Potassium in the studied soils (mg kg⁻¹ soil)

S. No.	Village Name	Water soluble K	Available K	Exchangeable K	Non-Exchangeable K	Fixed K
1	Nandipalli	16.5	103.0	86.5	237.0	340
2	Kambalapalli	24.5	283.0	258.5	449.0	732
3	Chennuru	13.5	144.0	130.5	247.0	391
4	Yerraguntla	31.5	221.0	189.5	348.0	569
5	Abdullapuram	11.0	115.0	104.0	239.0	354
6	Bathuunuru	15.0	157.0	142.0	264.0	421
7	Bachapuram	15.0	123.0	108.0	276.0	399
8	Gadivemula	15.5	243.5	228.0	277.5	521
9	Nallagatla	30.5	287.5	257.0	344.5	632
10	RARS, Nandyal	13.5	194.5	181.0	297.5	492
11	Padakandla	17.5	207.5	190.0	385.5	593
12	Nagulavaram	12.0	128.0	116.0	311.0	439
13	Mandalluru	16.0	111.0	95.0	367.0	478
14	M.C.Farm, College	19.0	369.0	350.0	315.0	684
15	Rollapadu	32.5	209.5	177.0	363.5	573
16	Korrapoluru	15.5	206.0	190.5	286.0	492
17	Midthur	37.5	431.0	393.5	711.0	1142
18	Alaganuru	23.5	169.0	145.5	269.0	438
19	Bollavaram	39.5	199.5	160.0	343.5	543
20	Bereli	23.5	234.0	210.5	439.0	673
21	Thellapuri	10.5	198.5	188.0	392.5	591
22	Gorukallu	17.0	185.5	168.5	347.5	533
23	Brahmanapalli	28.0	140.5	112.5	322.5	463
24	Ayyavari Koduru	14.0	203.0	189.0	379.0	582
25	Pamulapadu	13.0	171.5	158.5	258.5	430
26	Nehrunagar	20.5	184.5	164.0	336.5	521
27	Parnapalle	23.0	101.0	78.0	266.0	367
28	Machenipalle	15.5	70.5	55.0	190.5	261
29	BandiAtmakuru	20.5	69.0	48.5	222.0	291
30	Krishnaraopeta	27.5	228.0	200.5	404.0	632
	Mean	20.42	189.60	169.18	329.63	519.23
	Range	10.5-39.5	69-431	48.5-393.5	190.5-711	261-1142

Table 4. Inter Correlations between different forms of potassium

	Water soluble K	Available K	Exchangeable K	Non-Exchangeable K	Fixed K
Water soluble K	1.000				
Available K	0.468**	1.000			
Exchangeable K	0.386*	0.996**	1.000		
Non-Exchangeable K	0.526**	0.754**	0.733**	1.000	
Fixed K	0.533**	0.924**	0.910**	0.948**	1.000

Table 5. Correlations between different forms of potassium and soil characteristics

	Water soluble K	Available K	Exchangeable K	Non-Exchangeable K	Fixed K
pH	0.121	0.169	0.164	0.233	0.217
EC	0.084	-0.084	-0.096	-0.078	-0.086
OC	0.084	0.095	0.091	0.039	0.069
CaCO₃	-0.002	-0.107	-0.112	0.032	-0.034
CEC	0.059	0.119	0.119	0.217	0.184
Clay %	0.199	0.281	0.273	0.363*	0.348
Silt %	0.253	-0.036	-0.063	-0.050	-0.047
Sand %	-0.310	-0.201	-0.178	-0.257	-0.247

* Significant at 0.05 per cent level

** Significant at 0.01 per cent level

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ASSOCIATION ANALYSIS IN GROUNDNUT (*Arachis hypogaea* L.) UNDER ORGANIC AND CONVENTIONAL FERTILIZER MANagements

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ABSTRACT

Fourty four genotypes of groundnut were used to study the correlation and path analysis for yield, quality and their contributing characters under two fertilizer managements viz., organic and conventional. Correlation analysis revealed that kernel yield per plant was significantly and positively correlated with days to 50 % flowering, primary branches per plant, total number of pods per plant, number of mature pods per plant, pod yield per plant, harvest index, 100 seed weight and protein content under both the managements. When both direct and indirect positive contributions were considered, pod yield per plant and shelling percentage influenced kernel yield per plant under both managements signifying the importance of these traits in the improvement of kernel yield.

KEYWORDS: Correlation, Groundnut, Path analysis

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is important oilseed crop of the world. It is a segmental allotetraploid ($2n=40$), self-pollinating annual legume and it is grown throughout the tropical, sub-tropical and warm temperate regions of the world. Its seeds are valued both for its oil and protein contents. The production of oilseed crops was much higher after 1980's and it brought yellow revolution in oilseed crops in India. But our traditional agro system suffered a great setback, especially owing to the indiscriminate use of fertilizers that created the problem of serious environmental consequences. It is believed that organic farming can solve many of these problems as this system is believed to maintain soil productivity and pest control by enhancing natural processes and cycles in harmony with the environment. Organic agriculture is continuously growing worldwide on land and farms in more than 160 countries.

There is a growing demand for the varieties suitable to organic and / or low input farming. The major constraint in organic farming is the lack of suitable varieties specifically bred for optimal production in organically managed systems (Dawson *et al.*, 2011). In the words of Murphy *et al.* (2007) with crop cultivars bred in and adapted to the unique conditions inherent in organic systems, organic agriculture will be better able to realize its full potential as a high-yielding alternative to

conventional agriculture. In several circumstances varieties that perform well in organic systems have different yield rankings under conventional management. Hence it would be a challenge for the breeders to develop cultivar for that condition. In organic agriculture, the immediate need is to make available greater quantity of organically produced seed. Hence there is essential need to encourage breeding programmes, designed in concert with organic farming.

The main objective of any breeding programme is the improvement of yield. Yield being a complex character and are the result of interaction of a number of components. It is essential to identify the component characters through which yield can be improved. Correlation which is the primary tool of breeding programme only provides the amount of association of characters, while path coefficient analysis measures the direct influence of one variable upon another and facilitates the separation of correlation coefficients into components of direct and indirect effects (Dewey and Lu, 1959). Thus, correlation in conjunction with path analysis would provide a better picture of cause and effect relationship between character pairs. Keeping this in view, the present study was carried out to formulate the selection strategies for improvement of pod yield in groundnut under organic and conventional fertilizer managements.

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MATERIAL AND METHODS

The material for the present investigation comprised of forty four genotypes of groundnut evaluated in two separate contiguous trials that differ only in fertilizers managements using a Randomized Block Design with three replications, during *kharif*, 2014 at dryland Farm of S.V. Agricultural College, Tirupati. Each genotype was sown in single row of 3 m length adopting recommended spacing of 30 × 10 cm. In organic fertilizer management trial, FYM at the rate of 20 t ha⁻¹ at the time of field preparation and at fifteen days interval Jeevamrutha was applied. The seed of groundnut was treated with bijamrutha. No inorganic chemicals were used. In order to encounter biotic stresses biopesticides (neemasthram, bramhastram, Gobanam) were used.

In conventional fertilizer management trial, FYM at the rate of 10 t ha⁻¹ at the time of field preparation and recommended dose of chemical fertilizers at the rate of 20 kg N, 40 kg P₂O₅ and 40 kg K₂O per hectare in the form of urea, single super phosphate and murate of potash were used. Seed treatment was done with Bavistin at the rate of 3 g kg⁻¹. The crop was raised with protective irrigation and 500 kg of gypsum ha⁻¹ was applied at peak flowering stage. Cultural practices like weeding and irrigation were followed in common for both trials to maintain good crop growth. Apart from these need based plant protection measures were adopted during the crop season for controlling diseases and pests.

The biometrical observations were recorded on five randomly selected plants per genotype per replication for twelve traits *viz.*, days to 50 % flowering, plant height, primary branches per plant, number of pods per plant, pod yield per plant, mature pods per plant, kernel yield per plant, shelling percentage, harvest index, 100 seed weight, oil content and protein content. The genotypic and phenotypic correlation coefficients were calculated using the method given by Johnson *et al.* (1955) and path coefficient analysis were carried out as suggested by Dewey and Lu (1959).

RESULTS AND DISCUSSION

Analysis of variance of twelve quantitative characters revealed highly significant differences among the genotypes for all the characters under both the fertilizer managements except shelling percentage, which showed non- significant difference under organic fertilizer management and significance under conventional

fertilizer management. The data on all the twelve characters were subjected to statistical analysis. Estimation of correlation coefficients at phenotypic and genotypic levels under both organic and conventional fertilizer managements were presented in Tables 1 and 2.

Higher values of genotypic coefficients than phenotypic coefficients revealed the influence of environment on phenotypic expression of characters under both fertilizer managements. Under organic fertilizer management pod yield per plant showed highly significant and positive correlation with kernel yield per plant ($r_p = 0.927^{**}$, $r_g = 0.978$), followed by mature pods per plant ($r_p = 0.728^{**}$, $r_g = 0.833$), number of pods per plant ($r_p = 0.687^{**}$, $r_g = 0.813$), harvest index ($r_p = 0.458^{**}$, $r_g = 0.520$), primary branches per plant ($r_p = 0.368^{**}$, $r_g = 0.395$), days to 50 % flowering ($r_p = 0.357^{**}$, $r_g = 0.442$), protein content ($r_p = 0.333^{**}$, $r_g = 0.456$) and 100-seed weight ($r_p = 0.297^{**}$, $r_g = 0.312$), at both phenotypic and genotypic levels, indicating that increase in these traits would result in an increase in the pod yield.

Under conventional fertilizer management the trait pod yield per plant showed highly significant and positive correlation with kernel yield per plant ($r_p = 0.938^{**}$, $r_g = 0.987$), followed by 100-seed weight ($r_p = 0.458^{**}$, $r_g = 0.622$), mature pods per plant ($r_p = 0.432^{**}$, $r_g = 0.451$), number of pods per plant ($r_p = 0.416^{**}$, $r_g = 0.333$), harvest index ($r_p = 0.412^{**}$, $r_g = 0.601$), primary branches per plant ($r_p = 0.298^{**}$, $r_g = 0.420$) and days to 50 % flowering ($r_p = 0.180^*$, $r_g = 0.512$) at both phenotypic and genotypic levels, showing that increase in these traits would result in increase in the pod yield. Similar kind of significant positive association of kernel yield per plant with pod yield per plant was reported by John *et al.* (2008), Kumar *et al.* (2012), Narasimhulu *et al.* (2012) and Rao *et al.* (2014). Significant and positive association of pod yield per plant with mature pods per plant were reported by Manoharan *et al.* (1988), Venkateswarlu *et al.* (2007), Kumar *et al.* (2012), and Vasanthi *et al.* (2015), with number of pods per plant by Kumar *et al.* (2012) and Rao *et al.* (2014), with harvest index and 100-seed weight by Korat *et al.* (2010), Suneetha *et al.* (2007) and Golakia *et al.* (2005) with primary branches per plant by Vasanthi *et al.* (2015) and days to 50 % flowering by Mahalakshmi *et al.* (2005).

Identification of important yield components and information about the association with yield and also with each other are necessary in developing efficient breeding

Association analysis in groundnut under organic management

strategy for evolving improved genotypes in any crop species. Under both fertilizer managements significant and positive correlation was observed for days to 50 % flowering with kernel yield per plant and primary branches per plant; primary branches per plant with number of pods per plant, mature pods per plant and kernel yield per plant; number of pods per plant with mature pods per plant and kernel yield per plant; mature pods per plant with kernel yield per plant; kernel yield per plant with shelling percentage, harvest index, 100 seed weight and protein content; Shelling percentage with harvest index and 100 seed weight; harvest index with 100 seed weight and 100 seed weight with protein content. Where as under organic fertilizer management significant and positive association was observed for days to 50 % flowering with number of pods per plant, mature pods per plant and harvest index; plant height with protein content; number of pods per plant with harvest index; mature pods per plant with harvest index and protein content.

Hence these characters could be emphasized during selection process to bring about improvement in the yield potential as well as quality of groundnut cultivars under organic and conventional fertilizer management. Selection of easily observable traits among these would ultimately enhance the mean performance of all concerned inter dependent characters and hence would be helpful in order to get improved pod yield under organic and conventional fertilizer management.

Oil content displayed significant negative association with pod yield under both organic and conventional fertilizer managements. Hence judicious selection programme might be formulated by repeated inter mating to break the negative correlation between oil content and pod yield per plant for simultaneous improvement of these characters under organic and conventional fertilizer management.

Path coefficient analysis was conducted using pod yield per plant as dependent variable and characters which exhibited significant correlation with pod yield as independent variables under both organic and conventional fertilizer managements and the results are presented in Tables 3 and 4. Under organic fertilizer management the trait kernel yield per plant recorded high positive direct effect (0.688) and mature pods per plant recorded moderate positive direct effect (0.2502) on pod yield per plant. On the other hand harvest index (-0.0565) and oil content (-0.0136) recorded negligible direct effect

on pod yield per plant. Days to 50 % flowering (0.2422) and 100 seed weight (0.2780) displayed moderate positive indirect effect through kernel yield per plant. The traits number of pods per plant (0.3963), mature pods per plant (0.4280) and harvest index (0.3965) showed high positive indirect effect on pod yield through kernel yield per plant. Number of pods per plant recorded moderate positive indirect effect (0.2369) through mature pods per plant. Kernel yield per plant displayed low positive indirect effect (0.1556) through mature pods per plant. Oil content recorded moderate negative indirect effect (-0.2628) through kernel yield per plant.

Under conventional fertilizer management the traits kernel yield per plant (0.8691) and number of pods per plant (0.2507) exhibited high and moderate positive direct effects on pod yield per plant respectively. Days to 50 % flowering exhibited low positive indirect effect (0.1947) through kernel yield per plant. Primary branches per plant (0.2034) and number of pods per plant (0.2720) recorded moderate positive indirect effect through kernel yield per plant. The traits mature pods per plant (0.3068), harvest index (0.4284) and 100 seed weight (0.4502) displayed high positive indirect effect through kernel yield per plant. Oil content recorded moderate negative indirect effect (-0.2851) through kernel yield per plant. Mature pods per plant showed moderate positive indirect effect (0.2371) through number of pods per plant.

High direct effects of kernel yield per plant with pod yield per plant was reported by Reddy *et al.* (1986), Vijayasekhar *et al.* (2002), Dhaliwal *et al.* (2003), Lakshmiddevamma *et al.* (2004), Venkateswarlu *et al.* (2007), Sudhir *et al.* (2008) and Kumar *et al.* (2012). High positive indirect effect of harvest index through kernel yield per plant was reported by Vijayasekhar (2002). Negative direct effect of mature pods per plant on pod yield per plant was reported by Sumathi and Muralidharan (2007). High indirect positive effect of mature pods per plant through kernel yield per plant on pod yield per plant was reported by Ahamad (1995) and Kumar *et al.* (2012).

Hence from the foregoing discussion, it could be inferred that kernel yield per plant, and mature pods per plant were the major contributing characters in groundnut under organic fertilizer management where as the traits kernel yield per plant and number of pods per plant were the major contributing characters in groundnut under conventional fertilizer management. Due weightage to these traits in the respective fertilizer management could

Table 1. Genotypic (r_g) and Phenotypic (r_p) correlation coefficients among pod yield per plant and its components in groundnut under organic fertilizer management

S. No.	Character	PH	PBP	NPP	MPP	KYP	SP	HI	100SW	OC	PC	PYP
1	DF	r_g	-0.139	0.540	0.438	0.471	0.177	0.292	-0.144	-0.287	0.002	0.442
		r_p	-0.191*	0.252**	0.217*	0.173*	0.352**	0.053	0.253**	0.058	-0.228**	-0.003
2	PH	r_g	-0.601	-0.202	-0.025	0.065	0.006	-0.171	0.201	-0.080	0.371	0.083
		r_p	-0.468**	-0.116	-0.027	-0.051	0.004	-0.189	0.138	-0.061	0.333**	-0.048
3	PBP	r_g	0.521	0.325	0.336	0.336	-0.359	0.096	-0.294	-0.073	-0.071	0.395
		r_p	0.421**	0.310**	0.289**	-0.176*	0.087	0.087	-0.103	-0.052	-0.047	0.368**
4	NPP	r_g	0.977	0.730	0.784	0.730	0.038	0.308	-0.284	-0.341	0.208	0.813
		r_p	0.947**	0.576**	0.622**	-0.120	0.215*	0.215*	-0.262**	-0.224**	0.143	0.687**
5	MPP	r_g	0.784	0.622**	0.784	0.784	0.038	0.376	-0.166	-0.361	0.285	0.833
		r_p	0.622**	-0.086	0.622**	-0.086	0.247**	0.247**	-0.179*	-0.238**	0.196*	0.728**
6	KYP	r_g	0.334	0.396**	0.334	0.334	0.396**	0.704	0.431	-0.552	0.390	0.978
		r_p	0.396**	0.575**	0.396**	0.396**	0.575**	0.575**	0.404**	-0.382**	0.271**	0.927**
7	SP	r_g	0.957	0.441**	0.957	0.957	0.441**	0.957	0.648	-0.196	-0.170	0.147
		r_p	0.441**	0.347**	0.441**	0.347**	0.347**	0.347**	0.347**	-0.074	-0.066	0.040
8	HI	r_g	0.545	-0.415	0.545	0.545	-0.415	0.545	-0.415	-0.308**	-0.045	0.458**
		r_p	0.372**	-0.308**	0.372**	-0.308**	-0.308**	-0.308**	0.372**	-0.308**	-0.045	0.458**
9	100SW	r_g	-0.254	-0.161	-0.254	-0.254	-0.161	-0.254	-0.161	-0.254	0.282	0.312
		r_p	-0.161	0.195*	-0.161	-0.161	0.195*	0.195*	-0.161	0.195*	0.282	0.297**
10	OC	r_g	-0.381	-0.381**	-0.381	-0.381	-0.381**	-0.381	-0.381	-0.381**	-0.381	-0.528
		r_p	-0.381**	-0.381**	-0.381**	-0.381**	-0.381**	-0.381**	-0.381**	-0.381**	-0.381**	-0.382**
11	PC	r_g	0.456	0.333**	0.456	0.456	0.333**	0.456	0.333**	0.456	0.456	0.456
		r_p	0.333**	0.333**	0.333**	0.333**	0.333**	0.333**	0.333**	0.333**	0.333**	0.333**

*Significant at 5% level; ** Significant at 1 % level

Legend: DF: Days to 50% flowering; PH: Plant height (cm); PBP: Primary branches per plant; NPP: Number of pods per plant; PYP: Pod yield per plant (g); MPP: Mature pods per plant; KYP: Kernel yield per plant (g); SP: Shelling percentage(%); HI: Harvest index; 100SW: 100 seed weight (g); OC: Oil content (%); PC: Protein content (%)

Table 2. Genotypic (r_g) and Phenotypic(r_p) correlation coefficients among pod yield per plant and its components in groundnut under conventional fertilizer management

S. No.	Character	PH	PBP	NPP	MPP	KYP	SP	HI	100SW	OC	PC	PYP	
1	DFF	rg	0.129	0.397	0.122	0.535	0.203	0.275	0.200	-0.290	0.158	0.512	
		rp	0.037	0.187*	0.006	0.003	0.224**	0.128	0.116	0.135	-0.215*	0.120	0.180*
2	PH	rg	-0.391	-0.391	-0.433	-0.296	-0.064	0.462	-0.262	0.130	0.163	0.196	-0.174
		rp	-0.310**	-0.310**	-0.123	0.004	0.021	0.113	-0.228**	0.089	0.133	0.170	-0.023
3	PBP	rg	0.823	0.800	0.823	0.800	0.332	-0.494	-0.118	-0.264	-0.030	-0.052	0.420
		rp	0.475**	0.406**	0.475**	0.406**	0.234**	-0.174*	-0.051	-0.187*	-0.014	-0.075	0.298**
4	NPP	rg	0.977	0.977	0.977	0.977	0.204	-0.704	0.077	-0.520	-0.112	-0.257	0.333
		rp	0.946**	0.946**	0.946**	0.946**	0.313**	-0.229**	0.022	-0.321**	-0.069	-0.170	0.416**
5	MPP	rg	0.342	0.342	0.342	0.342	-0.582	0.230	-0.545	-0.258	-0.206	-0.206	0.451
		rp	0.353**	0.353**	0.353**	0.353**	-0.152	0.046	-0.285**	-0.131	-0.108	-0.108	0.432**
6	KYP	rg	0.308	0.308	0.308	0.308	0.653	0.653	0.660	-0.473	0.280	0.987	
		rp	0.361**	0.361**	0.361**	0.361**	0.493**	0.493**	0.518**	-0.328**	0.189*	0.189*	0.938**
7	SP	rg	0.527	0.527	0.527	0.527	0.330**	0.330**	0.443	-0.457	0.349	0.151	
		rp	0.330**	0.330**	0.330**	0.330**	0.330**	0.330**	0.303**	-0.179*	0.138	0.034	
8	HI	rg	0.416	0.416	0.416	0.416	0.273**	0.273**	0.416	-0.510	-0.045	0.601	
		rp	0.273**	0.273**	0.273**	0.273**	0.273**	0.273**	0.273**	-0.333**	-0.030	0.412**	
9	100SW	rg	-0.255	-0.255	-0.255	-0.255	0.426	0.426	-0.255	0.426	0.426	0.622	
		rp	-0.206*	-0.206*	-0.206*	-0.206*	0.357**	0.357**	0.357**	-0.206*	0.357**	0.357**	0.458**
10	OC	rg	-0.146	-0.146	-0.146	-0.146	-0.146	-0.146	-0.146	-0.146	-0.146	-0.146	
		rp	-0.302**	-0.302**	-0.302**	-0.302**	-0.302**	-0.302**	-0.302**	-0.302**	-0.302**	-0.302**	
11	PC	rg	0.210	0.210	0.210	0.210	0.145	0.145	0.210	0.145	0.210		
		rp	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145		

*Significant at 5% level; ** Significant at 1 % level

Legend: DF: Days to 50% flowering; PH: Plant height (cm); PBP: Primary branches per plant; NPP: Number of pods per plant; PYP: Pod yield per plant (g); MPP: Mature pods per plant; KYP: Kernel yield per plant (g); SP: Shelling percentage(%); HI: Harvest index; 100SW: 100 seed weight (g); OC: Oil content (%); PC: Protein content (%)

Table 3. Phenotypic path coefficient analysis for pod yield per plant and its components in groundnut under organic fertilizer management

S. No.	Character	DFP	PBP	NPP	MPP	KYP	HI	100 SW	OC	PC	PYP
1	DFP	0.0514	0.0210	0.0059	0.0433	0.2422	-0.0143	0.0047	0.0031	-0.0002	0.357**
2	PBP	0.0129	0.0832	0.0115	0.0776	0.1988	-0.0049	-0.0083	0.0007	-0.0035	0.368**
3	NPP	0.0112	0.0350	0.0273	0.2369	0.3963	-0.0121	-0.0212	0.0030	0.0106	0.687**
4	MPP	0.0089	0.0258	0.0258	0.2502	0.4280	-0.0139	-0.0145	0.0032	0.0145	0.728**
5	KYP	0.0181	0.0240	0.0157	0.1556	0.6880	-0.0325	0.0327	0.0052	0.0201	0.927**
6	HI	0.0130	0.0072	0.0059	0.0618	0.3956	-0.0565	0.0301	0.0042	-0.0033	0.458**
7	100 SW	0.0030	-0.0086	-0.0071	-0.0448	0.2780	-0.0210	0.0809	0.0022	0.0145	0.297**
8	OC	-0.0117	-0.0043	-0.0061	-0.0596	-0.2628	0.0174	-0.0130	-0.0136	-0.0283	-0.382**
9	PC	-0.0002	-0.0039	0.0039	0.0490	0.1865	0.0025	0.0158	0.0052	0.0742	0.333**
Residual effect (Phenotypic): 0.29034											

*Significant at 5% level; ** Significant at 1 % level

Legend: DF: Days to 50% flowering; PBP: Primary branches per plant; NPP: Number of pods per plant; PYP: Pod yield per plant (g); MPP: Mature pods per plant; KYP: Kernel yield per plant (g); HI: Harvest index; 100SW: 100 seed weight (g); OC: Oil content (%); PC: Protein content (%)

Table 4. Phenotypic path coefficient analysis for pod yield per plant and its components in groundnut under conventional fertilizer management

S. No.	Character	DFP	PBP	NPP	MPP	KYP	HI	100 SW	OC	PYP
1	DFP	-0.0322	0.0068	0.0015	-0.0003	0.1947	-0.0044	0.0103	0.0036	0.180*
2	PBP	-0.0060	0.0365	0.1191	-0.0428	0.2034	0.0019	-0.0143	0.0002	0.298**
3	NPP	-0.0002	0.0173	0.2507	-0.0996	0.2720	-0.0008	-0.0245	0.0012	0.416**
4	MPP	-0.0001	0.0148	0.2371	-0.1053	0.3068	-0.0018	-0.0218	0.0022	0.432**
5	KYP	-0.0072	0.0085	0.0785	-0.0372	0.8691	-0.0187	0.0396	0.0055	0.938**
6	HI	-0.0037	-0.0019	0.0055	-0.0048	0.4284	-0.0380	0.0208	0.0056	0.412**
7	100 SW	-0.0043	-0.0068	-0.0805	0.0300	0.4502	-0.0104	0.0764	0.0035	0.458**
8	OC	0.0069	-0.0005	-0.0173	0.0138	-0.2851	0.0126	-0.0157	-0.0168	-0.302**

Residual effect (Phenotypic): 0.31076

*Significant at 5% level; ** Significant at 1 % level

Legend: DFP: Days to 50% flowering; PBP: Primary branches per plant; NPP: Number of pods per plant; MPP: Pod yield per plant (g); MPP: Mature pods per plant; KYP: Kernel yield per plant (g); HI: Harvest index; 100SW: 100 seed weight (g); OC: Oil content (%)

be highly beneficial. Therefore, these traits should be given due consideration for indirect selection to improve yield to obtain superior genotypes under the respective management conditions.

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YIELD AND ECONOMICS OF BROADCASTED SESAME (*Sesamum indicum* L.) AS INFLUENCED BY DIFFERENT PRE-AND POST-EMERGENCE HERBICIDES

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ABSTRACT

A field experiment was conducted during summer, 2015 at S.V. Agricultural College Farm, Tirupati to identify the effective and economical weed management practices for the control of weeds in sesame. The weed flora associated in the experimental field were *Cyperus rotundus* (40.0%), *Commelina benghalensis* (10.0%), *Cleome viscosa* (8.0%), *Boerhavia diffusa* (5.0%), *Phyllanthus niruri* (5.0%), *Dactyloctenium aegyptium* (5.0%) and *Digitaria sanguinalis* (4.0 %). Among the different weed management practices tried, two hand weedings at 20 and 40 DAS has recorded the lowest weed dry weight and highest crop dry matter production, seed yield and haulm yield. The next best weed management practice was the pre-emergence application of oxyfluorfen 75 g ha⁻¹ + quizalofop 50 g ha⁻¹ in recording higher seed and haulm yield. However, the highest benefit-cost ratio (2.27) was realized with pre-emergence application of oxyfluorfen 75 g ha⁻¹ + propaquizafop 60 g ha⁻¹ applied at 20 DAS, which was at par with pre-emergence application of oxyfluorfen 75 g ha⁻¹ + quizalofop 50 g ha⁻¹ applied at 20 DAS (2.25).

KEYWORDS: Herbicides, Sesame, Weed management, Yield.

INTRODUCTION

Sesame (*Sesamum indicum* L.) is the oldest oilseed crop known to human being and used by man since antiquity. It is a major oilseed crop because of its drought resistance, ease of extraction and greater stability of oil. The importance of sesame lies in its high oil content upto 50 per cent, rich in protein, calcium, iron and methionine, which are very important for pregnant and lactating women (Gupta *et al.*, 1998). Sesame oil serves as an antioxidant in the manufacture of margarine and salad creams. In India, sesame is occupying an area of 1.70 million hectares and total production of 0.68 million tonnes with average productivity of 402 kg ha⁻¹ during 2012-13. In Andhra Pradesh, it is grown in an area of 0.67 lakh ha with annual production of 0.21 lakh tonnes and average productivity of 313 kg ha⁻¹ during 2012-13 (www.indiastat.com). The crop is grown during *kharif*, *rabi* and summer seasons.

MATERIAL AND METHODS

A field experiment was conducted at S.V. Agricultural College Farm, Tirupati campus of Acharya N.G. Ranga Agricultural University during summer, 2015. The soil of the experimental site was sandy loam in texture, acidic in soil reaction, low in organic carbon, available nitrogen, phosphorus and medium in available

potassium. The experiment was laid out in randomized block design with eleven treatments and replicated thrice. The treatments consisted of eleven weed management practices *viz.*, pre-emergence application of pendimethalin 750 g ha⁻¹, oxyfluorfen 75 g ha⁻¹, oxadiargyl 75 g ha⁻¹ and these herbicides were applied as pre-emergence followed by post-emergence application of herbicides *viz.*, quizalofop 50 g ha⁻¹ and propaquizafop 60 g ha⁻¹ at 20 DAS, including hand weedings twice at 20 and 40 DAS treatment and unweeded check. Pre- and post-emergence herbicides were applied at 1 and 20 DAS of crop with help of knap sack sprayer fitted with flat fan nozzle by using spray fluid of 500 l ha⁻¹ for uniform distribution. All the agronomic except weed management practices adopted as per the university manual for broadcasted sesame. The variety sarada (YLM-66) was sown on 12-01-2015 and harvested on 09-04-2015. Weed and crop dry matter production including seed, haulm yield were recorded.

RESULTS AND DISCUSSION

Different weed management practices significantly influenced the weed dry weight and crop dry matter production including yield and economics of broadcasted sesame. The predominant weed species observed in the experimental field were *Cyperus rotundus* (40.0%), *Commelina benghalensis* (15.0%), *Cleome viscosa*

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Yield and economics of broadcasted sesame

Table 1. Weed dry weight, yield and economics of sesame as influenced by different weed management practices

Treatments	Dose (g a.i ha ⁻¹)	Time of application (DAS)	Weed dry weight at harvest (g m ⁻²)	Dry matter production (kg ha ⁻¹)	Seed yield (kg ha ⁻¹)	Haulm yield (kg ha ⁻¹)	Harvest index (%)	B : C ratio
Pendimethalin	750	1	98.30 (9.98)	2964	554	1085	33.80	1.67
Oxyfluorfen	75	1	98.94 (10.01)	3123	582	1108	34.43	1.88
Oxadiargyl	75	1	102.88 (10.20)	3071	527	1046	33.50	1.70
Pendimethalin + quizalofop	750 + 50	1 + 20	68.93 (8.36)	4199	752	1332	36.08	2.04
Oxyfluorfen + quizalofop	75 + 50	1 + 20	57.50 (7.67)	4567	784	1374	36.32	2.25
Oxadiargyl + quizalofop	75 + 50	1 + 20	77.95 (8.89)	3293	677	1255	35.04	1.95
Pendimethalin + propaquizafop	750 + 60	1 + 20	72.94 (8.60)	4060	751	1331	36.07	2.06
Oxyfluorfen + propaquizafop	75 + 60	1 + 20	60.82 (7.86)	4421	779	1366	36.31	2.27
Oxadiargyl + propaquizafop	75 + 60	1 + 20	80.47 (9.03)	3274	666	1236	35.01	1.94
Two hand weeding	-	20 + 40	18.37 (4.36)	5059	833	1418	37.00	1.97
Unweeded check			144.52 (12.04)	2813	486	993	32.86	1.65
CD (P=0.05)			0.75	148.3	25.0	32.5	0.53	0.03

(10.0%), *Boerhavia diffusa* (10.0%), *Phyllanthus niruri* (5.0%) and *Dactyloctenium aegyptium* (5.0%) in unweeded check plots at harvest.

Among the different weed management practices, the lowest weed dry weight and the highest crop dry matter production were recorded with two hand weedings at 20 and 40 DAS, which was significantly higher than with rest of the weed management practices (Table-1). The next best weed management practice was the pre-emergence application of oxyfluorfen 75 g ha⁻¹ + quizalofop 50 g ha⁻¹ applied at 20 DAS. This might be due to elimination of weed competition during the critical stage of the crop might have increased the crop dry matter production. These results are in conformity with those of Gnanavel and Anbhazhagan (2006). Pre-emergence application of oxadiargyl alone or in combination with quizalofop 50 g ha⁻¹ or propaquizafop 60 g ha⁻¹ applied at 20 DAS were not effective in suppressing the weed biomass and increasing the crop dry matter production significantly. Unweeded check resulted in the highest weed dry weight due to heavy weed infestation, which in turn reduced the crop dry matter production owing to severe competition for growth resources.

Seed yield, haulm yield and harvest index of sesame were significantly influenced by pre-and post-emergence herbicides. Hand weeding twice at 20 and 40 DAS resulted in increased seed and haulm yield including higher harvest index. All these parameters were comparable with pre-emergence application of oxyfluorfen 75 g ha⁻¹ + quizalofop 50 g ha⁻¹ applied at 20 DAS. This might be due to maintenance of weed free environment, resulted in increased growth and yield attributes, owing to better partitioning of photosynthates from source to sink. Similar results were also recorded with the findings of Chauhan *et al.* (2005). The seed yield of sesame was increased by 71.39 and 38.36 per cent with two hand weedings at 20 and 40 DAS and pre-emergence application of oxyfluorfen 75 g ha⁻¹ + quizalofop 50 g ha⁻¹ applied 20 DAS, compared to unweeded check. Among the sequential application of herbicides, the lowest seed and haulm yield including

harvest index was recorded with pre-emergence application of oxadiargyl 75 g ha⁻¹ + quizalofop 50 g ha⁻¹ applied at 20 DAS due to phytotoxicity of oxadiargyl coupled with poor weed control efficiency. The lowest seed and haulm yield with lower harvest index was registered with unweeded check, due to reduced availability of growth resources led to reduced growth and yield components. These results are in agreement with those of Vafaei *et al.* (2013). The highest benefit-cost ratio was realized with pre-emergence application of oxyfluorfen 75 g ha⁻¹ + quizalofop 50 g ha⁻¹ applied at 20 DAS, which was significantly higher than two hand weedings at 20 and 40 DAS, due to decreased cost of weeding in sequential application of herbicides than two hand weedings (Sheoran *et al.*, 2012).

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EFFECT OF FOLIAR NUTRITION ON PHYSIOLOGICAL AND YIELD PARAMETERS OF BLACKGRAM (*Vigna mungo* (L) Hepper)

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ABSTRACT

An investigation was carried out at S.V. Agricultural College, Tirupati to know the effect of foliar application of aminoacids, growth promoting substances, micronutrients and urea on physiological parameters, yield and its attributes in blackgram. The results revealed that spraying amino acids (arginine and glutamine @ 1000 ppm) either alone or in combinations recorded significantly highest plant height, number of primary branches, number of root nodules, days to 50% flowering, SCMR values, leaf area and total dry matter. However 2 per cent urea spray also recorded on par values. Increased LAI, LAD and CGR by amino acids and 2 per cent urea spray resulted in higher dry matter production and better partitioning efficiency thus resulted significant increase in number of pods, pod yield plant⁻¹ and seed yield kg⁻¹.

KEYWORDS: Foliar application - Blackgram- Amino acids – Growth promoting substances – Micro nutrients – Yield parameters.

INTRODUCTION

Blackgram is cultivated in about 3 m ha in India with 1.7 m tonnes of production and 500 kg ha⁻¹ productivity in 2013-14. In Andhra Pradesh its area of cultivation is about 0.59 m ha with 0.85 m tonnes of production and 449 kg ha⁻¹ of productivity during 2013-14 (www.Indiastat.com). The yield of blackgram is very low due to various inherent physiological and biochemical factors associated with the crop. Besides it is mainly grown in rainfed conditions with poor management practices. Insufficient partitioning of assimilates, poor pod setting due to flower abscission and lack of nutrients during critical stages of crop growth, are some important physical causes for poor yield in this crop.

The growth promoting or regulating chemicals like amino acids, plant hormones and micronutrients manipulate source-sink relationship through increased capacity of source and increased translocation of assimilates to sink. Foliar application of growth regulating or growth promoting chemicals at the critical growth stages of the crop to improve their performance is one of potential options. During the last decade, foliar application of nutrients has become an established method in crop production to increase yield and to improve the quality (Khalilzede, 2012). Nutritional spraying on plants decrease the delay between absorption and consumption

of elements by plants, which is very important for accelerating the plant growth.

Amino acids are the building blocks of proteins and serve in a variety of important path ways. They are important in many biological molecules, such as forming part of coenzymes, or as precursors for biosynthesis of molecules such as glutamine (Glu) and ornithine, which serve as precursors for nucleotides and polyamines respectively (Alcazar *et al.*, 2010). When applied together with amino acids the absorption and transportation of micronutrients inside the plant is easier (Ibrahim *et al.*, 2010). Deficiency of micronutrients during the last three decades has grown in both magnitude and extent because of increased use of high analysis fertilizers, use of high yielding crop varieties and increased cropping intensity. This has become a major constraint to production and productivity of rice, wheat and pulses.

Further, plant hormones are related to play an important role in manipulation of source sink relationship in pulse crops. Auxins help in retention of flowers and pods, thus facilitate increased sink demand. Cytokinins promote extended period of green leaf retention and thus help to attain increased source capacity.

There are many independent studies on effect of either amino acids or micronutrients or plant hormones

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alone. However, very less attention was paid to work out a suitable combination of these growth promoting chemicals for manipulation of source sink relationship in pulses. Besides, there is a dearth of literature on compatibility among micronutrients, amino acids and plant hormones. Thus, the objective of the present study was to know the effect of foliar applied amino acids, growth promoting substances, micronutrients and urea on various physiological and yield parameters of blackgram.

MATERIALS AND METHOD

A field experiment was conducted during *rabi* season of 2014-15 at S.V. Agricultural College Farm, Tirupati. The experiment was laid out in randomized block design with 17 treatments replicated thrice. Where in T₁ was Glutamine + Arginine; T₂ Glutamine; T₃ Arginine ;T₄ Ammonium molybdate + Borax; T₅ Ammonium molybdate; T₆ Borax; T₇ NAA + BAP; T₈ NAA; T₉ BAP; T₁₀ Ammonium molybdate + Borax + NAA + BAP; T₁₁ Borax+ NAA + BAP; T₁₂ Ammonium molybdate + NAA + BAP; T₁₃ Glutamine + Arginine + Ammonium molybdate + Borax + NAA + BAP; T₁₄ Arginine + Ammonium molybdate + Borax+ NAA + BAP; T₁₅ Glutamine + Ammonium molybdate +Boron + NAA + BAP;T₁₆ Control *i.e* water spray and T₁₇ was Urea spray.

The concentration of the chemicals was fixed irrespective of its application either alone or in combination. The concentrations used in the experiment were - Glutamine @1000 ppm, Arginine @1000 ppm, Ammonium molybdate @ 0.3 %, Borax @ 0.5 %, NAA @ 100 ppm and BAP @ 50 ppm and urea @ 2%. Concentration of different spray solutions were decided based on literature search. In the control treatment 100 % recommended dose of fertilizers were supplied as basal dose and in the rest of the treatments fertilizers were applied @ 75% RDF. The experiment was conducted in sandy clay loam soil with a plot size of 2x6 mt following standard package of practices. Black gram variety PU-31 was selected for the study. The spacing adopted was 30 x 10 cm. Three irrigations were given to the crop *i.e.*, at sowing, 20 DAS and at flowering stage.

Foliar application of growth promoters (NAA & BAP), micronutrients (borax & ammonium molybdate) and amino acids (arginine & glutamine) as described in experimental details was done at vegetative stage, flowering stage and pod formation stage *i.e.* at 20 DAS,

40 DAS & 60 DAS respectively. Morphological, physiological and yield observations were recorded at 15 days interval. Destructive sampling of 5 plants from each replication was done.

The experimental data were analyzed by the method of analysis of variance following RBD as per the procedure outlined by Panse and Sukhtame (1985). Significance was tested by comparing F-value at 5 % level of probability wherever F- test was significant.

RESULTS AND DISCUSSION

I) Morpho -physiological parameters

a) Plant height (cm)

There was a significant difference observed among different treatments with respect to plant height. At 45 DAS, T₁ (Glutamine @ 1000 ppm + Arginine @ 1000 ppm) recorded significantly highest plant height (15.39 cm) followed by T₃ (Arginine @ 1000 ppm) (13.93 cm), T₂ (Glutamine @ 1000 ppm) (13.91 cm) and T₁₇ (Urea spray 2per cent) (12.95 cm). T₁₅ (Glutamine @1000 ppm + Ammonium molybdate @ 0.3per cent +Borax @ 0.5 per cent + NAA @100 ppm + BAP @ 50 ppm)recorded significantly lowest plant height (7.84 cm). Similar trend was observed at 60 DAS and at 75 DAS.

b) Number of primary branches

As per the results it was found that amino acids (glutamine and arginine) either alone or in combination (T₁, T₂ & T₃), urea 2 percent spray (T₁₇), ammonium molybdate (0.3 per cent) (T₅) and Borax (0.5 per cent) (T₆) either alone or in combination were proved to be effective in influencing the number of primary branches. T₁₅ (the combination of glutamine, ammonium molybdate, Borax, NAA and BAP) showed antagonistic effect on crop growth. This might be due to the incompatible reaction of the components or over dose of their concentrations.

T₁ (Glutamine @ 1000 ppm + Arginine @ 1000 ppm) recorded significantly higher number of primary branches (6.13) compared to control (4.66).

c) Days to 50% flowering

Significantly early flower initiation was observed in T₃ (35.00) followed by T₂ (35.67), T₁ (35.67), and T₁₇ (36.33) when compared to control (43.33). A significant late flowering was observed in T₈ (49.67) followed by T₇ (48.33) compared to control. However, the remaining treatments were found to be at par with control.

d) Leaf area

Irrespective of the treatments applied, leaf area increased continuously from 15 to 60 DAS and thereafter decreased at 75 DAS. At 30 DAS T₁ recorded significantly high leaf area (103.39 cm²), followed by T₂ (19.51 cm²) and T₃ (91.06 cm²) compared to control. Significantly low leaf area was observed in T₁₅ (27.45 cm²) followed by T₁₄ (30.29 cm²). Almost a similar trend was observed at 45, 60 and 75 DAS.

e) Leaf area index

The results indicated that the LAI was continuously increased from 15 DAS to 60 DAS and decreased thereafter at 75 DAS irrespective of the treatments applied. However at 30 DAS, T₁ (0.345) recorded significantly higher LAI followed by T₂ (0.305) and T₃ (0.304) compared to control (0.27). T₁₅ recorded significantly lower LAI (0.092) followed by T₁₄ (0.101). A similar trend was observed at 45, 60 and 75 DAS. (Figure.1)

f) SPAD Chlorophyll Meter Readings (SCMR values)

At 30 DAS T₁ recorded significantly highest SCMR (51.86) and T₁₅ recorded significantly lowest SCMR (33.2) compared to that of control (43.5). A similar trend was observed at 45 DAS. Further, at 60 and 75 DAS T₁₅ recorded a significantly lowest SCMR (32.73) values. The results indicated that amino acids (glutamine and arginine) either alone or in combination, urea 2 percent spray, ammonium molybdate (0.3 per cent) and Borax (0.5 per cent) either alone or in combination, NAA alone and in combination with BAP were proved to be effective in influencing SPAD Chlorophyll meter readings. T₁₄ and T₁₅ (the combination of glutamine or arginine, ammonium molybdate, borax, NAA and BAP) showed antagonistic effect on crop growth. This might be due to the incompatible reaction of the components or over dose of their concentrations.

g) Leaf area duration (cm² day⁻¹)

At 15-30 DAS, T₁ recorded significantly highest LAD (3.07) where as T₁₅ (1.17) recorded significantly lowest LAD compared to control (2.53) (Figure.2). However, at 30-45 DAS compared to control (6.55), T₁ (8.86) recorded significantly highest LAD followed by T₂ (7.54) and T₃ (7.46). Significantly lowest LAD was recorded by T₁₅ (2.57). A similar trend was observed at 45-60DAS and 60-75 DAS.

T₁ (20.5) followed T₃ (18.8), T₁₇ (18.1) and T₂ (18.0) were found to recorded a higher leaf area duration even at 60-75 DAS. The Leaf Area Duration (LAD) during later stage of growth had positive effect on pod filling, resulting to more number of pods per plant.

h) Total dry matter

At 30 DAS T₁ recorded significantly higher total dry matter (2.50) followed by T₂ (2.23) and T₃ (2.21) compared to control (1.81). Significantly lowest total dry matter was produced in T₁₅ (1.02) followed by T₁₄ (1.19). (Table 1).

A similar trend was observed at 45, 60 and 75 DAS. During most of the crop growth period T₄ recorded total dry matter at par with control.

II) Yield parameters

Pod yield (g plant⁻¹) was found significantly higher in T₁ (11.96g) compared to that of control (10.54g) followed by T₃ (11.21g), T₂ (10.75g), T₁₇ (10.67g), T₄ (10.20g), T₅ (9.82g), T₆ (9.71g), T₇ (9.36g), T₈ (9.09g), T₉ (8.89g), T₁₁ (8.76g) and T₁₀ (7.78g). All these treatments were at par with control (10.54). A significant variation among treatments was observed in number pods plant⁻¹ and test weight where as seed number per pod did not differ significantly.

A significant difference among various treatments with respect to seed yield (Kg ha⁻¹) was recorded. Highest seed yield was observed in T₁ (751.3 Kg ha⁻¹), followed by T₂ (709.7 Kg ha⁻¹), T₃ (697.1 Kg ha⁻¹), T₁₇ (672.5 Kg ha⁻¹), T₆ (645.0 Kg ha⁻¹), T₅ (610.5 Kg ha⁻¹), T₄ (587.8 Kg ha⁻¹), T₇ (572.2 Kg ha⁻¹), T₈ (545.8 Kg ha⁻¹), T₉ (526.1 Kg ha⁻¹) T₁₀ (501.9 Kg ha⁻¹) and T₁₁ (506.1 Kg ha⁻¹). They were found to be at par with control (672.5 Kg ha⁻¹) (Table 2).

Significantly lowest Pod yield (g plant⁻¹) and seed yield (kg ha⁻¹) was recorded in T₁₅ (7.14 and 467.2) followed by T₁₄ (7.16 and 480.0), T₁₂ (7.75 and 490.56) and T₁₃ (7.60 and 490.2).

The results are in conformity with Li Yunsheng *et al.*, (2015) in snap bean, Surendar *et al.*, (2013) in blackgram, Saeed *et al.*, (2005) in soybean and Bhattacharya *et al.*, (2004) in blackgram and green gram.

CONCLUSION

Spraying of amino acids either alone or in combination (Glutamine, Arginise and Glutamine + Arginise) and 2 per cent urea might supply a readily

Table 1. Effect of foliar application of amino acids, growth promoting substances, micronutrients and urea on total dry matter (g plant⁻¹) at different growth stages of Blackgram

S. No.	Treatments	Total dry matter(g plant ⁻¹)				
		15 DAS	30 DAS	45 DAS	60 DAS	75 DAS
1	Glutamine @ 1000 ppm+ Arginine @ 1000 ppm (T ₁)	0.193	2.50	5.10	7.76	9.79
2	Glutamine @ 1000 ppm (T ₂)	0.197	2.23	4.68	7.11	9.26
3	Arginine @ 1000 ppm (T ₃)	0.198	2.21	4.53	6.99	9.16
4	Ammonium molybdate @ 0.3% + Borax @ 0.5 % (T ₄)	0.183	1.78	3.77	6.22	7.62
5	Ammonium molybdate @ 0.3% (T ₅)	0.196	1.67	3.20	5.86	6.93
6	Borax@ 0.5 % (T ₆)	0.190	1.58	2.69	5.46	6.25
7	NAA @100 ppm + BAP @ 50 ppm (T ₇)	0.184	1.51	2.36	5.10	5.93
8	NAA @100 ppm (T ₈)	0.195	1.44	2.04	4.75	5.58
9	BAP @ 50 ppm (T ₉)	0.186	1.38	1.71	4.23	5.03
10	Ammonium molybdate@ 0.3% + Borox @ 0.5 % + NAA @100 ppm + BAP @ 50 ppm (T ₁₀)	0.180	1.30	1.38	3.54	4.07
11	Borox@ 0.5 % + NAA @100 ppm+ BAP @ 50 ppm (T ₁₁)	0.191	1.34	1.47	3.89	4.59
12	Ammonium molybdate @ 0.3% + NAA @100 ppm + BAP @ 50 ppm (T ₁₂)	0.174	1.24	1.31	3.07	3.53
13	Glutamine @ 1000 ppm + Arginine @ 1000 ppm + Ammonium molybdate @ 0.3% + Borox @ 0.5% + NAA @ 100 ppm+ BAP @ 50 ppm (T ₁₃)	0.164	1.19	1.24	2.60	3.19
14	Arginine @ 1000 ppm + Ammonium molybdate @ 0.3% + Borox@ 0.5 % + NAA @100 ppm + BAP@ 50 ppm (T ₁₄)	0.173	1.10	1.12	2.06	2.62
15	Glutamine @1000 ppm + Ammonium molybdate @ 0.3%+ Borax @ 0.5 % + NAA @100 ppm + BAP @ 50 ppm (T ₁₅)	0.156	1.02	1.04	1.74	2.23
16	Control (water spray) (T ₁₆)	0.189	1.81	3.82	6.27	7.84
17	Urea spray (2%) (T ₁₇)	0.202	1.99	4.37	6.66	8.65
	Mean	0.185	1.60	2.69	4.89	6.01
	C.D	NS	0.35	0.45	0.70	0.81
	SE (m)	0.010	0.123	0.157	0.244	0.283
	CV	9.49	13.23	10.09	8.62	8.14

Table 2. Effect of foliar application of amino acids, growth promoting substances, micronutrients and urea on yield and yield components in Blackgram

S. No.	Treatments	Yield and yield components					
		No. of pods plant ⁻¹	No. of seeds pods ⁻¹	Pod yield (g plant ⁻¹)	Seed yield (kg ha ⁻¹)	Test weight (g)	Harvest index
1	Glutamine @ 1000 ppm+ Arginine @ 1000 ppm (T ₁)	33.78	8.00	11.96	751.39	5.02	36.05
2	Glutamine @ 1000 ppm (T ₂)	28.56	7.66	10.75	709.72	4.96	34.61
3	Arginine @ 1000 ppm (T ₃)	30.56	7.69	11.21	679.17	4.94	33.20
4	Ammonium molybdate @ 0.3% + Borax @ 0.5 % (T ₄)	27.67	7.67	10.20	587.87	4.76	34.04
5	Ammonium molybdate @ 0.3% (T ₅)	21.44	7.63	9.82	610.56	4.6	33.95
6	Borax@ 0.5 % (T ₆)	26.22	7.59	9.71	645.00	4.60	35.03
7	NAA @100 ppm + BAP @ 50 ppm (T ₇)	24.11	7.70	9.36	572.22	4.46	34.18
8	NAA @100 ppm (T ₈)	22.56	7.63	9.09	545.83	4.42	33.68
9	BAP @ 50 ppm (T ₉)	24.55	7.58	8.89	526.11	4.41	34.21
10	Ammonium molybdate@ 0.3% + Borox @ 0.5 % + NAA @100 ppm + BAP @ 50 ppm (T ₁₀)	15.78	7.64	7.78	501.94	4.39	30.79
11	Borox@ 0.5 % + NAA @100 ppm+ BAP @ 50 ppm (T ₁₁)	20.56	7.59	8.76	506.11	4.40	34.73
12	Ammonium molybdate @ 0.3% + NAA @100 ppm + BAP @ 50 ppm (T ₁₂)	20.00	7.66	7.75	490.56	4.30	22.22
13	Glutamine @ 1000 ppm + Arginine @ 1000 ppm + Ammonium molybdate @ 0.3% + Borox @ 0.5% + NAA @ 100 ppm+ BAP @ 50 ppm (T ₁₃)	15.66	7.53	7.60	490.28	4.25	22.45
14	Arginine @ 1000 ppm + Ammonium molybdate @ 0.3% + Borox@ 0.5 % + NAA @100 ppm + BAP@ 50 ppm (T ₁₄)	13.11	7.67	7.16	480.00	4.25	23.96
15	Glutamine @1000 ppm + Ammonium molybdate @ 0.3%+Borax @ 0.5 % + NAA @100 ppm + BAP @ 50 ppm (T ₁₅)	13.00	7.69	7.14	467.22	4.22	24.16
16	Control (water spray) (T ₁₆)	15.00	7.61	10.54	657.50	4.77	34.87
17	Urea spray (2%) (T ₁₇)	28.22	7.6	10.67	672.50	4.93	33.88
	Mean	22.40	7.65	9.32	581.99	4.57	31.53
	C.D	4.09	N.S.	1.10	162.80	0.53	4.55
	SE (m)	1.41	0.466	0.381	56.262	0.185	1.574
	CV	10.93	7.45	7.08	16.74	7.00	8.64

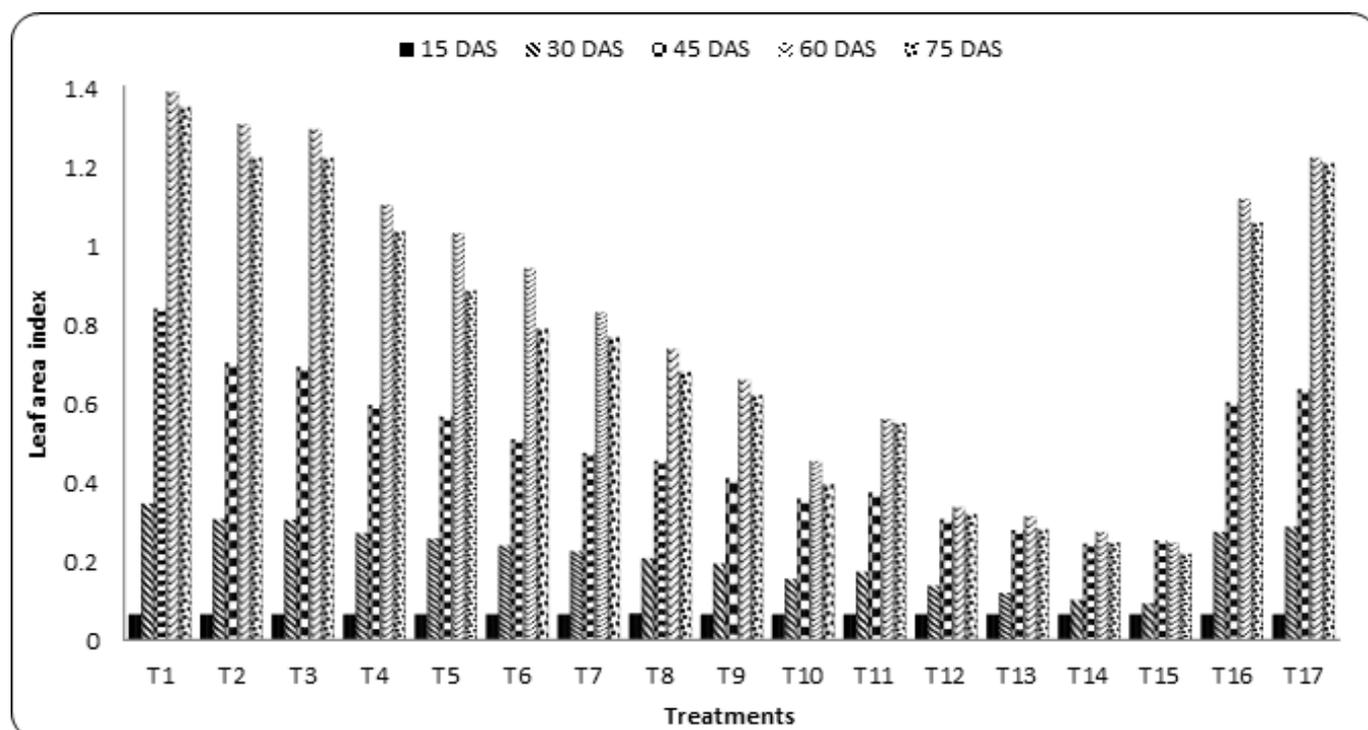


Fig. 1. Effect of foliar application of amino acids, growth promoting substances, micronutrients and urea on leaf area index at different growth stages of Blackgram

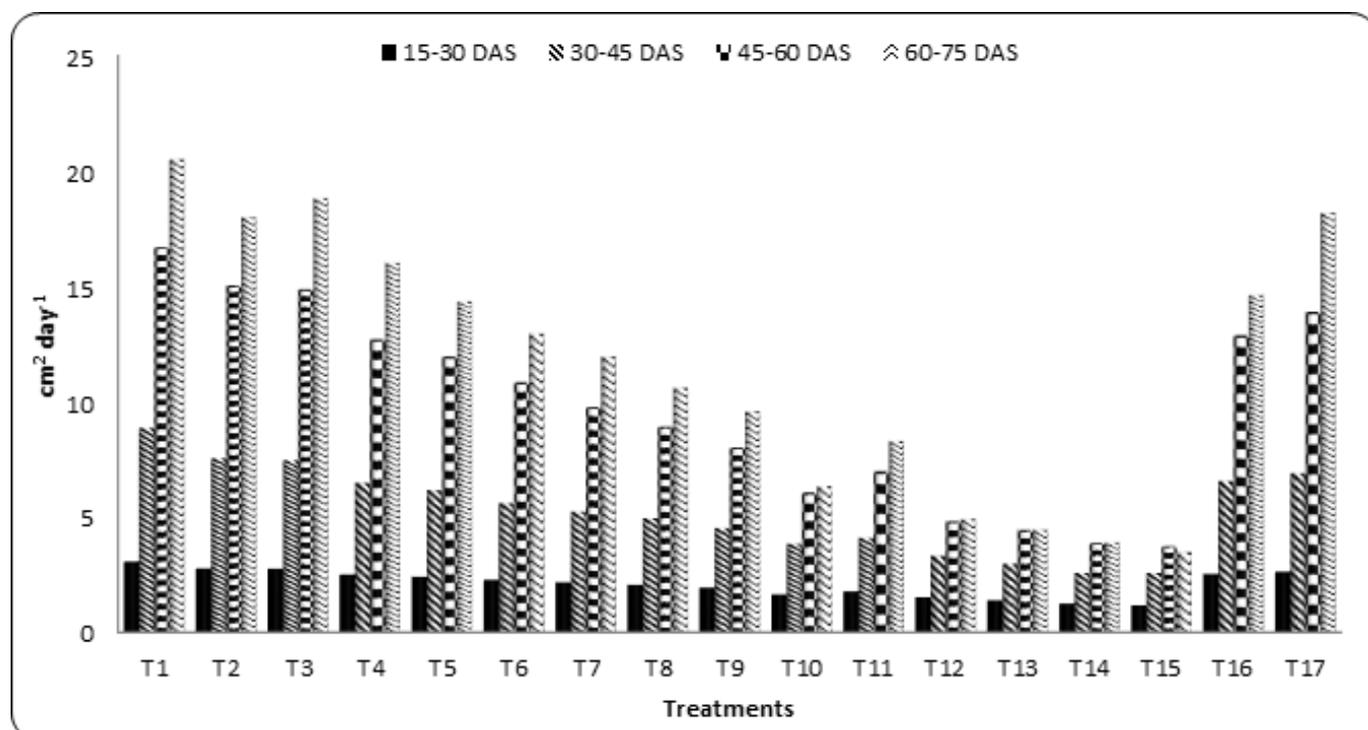


Fig. 2. Effect of foliar application of amino acids, growth promoting substances, micronutrients and urea on leaf area duration (cm² day⁻¹) at different growth stages of Blackgram

available source of nitrogen to the plants. This readily available nitrogen at all the crop growth stages might help to maintain a good leaf nitrogen content which was reflected from the SPAD chlorophyll meter readings. Increased chlorophyll content helped in increasing the photosynthetic assimilation and for development of early canopy. A good canopy developed in the initial stages of the crop helped to intercept more light and caused a better dry matter production. This was observed from the increased values of both leaf area and leaf area index.

Continuous availability of a ready source of nitrogen in the form of amino acids and urea helped to maintain an effective leaf area, represented as Leaf area duration. A continuous increase in LAI, a prolonged LAD, moderate NAR caused an increased crop growth rate. Which was reflected in higher production of total dry matter. Further, more availability of current photosynthates in these treatments might helped to achieve a better pod yield and seed yield.

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RESPONSE OF FOXTAIL MILLET (*Setaria italica* L.) VARIETIES TO DIFFERENT LEVELS OF NITROGEN

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ABSTRACT

A field experiment was conducted during *kharif*, 2014 at S.V. Agricultural College Farm, Tirupati with four foxtail millet varieties (SiA 3088, SiA 3085, SiA 3156 and Srilaxmi) in combination with three nitrogen levels (0, 25, 50 kg N ha⁻¹). The results revealed that SiA 3085 recorded higher stature of growth, yield attributes and yield. The above parameters were at their lower level with SiA 3088 variety. Application of 50 kg N ha⁻¹ markedly improved the growth and yield while, they were found to be at their lower with no nitrogen application. The results concluded that the foxtail millet variety SiA 3085 with the application of 50 kg N ha⁻¹ was profitable to the farmers in sandy loam soils of Southern Agro-Climatic Zone of Andhra Pradesh.

KEYWORDS: Economics, Foxtail millet, Nitrogen, Varieties, Yield.

INTRODUCTION

Foxtail millet (*Setaria italica* L.) is one of the oldest cultivated small millets for food and fodder. It is known for its drought tolerance (Cheng and Liu, 2003) and can withstand severe moisture stress and also suited to wide range of soil conditions. It has an excellent nutritional profile and is miles ahead of rice and wheat in terms of protein, fiber, minerals and vitamins. It is rich in dietary fibre (6.7%), protein (11 %), and low in fat (4 %). Unlike rice, foxtail millet releases glucose steadily without affecting the metabolism of the human body. As the consumption of foxtail millet is increasing day by day particularly by the people suffering with diabetes, there is an increasing demand for foxtail millet. The yield potential of foxtail millet is very low because of inadequate application of fertilizers, conventional cultivation of low yielding cultivars and lack of good management practices. The common belief that foxtail millet may not respond profitably to applied nutrients does not hold good under suitable management practices.

Application of fertilizers has become essential for high yielding varieties of foxtail millet to realize their maximum yield potential.

Recent studies of Basavarajappa *et al.* (2002), Rathore and Sharma (2004) and Hasan *et al.* (2013) indicated that there was a good response of foxtail millet to varied levels of nitrogen under rainfed conditions.

Hence, promising foxtail millet varieties were tested for their response to nitrogen levels to evaluate their yield potentiality.

MATERIAL AND METHODS

A field experiment was carried out during *kharif*, 2014 at S.V. Agricultural College Farm, Tirupati. The experimental soil was sandy loam in texture, neutral in reaction (pH 6.9), low in organic carbon (0.43 per cent) and available nitrogen (188.0 kg ha⁻¹), high in available phosphorus (44.2 kg ha⁻¹) and medium in potassium (170.2 kg ha⁻¹). The experiment was laid out in a randomised block design with factorial concept with twelve treatment combinations and replicated thrice. The treatment combinations comprised of four varieties (SiA 3088, SiA 3085, SiA 3156 and Srilaxmi) and three nitrogen levels (0, 25 and 50 kg N ha⁻¹). The crop was sown in lines at 20 cm apart by adopting all the standard package of practices as per the recommendation of Acharya N.G. Agricultural University, except the imposed treatments. A basal dose of 30 kg P₂O₅ and 20 kg K₂O was applied uniformly to all the treatments. The scheduled nitrogen was applied in two equal splits *viz.*, first half at the time of sowing as basal and remaining half as top dressing at 30 DAS. All the varieties of foxtail millet were sown on 15th July, 2015. The time of harvesting varied from 75 days to 100 days after sowing, depending upon the varietal duration.

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RESULTS AND DISCUSSION

Performance of varieties

Among the four varieties evaluated, the taller plants were produced by the variety SiA 3156 followed by SiA 3085, without any significant difference between them. While, the shorter plants were produced by SiA 3088. Maximum leaf area index and dry matter production were recorded with the variety SiA 3085, which was however comparable with that of SiA 3156 variety. The lower values of these growth parameters viz., plant height, leaf area index and dry matter production were registered with the variety SiA 3088. The total number of tillers m^{-2} were not significantly influenced by the different varieties (Table 1).

Number of panicles m^{-2} at harvest was found to be non significant with the choice of variety. The other yield attributing characters viz., panicle length, weight of the panicle, number of filled grains panicle $^{-1}$ and thousand grain weight were significantly influenced by the varieties. The variety, SiA 3085 resulted in higher values of number of filled grains panicle $^{-1}$, weight of the panicle, thousand grain weight, which was statistically at par with that of the variety SiA 3156. However, the panicle length of SiA 3085 variety was significantly higher than other varieties tried. The lowest values of these yield attributes were produced with SiA 3088 variety (Table 1).

The variety SiA 3085 produced the highest grain and straw yield, which was however comparable with that of SiA 3156, while they were at their lowest with SiA 3088 variety (Table 1). Difference in yields among the varieties can be attributed to their genetic potentiality to utilize and translocate photosynthates from source to sink. Superiority of variety SiA 3085 in producing higher plant height, number of tillers per plant, leaf area has resulted in higher dry matter accumulation, which has contributed to more yield attributes and was reflected in higher yields. The results were in conformity with the findings of Saini and Negi (1996), Munirathnam *et al.* (2006).

The highest benefit-cost ratio was recorded with SiA 3085 followed by SiA 3156. While, the lowest benefit-cost ratio was recorded with SiA 3088 variety. Nitrogen uptake was also highest with the variety SiA 3085, which was however comparable with that of variety SiA 3156. SiA 3088 registered the lowest uptake of nitrogen. The differential rooting pattern of varieties might have resulted in a difference in nitrogen uptake. SiA 3085 could be

efficient in exploring the nutrients exhaustively from the soil (Table 1).

Effect of nitrogen

The highest expression of all the growth parameters and yield attributes were observed with the application of 50 kg N ha^{-1} . While all these parameters were at their lowest value with no nitrogen application (Table 1).

Significant increase in grain and straw yields were observed with increase in nitrogen level from 0 to 50 kg N ha^{-1} . The benefit-cost ratio was also found maximum at 50 kg N ha^{-1} (Table 1).

The highest grain yield was obtained with the application of nitrogen @ 50 kg N ha^{-1} , which was significantly higher than nitrogen application @ 25 kg N ha^{-1} . The increase in yield with 50 kg N ha^{-1} was upto 30 per cent than 25 kg N ha^{-1} . This might be attributed to better availability and uptake of nitrogen which inturn lead to efficient metabolism and higher biomass accrual and efficient translocation of photosynthates from source to sink. The increase in sink capacity resulted in improved yield attributes and consequently enhanced the grain yield of foxtail millet. The above results are in conformity with the findings of Kalaghatagi *et al.* (2000), Hasan *et al.* (2013).

The highest uptake of nitrogen by the crop was observed with the application of 50 kg N ha^{-1} , which was significantly higher than with 25 kg N ha^{-1} and no nitrogen application. The increase in dry matter yield with higher dose of nitrogen application has led to the higher uptake of nitrogen by plants. Incremental doses of nitrogen might have resulted in its increased absorption from the soil (Table 1). The present investigation confirms the documented evidence of Naik *et al.* (1995) and Basavarajappa *et al.* (2002). The highest benefit-cost ratio was obtained with the application of nitrogen @ 50 kg N ha^{-1} .

Interaction between varieties and nitrogen levels was found non-significant with respect to any of the observation made on foxtail millet.

The gradual increase in grain yield and straw yield was observed in all the varieties with increasing levels of nitrogen, but the incremental increase was comparatively higher with variety SiA 3085, which indicated its suitability for cultivation with 50 kg N ha^{-1} application. The above combination also maintained high monetary returns thus satisfying the sustainability criterion.

Table 1. Performance of foxtail millet as influenced by varieties and nitrogen levels

Treatments	Plant height (cm)	Leaf area index	Number of tillers m ⁻²	Drymatter production (kg ha ⁻¹)	Number of panicles m ⁻²	Length of the panicle (cm)	Weight of the panicle (g)	Number of filled grains panicle ⁻¹	1000-grain weight (g)	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	B : C ratio	N uptake (kg ha ⁻¹)
Varieties													
SiA 3088	79.9	1.61	73	2848	66.3	11.9	3.81	821	2.75	1001	1772	1.51	25.9
SiA 3085	91.3	1.82	76	3153	67.0	14.4	4.53	965	2.86	1141	1956	1.72	31.5
SiA 3156	93.7	1.80	76	3135	65.9	13.6	4.43	932	2.83	1106	1943	1.67	30.7
Srilaxmi	89.8	1.68	75	2970	66.6	12.7	4.09	859	2.79	1022	1823	1.55	28.2
CD(P=0.05)	3.7	0.05	NS	159	NS	0.6	0.28	51	0.03	77	124	0.11	1.6
Nitrogen levels (kg ha⁻¹)													
0	66.4	0.85	58	2058	53.3	7.33	1.60	536	2.73	730	1257	1.14	17.1
25	93.9	1.77	76	2956	68.5	14.0	4.07	909	2.80	1075	1789	1.63	29.6
50	105.6	2.56	92	4069	77.5	18.1	6.60	1239	2.89	1398	2574	2.07	40.6
CD(P=0.05)	3.2	0.05	2	138	2.7	0.5	0.25	44	0.29	67	108	0.10	1.4
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Response of foxtail millet to nitrogen

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PRODUCTIVITY OF QUALITY PROTEIN MAIZE AS INFLUENCED BY NITROGEN AND SULPHUR NUTRITION

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ABSTRACT

A field experiment was conducted during *rabi*, 2014-15 at S.V. Agricultural College Farm, Tirupati to find out the response of quality protein maize hybrid (HQPM-1) to various N and S levels. The treatments consisted of four nitrogen levels (60, 120, 180, 240 kg N ha⁻¹) in combination with three sulphur levels (15, 30, 45 kg S ha⁻¹). The results of the experiment revealed that among the four nitrogen levels, application of 240 kg N ha⁻¹ recorded the maximum cob length, cob girth, number of rows cob⁻¹, number of grains row⁻¹, grain weight cob⁻¹, test weight, grain yield (5101 kg ha⁻¹), stover yield (5569 kg ha⁻¹) and harvest index (47.79 %) followed by 180, 120 and 60 kg N ha⁻¹. Similarly, application of 45 kg S ha⁻¹ resulted in significantly more cob length, cob girth, number of rows cob⁻¹, number of grains row⁻¹, grain weight cob⁻¹, test weight, grain yield (3679 kg ha⁻¹), stover yield (4029 kg ha⁻¹) and harvest index (47.28 %) followed by lower levels of sulphur. Hence, N and S can be applied at the rate of 240 kg ha⁻¹ and 45 kg ha⁻¹, respectively to obtain higher yield.

KEYWORDS: Nitrogen, Quality protein maize, Sulphur, Yield components and Yield.

INTRODUCTION

Maize (*Zea mays L.*) is an important cereal crop in the world grown after wheat and rice. It is used as a food and feed crop and is known as the “Queen of Cereals” due to its high yielding potential. Maize grain accounts for about 15 to 56 per cent of total daily diet of people in 25 developing countries but the nutritional profile of maize is poor as it is deficient in essential amino acids such as lysine and tryptophan. Quality Protein Maize (QPM) is a special type of maize developed by researchers of International Maize and Wheat Improvement Center (CIMMYT) which is exactly similar to normal maize but contains the higher level of lysine (4%) and tryptophan (0.8%) thus giving the protein a balanced composition of amino acids. Hence, quality protein maize is necessary to minimize prevalence and persistence of malnutrition in developing countries and to ensure better income to the farmers, food and nutritional security to the consumers, where maize is consumed as staple food. Maize has high productiveness, but some production constrains lower its quantity and quality of production. Among these constraints for maize, imbalance and inadequate nutrition is consider to be one of the important factors. Therefore, a field study was undertaken to study the effect of nitrogen and sulphur on yield attributes and yield of Quality Protein Maize.

MATERIAL AND METHODS

A field experiment was carried out during *rabi*, 2014-15 at S.V. Agricultural College Farm, Tirupati. The experimental soil was sandy loam in texture, neutral in reaction (pH 6.9), low in organic carbon (0.43 per cent) and available nitrogen (125.4 kg ha⁻¹), high in available phosphorus (43.7 kg ha⁻¹), medium in potassium (146 kg ha⁻¹) and sufficient in sulphur (18.5 kg ha⁻¹). The experiment was laid out in randomized block design with factorial concept with twelve treatment combinations and replicated thrice. The treatments comprised of four nitrogen levels (60, 120, 180, 240 kg N ha⁻¹) in combination with three sulphur levels (15, 30, 45 kg S ha⁻¹). Quality Protein Maize hybrid (HQPM-1) was sown on 15th November, 2014 with a seed rate of 20 kg ha⁻¹ at a spacing of 60 × 25 cm. A basal dose of 80 kg P₂O₅ and 80 kg K₂O was applied uniformly to all the treatments. Sulphur was applied as basal as per the treatments. The source of sulphur used was gypsum. The scheduled nitrogen was applied in three equal splits *viz.*, first half at the time of sowing as basal, ¼ as top dressing at knee high stage and remaining ¼ as top dressing at tasseling stage.

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Table 1. Effect of nitrogen and sulphur levels on yield components of quality protein maize

Treatments	No. of cobs plant ⁻¹	No. of rows cob ⁻¹	No. of grains row ⁻¹	Grain weight cob ⁻¹ (g)	Cob length (cm)	Cob girth (cm)	1000 grain weight (g)
Nitrogen Levels (kg ha⁻¹)							
N ₁ (60)	1.00	12.7	25.3	77.8	15.0	12.5	221.9
N ₂ (120)	1.00	12.9	27.2	88.7	15.5	12.4	236.6
N ₃ (180)	1.33	13.3	31.1	122.5	16.5	13.4	262.3
N ₄ (240)	1.33	13.8	33.3	129.3	17.8	13.8	264.4
SEm±	0.11	0.2	0.9	5.0	0.3	0.2	5.8
CD (P=0.05)	NS	0.6	2.5	14.6	1.0	0.7	17.1
Sulphur Levels (kg ha⁻¹)							
S ₁ (15)	1.16	12.5	26.2	85.3	14.7	12.2	227.2
S ₂ (30)	1.16	13.2	29.5	107	16.2	13.0	247.1
S ₃ (45)	1.16	13.8	32.0	121.4	17.7	13.9	264.6
SEm±	0.11	0.2	0.7	4.3	0.3	0.2	5.1
CD (P=0.05)	NS	0.5	2.2	12.6	0.8	0.6	14.8
Interaction							
SEm±	0.22	0.4	1.5	8.6	0.6	0.4	10.1
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS

Table 2. Effect of nitrogen and sulphur levels on grain yield, stover yield and harvest index of quality protein maize

Treatments	Grain yield (kg ha ⁻¹)	Stover yield (kg ha ⁻¹)	Harvest index (%)
Nitrogen levels (kg ha⁻¹)			
N ₁ (60)	1561	2006	43.88
N ₂ (120)	2577	2835	47.56
N ₃ (180)	3993	4269	48.29
N ₄ (240)	5101	5569	47.79
SEm±	50	72	0.80
CD (P=0.05)	147	210	2.36
Sulphur levels (kg ha⁻¹)			
S ₁ (15)	2997	3390	46.41
S ₂ (30)	3247	3591	46.96
S ₃ (45)	3679	4029	47.28
SEm±	44	62	0.70
CD (P=0.05)	128	182	NS
Interaction			
SEm±	87	124	1.39
CD (P=0.05)	NS	NS	NS

RESULTS AND DISCUSSION

Yield components

With increase in N and S levels all the yield components increased significantly except number of cobs plant⁻¹. Treatment with higher dose of N (240 kg ha⁻¹) (N₄) resulted in significantly higher cob length (17.8 cm), cob girth (13.8 cm), number of rows cob⁻¹ (13.8), number of grains row⁻¹ (33.3), grain weight cob⁻¹ (129.3 g) and test weight (264.4 g), which was however, comparable with 180 kg N ha⁻¹ (N₃) except for cob length. While, the least values for all the above parameters were obtained with 60 kg N ha⁻¹ (N₁) and was found to be on par with 120 kg N ha⁻¹ (N₂). Sulphur @ 45 kg S ha⁻¹ (S₃) had shown longer cob length (17.7 cm), cob girth (13.9 cm), number of rows cob⁻¹ (13.8), number of grains row⁻¹ (31.9), grain weight cob⁻¹ (121.4 g) and test weight (264.6 g) which were significantly superior over 30 and 15 kg S ha⁻¹ (Table. 1).

Nitrogen is an essential nutrient required for the promotion of the meristematic tissue and physiological activities such as leaf spread, root development, plant dry matter production, leading to efficient absorption and translocation of water and nutrients and interception of solar radiation. Sulphur is essential for many growth functions of the plant like nitrogen metabolism and enzyme activity. These activities promote higher photosynthetic process which is translocates assimilates into various sink components *viz.*, cob length, cob girth, number of rows cob⁻¹, number of grains row⁻¹, grain weight cob⁻¹ and test weight (Sutar, 2012 and Jena *et al.*, 2013).

Yield

Quality protein maize fertilized with 240 kg N ha⁻¹ had resulted in higher grain yield (5101 kg ha⁻¹), stover yield (5569 kg ha⁻¹) and harvest index (47.79 %). The percentage increase in grain yield with 120, 180 and 240

N & S influence on quality protein maize

kg N ha⁻¹ over 60 kg N ha⁻¹ was 39.42 per cent, 60.9 per cent and 69.39 per cent, respectively. Similarly, the highest grain yield (3679 kg ha⁻¹), stover yield (4029 kg ha⁻¹) and harvest index (47.28 %) were recorded with application of 45 kg S ha⁻¹ followed by other lower levels (Table. 2).

The highest grain yield, stover yield and harvest index was due to better translocation of photosynthates from source to sink and higher growth attributing characters into different parts of plant and yield attributing characters like cob length, cob girth, number of grains per cob, test weight etc. (Naik *et al.*, 2012 and Chaudhary *et al.*, 2013).

CONCLUSION

From the study it can be concluded that application of 240 kg N ha⁻¹ along with 45 kg S ha⁻¹ resulted in higher yield attributes and yield of Quality Protein Maize.

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ECONOMICS OF RICE BASED CROPPING SYSTEM

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ABSTRACT

The study was conducted in Pellakur mandal of Nellore district of Andhra Pradesh during 2014-2015. The cost of cultivation was highest in the case of groundnut (₹ 68,874.71/ha) followed by *rabi* paddy (₹ 65,370.80/ha) and *kharif* paddy (₹ 63,999.44/ha). Among the three crops, groundnut (₹ 1.77) recorded the highest returns per rupee of expenditure followed by *rabi* paddy (₹ 1.59) and *kharif* paddy (₹ 1.42). For the system as a whole returns per rupee of expenditure was ₹ 1.60.

KEYWORDS: Paddy, Groundnut, costs and returns, input use pattern.

INTRODUCTION

The objective of any cropping system is efficient utilization of all resources viz. land, labour, water, and solar radiation maintaining stability in production and obtaining higher net returns. The cropping system should provide enough food for the family, fodder for cattle and generate sufficient cash income for domestic and cultivation expenses. Paddy is the most important cereal crop grown all over the world and is a staple food for a large part of the world human population. In Andhra Pradesh paddy is grown over an area of 4.75 million hectares with production and productivity of 14.42 million tonnes and 3.04 tonnes per hectare respectively (Directorate of Economics and Statistics, 2013). In Nellore district paddy is the major crop which is grown in all the seasons. The major cropping system identified in the study area was paddy-paddy-groundnut. The present study was under taken to study the economics of the said cropping system.

METHODOLOGY

Nellore district was purposively selected for the present study as it is one of the important districts of Rayalaseema region of Andhra Pradesh in cultivation of rice based cropping systems. From the district, Pellakur mandal which had similar cropping pattern of district was purposively selected for the study. From the selected mandal, a list of villages under rice based cropping systems was arranged and two villages namely Eguva chavalli, Chembedupalem were selected at random. From each of the selected village, 15 farmers were selected at

random. The total number of respondents selected for the purpose of the study was 30. Primary data were collected by the survey method through well designed schedule for the agricultural year 2014-15. The study was conducted to examine costs and returns, input use pattern in the cultivation of rice- based cropping system.

RESULTS AND DISCUSSION

Labour utilization pattern of three crops under the cropping system

Human labour is one of the most important factors of production and also a major item of cost structure influencing the cultivation of any crop. The total human labour requirement for *kharif* paddy, *rabi* paddy and groundnut was 105.97, 109.82 and 106.82 mandays respectively. Total human labour requirement for the three crops was 322.61 mandays.

The cattle labour was used only in groundnut cultivation in the cropping system. The total cattle labour used by the groundnut farmers was 3.48 cattle pair days per hectare for sowing operation. Land preparation was the major machine labour absorbing operation in cultivation of any crop. Machinery power for *kharif* paddy, *rabi* paddy and groundnut was 10.85, 10.85 and 5.98 hours respectively. Machine power utilization was highest in groundnut when compared to paddy. This is because, in paddy cultivation machine power was also used for puddling and harvesting.

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Material inputs utilization pattern in rice-based cropping system

It is seen from Table 2 that seed rate for *kharif* paddy was 77.60 kg per hectare. On an average, 4.82 tonnes of farm yard manure was used. The application of N, P and K through chemical fertilizer was of the order of 107.94 kg, 61.98 kg and 71.89 kg per hectare respectively, and zinc was applied 64.38 kg per hectare. The per hectare use of plant protection chemicals was 0.81 kg of Beem, 0.91 kg of Keldon, 2.38 kg of Fire and 1.50 liter of Monocrotophos. Herbicides were also applied as preventive and remedial measure against the attack of weeds. The per hectare use of herbicides was 3.80 liter of Pendimetholin.

In the case of *rabi* paddy seed rate was 77.59 kg per hectare. On an average, 4.82 tonnes of farm yard manure was used. The application of N, P and K through chemical fertilizer was of the order of 209.20, 68.65 and 80.05 kg per hectare respectively, and zinc was applied to an extent of 64.38 kg per hectare. Plant protection chemicals were applied as preventive and remedial measure against the attack of pest and disease. The per hectare use of plant protection chemicals was 1.04 kg of Keldon, 2.50 kg of Fire, 1.75 liters of Monocrotophos and 0.81 kg of Beem.

The seed rate was 175.65 kg per hectare in the cultivation of summer groundnut. The application of N, P, Ca and S through chemical fertilizers was of the order

Table 1. Labour utilization pattern in three crops under cropping system

Particulars	Human labour (man days per hectare)	Cattle labour (cattle pair day per hectare)	Machine labour (hour per hectare)
Paddy (<i>Kharif</i>)	105.97 (32.85)	-	10.85 (39.20)
Paddy(<i>Rabi</i>)	109.82 (34.04)	-	10.85 (39.20)
Groundnut	106.82 (33.11)	3.48 (100)	5.98 (21.60)
Total cropping system	322.61 (100)	3.48 (100)	26.70 (100)

Note: Figures in parentheses indicate percentages to the total

of 162.37 kg, 95.52 kg, 53.32 kg and 27.91 kg per hectare respectively. The per hectare use of plant protection chemicals was 0.85 liters of monocrotophos, 0.25 kg of Mancozeb and 8.8 kg of Phorate granules.

Costs and returns of different crops under the rice-based cropping system

On an average, the total cost of cultivation per hectare of *kharif* paddy in the cropping system was ₹ 63,999.44. The breakup of total costs into operational and fixed costs indicated that the operational costs were ₹ 53,655.46 and fixed costs were ₹ 10,343.98 (Table 3). Expenditure on human labour, seeds, fertiliser and manure, and plant protection chemicals were the important components of operational cost. Similarly rental value of owned land, interest on fixed capital and depreciation charges were the major components of fixed cost. On an average, the per hectare cost of cultivation of *rabi* paddy in the cropping system worked out to ₹ 65,370.80. Out of the

total costs, ₹ 55,026.82 were operational costs and ₹ 10,343.98 fixed costs (Table 4). The per hectare cost of cultivation of groundnut in the cropping system worked out to be ₹ 68,874.71. Out of the total costs, ₹ 58,530.73 were operational costs and ₹ 10,343.98 fixed costs (Table 5).

The total cost of cultivation of all crops in the cropping system as a whole was ₹ 1,98,244.95. Among the crops highest share in total cost was from groundnut (34.74%) followed by *rabi* paddy (32.98%) and *kharif* paddy (32.28%) (Table 6).

The gross income realized from the cropping system as a whole was ₹ 3,17,500.00 and the net income was ₹ 1,19,255.05. Among the crops, highest share in gross income was from groundnut (38.50%) followed by *rabi* paddy (32.75%) and *kharif* paddy (28.67%). Net income was also from groundnut (44.96 %) followed by *rabi* paddy (32.40%) and *kharif* paddy (22.64%).

Table 2. Material inputs used in the rice-based cropping system

S. No.	Particulars	Units	Paddy (Kharif)	Paddy (Rabi)	Groundnut
1	Seeds	Kgs	77.60	77.59	175.65
2	FYM	Tonnes	4.82	4.82	-
3	Fertilizers.				
i	N	Kgs	107.94	209.20	162.37
ii	P	Kgs	61.98	68.65	95.52
iii	K	Kgs	71.89	80.05	-
iv	Zn	Kgs	64.38	64.38	-
v	Ca	Kgs	-	-	53.32
vi	S	Kgs	-	-	27.91
4	Plant protection chemicals				
i	Beem	Kgs	0.81	0.81	-
ii	Keldon	Kgs	0.91	1.04	-
iii	Fire	Kgs	2.38	2.50	-
iv	Monocrotophos	Lit	1.50	1.75	0.85
vi	Pendimetholin	Lit	3.80	-	3.78
vii	Mancozeb	Kgs	-	-	0.25
viii	Phorate	Kgs	-	-	8.8

Table 3. Cost of cultivation of *kharif* paddy (Rupees per hectare)

S. No.	Particulars.	Per hectare
I	VARIABLE COSTS	
1	Human labour	18,544.75
2	Tractor power	8,260.00
3	Combined harvester	3,885.00
4	Seeds	1,939.77
5	Manures and fertilizers	14616.11
a)	Manures	4,820.00
b)	Fertilizers	9,796.11
6	Plant protection chemicals	4,847.05
7	Interest on working capital	1,562.78
	Total variable costs	53,655.46
II	FIXED COSTS	
1	Land revenue	166.66
2	Rental value of owned land	8,333.00
3	Depreciation	799.00
4	Interest on fixed capital	1,045.32
	Total fixed costs	10,343.98
	Total costs	63,999.44

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Table 4. Cost of cultivation of *rabi* paddy (Rupees per hectare)

S. No.	Particulars.	Per hectare
I	VARIABLE COSTS	
1	Human labour	19,218.50
2	Tractor power	8,250.00
3	Combined harvester	3,900.00
4	Seeds	2,327.72
5	Manures and fertilizers.	15988.12
a)	Manures	4,820.00
b)	Fertilizers.	11,168.12
6	Plant protection chemicals	3,739.76
7	Interest on working capital	1,602.72
	Total variable costs	55,026.82
II	FIXED COSTS	
1	Land revenue	166.66
2	Rental value of owned land	8,333.00
3	Depreciation	799.00
4	Interest on fixed capital	1,045.32
	Total fixed costs	10,343.98
	Total costs	65,370.80

Table 5. Cost of cultivation of groundnut (Rupees per hectare)

S. No	Particulars.	Per hectare
I	VARIABLE COSTS	
1	Human labour	18,693.50
2	Tractor power	5,980.00
3	Cattle pair (sowing)	1,392.00
4	Seeds	16,440.62
5	Fertilizers.	11,655.38
6	Plant protection chemicals	2,664.45
7	Interest on working capital	1,704.78
	Total variable costs	58,530.73
II	FIXED COSTS	
1	Land revenue	166.66
2	Rental value of owned land	8,333.00
3	Depreciation	799.00
4	Interest on fixed capital	1,045.32
	Total fixed costs	10,343.98
	Total costs	68,874.71

Table 6. Costs and returns structure of different crops under rice-based cropping system (Rupees per hectare)

S. No	Particulars	Paddy (Kharif)	Paddy (Rabi)	Groundnut	₹ / Cropping system
I	Costs				
i	TVC	53,655.46 (32.09)	55,026.82 (32.91)	58,530.73 (35.00)	1,67,213.01 (100)
ii	TFC	10,343.98 (33.33)	10,343.98 (33.33)	10,343.99 (33.34)	31,031.94 (100)
iii	TC	63,999.44 (32.28)	65,370.80 (32.98)	68,874.71 (34.74)	1,98,244.95 (100)
II	Returns				
i	Yield (tonnes)	7.28	8	3.5	
ii	Gross income	91,000.00 (28.70)	1,04,000.00 (32.80)	1,22,500.00 (38.50)	3,17,500.00 (100)
iii	Net income	27,000.56 (22.64)	38,629.20 (32.40)	53,625.29 (44.96)	1,19,255.05 (100)
iv	Gross margin	37,344.54 (24.85)	48,973.18 (32.59)	63,969.27 (42.56)	1,50,286.99 (100)
v	Return per rupee expenditure	1.42	1.59	1.77	1.60

The returns per rupee of expenditure was observed to be the highest in groundnut (1.77) followed by *rabi* paddy (1.59) and *kharif* paddy (1.42) and for the system as a whole it was found to be 1.60 (Table 6).

CONCLUSIONS

The total cost of cultivation for the cropping system as a whole was ₹ 1,98,244.95 per hectare. Out of the total costs, ₹ 31,031.94 were fixed costs and ₹ 1,67,213.01 variable costs. The gross income, net income realized from the cropping system as a whole was ₹ 3,17,500 and ₹ 1,19,255.05 per gross hectare respectively. The return per rupee of expenditure for the cropping system as a whole was 1.60.

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PRODUCTIVITY OF FINGER MILLET AS INFLUENCED BY CROP GEOMETRY AND AGE OF SEEDLINGS

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ABSTRACT

A field experiment was conducted to study the influence of crop geometry and age of seedlings on the productivity of finger millet during *rabi*, 2014- 15 at S.V Agricultural college farm, Tirupati. The experiment was laid out in randomized block design and replicated thrice. The results revealed that the yield attributes *i.e.*, number of productive tillers m⁻², thousand grain weight, length of the finger, grain yield, straw yield and harvest index were higher with transplanting of 15 days old seedlings at 20 cm × 20 cm with single seedling hill⁻¹. The yield increase in finger millet with this treatment was 17.8 per cent higher compared to ANGRAU package.

KEYWORDS: Age of seedlings, crop geometry, finger millet, Yield attributes, Yield

INTRODUCTION

Finger millet or *Mandua* or Bird's foot millet commonly known as *Ragi* (*Eleusine coracana* (L.) Gaertn.) is an important small millet crop ranked third in India with respect to area, production and has the pride of place due to the highest productivity among the millets (Seetharam and Krishne Gowda, 2007). It is a staple food crop in many hilly regions of the country. Finger millet is a small cereal grain with outstanding properties *viz.*, rich in calcium, iron, dietary fibre and polyphenols. Finger millet is the richest source in calcium content and 10 times higher than that of paddy or wheat (Stanly and Shanmugam, 2013).

Over the last three decades, finger millet crop has been declining in area and production due to low price in the market and forced the farmers to shift to cash crop cultivation. However, there is every need to increase the productivity of finger millet for reducing the burden on rice and wheat production to meet the food needs of ever increasing population in India. Major constraint in finger millet production is lack of suitable improved crop management practices. Age of seedling and optimum spacing were the key agronomic practices for realizing higher yield in finger millet. The information related to influence of crop geometry and age of the seedlings on productivity of finger millet is lacking in Andhra Pradesh. In this context, the present work was under taken to study

the influence of crop geometry and age of seedlings on the performance of finger millet.

MATERIAL AND METHODS

A field experiment was carried out during *rabi*, 2014 at S.V. Agricultural College Farm, Tirupati. The experimental soil was sandy loam in texture, neutral in reaction (pH 6.9), low in organic carbon (0.43 %) and available nitrogen (213 kg ha⁻¹), high in available phosphorus (24.2 kg ha⁻¹) and medium in potassium (250.2 kg ha⁻¹). The present experiment was laid out in a randomized block design with ten treatments and replicated thrice. The treatments consisted of T₁ - ANGRAU package (Transplanting of 25 days old seedlings at 15 cm × 10 cm @ 2-3 seedlings hill⁻¹), T₂ - Transplanting of 12 days old seedlings at 20 cm × 20 cm, T₃ - Transplanting of 12 days old seedlings at 25 cm × 25 cm, T₄ - Transplanting of 12 days old seedlings at 30 cm × 30 cm, T₅ - Transplanting of 15 days old seedlings at 20 cm × 20 cm, T₆ - Transplanting of 15 days old seedlings at 25 cm × 25 cm, T₇ - Transplanting of 15 days old seedlings at 30 cm × 30 cm, T₈ - Transplanting of 18 days old seedlings at 20 cm × 20 cm, T₉ - Transplanting of 18 days old seedlings at 25 cm × 25 cm, T₁₀ - Transplanting of 18 days old seedlings at 30 cm × 30 cm. Transplanting of different aged seedlings in main field was done in staggered fashion as per the spacings. In all the treatments, single seedling hill⁻¹ was planted except with ANGRAU

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package, where 2-3 seedlings hill⁻¹ were planted. First irrigation was given immediately after transplanting and life saving irrigation on third day after transplanting. Subsequent irrigations were given at an interval of 7-8 days as and when required. The test variety used in the experiment was 'Vakula', a recently released variety from Agricultural Research Station, Perumallapalle, Chittoor district, Acharya N.G. Ranga Agricultural University, Andhra Pradesh.

The recommended dose of fertilizer 60-30-30 kg N, P₂O₅ and K₂O ha⁻¹ was applied through urea, single super phosphate and muriate of potash, respectively. Entire dose of phosphorous, potassium and half dose of nitrogen were applied as basal. The remaining half dose of the nitrogen was top dressed at 30 DAT.

The data on yield attributes and yield were subjected to statistical scrutiny by the method of analysis of variance outlined by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

The experimental results revealed that yield attributes like productive tillers, number of fingers earhead⁻¹, thousand grain weight, length of finger were significantly higher under transplanting of 15 days old seedlings (DOS) at 20 cm × 20 cm with single seedling hill⁻¹ followed by transplanting of 12 DOS planted at 20 cm × 20 cm with single seedling hill⁻¹ and it was statistically at par with transplanting of 18 DOS at 20 cm × 20 cm with single seedling hill⁻¹. Optimum plant spacing of 20 cm × 20 cm provides favourable microclimate to crop for effective utilization of available moisture and nutrients leading to better partitioning of photosynthates to reproductive parts might be the reason of getting higher yield attributes. Similar findings were also reported by Umair *et al.* (2014).

The highest grain yield of finger millet was obtained with transplanting of 15 days old seedlings at 20 cm × 20 cm with single seedling hill⁻¹, which was statistically significant than other treatments. Transplanting of 12 days old seedlings at 20 cm × 20 cm with single seedling hill⁻¹ recorded significantly higher grain yield which was however, comparable with transplanting of 18 days old seedlings at 20 cm × 20 cm with single seedling hill⁻¹. Higher grain yield with transplanting of 15 days old seedlings at 20 cm × 20 cm with single seedling hill⁻¹ might be due to enhanced stature of yield attributes, forming larger sink size coupled with efficient translocation of photosynthates to the sink was noticed

under optimum planting pattern with transplanting of young seedlings. These results are in line with the findings of Jogi Naidu *et al.* (2013).

Among all the treatments, ANGRAU package *i.e.*, transplanting of 25 days old seedlings at 15 cm × 10 cm @ 2-3 seedlings hill⁻¹ resulted in significantly the highest straw yield due to maintenance of more plant population owing to closer spacing 15 cm × 10 cm and maintenance of two seedlings hill⁻¹ might have contributed to maximum LAI and DMP which ultimately enhanced the straw yield. Similar findings were also reported by Kalaraju *et al.* (2011).

Higher harvest index is indicative of high efficiency of partitioning of photosynthates into grain than other plant parts. The highest harvest index of finger millet was registered with transplanting of 15 days old seedlings at 20 cm × 20 cm spacing with single seedling hill⁻¹ which was comparable with transplanting of 12 days old seedlings at same spacing with single seedling hill⁻¹. The lowest harvest index of finger millet was recorded with ANGRAU package *i.e.*, transplanting of 25 days old seedlings at 15 cm × 10 cm @ 2-3 seedlings hill⁻¹ due to the less conversion of total number of tillers into productive tillers and it causes less increase in grain yield corresponding to increase in biological yield whereas greater the conversion of total number of tillers into productive tillers in case of transplanting of 15 days old seedlings at 20 cm × 20 cm with single seedling hill⁻¹. Similar finding was also reported by Hardev Ram *et al.* (2014).

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Table 1. Yield attributes of finger millet as influenced by crop geometry and age of seedlings

Treatments	Productive tillers (m ²)	No. of finger earhead ⁻¹	Length of finger (cm)	No. of grains earhead ⁻¹	Test weight (g)
T ₁ : ANGRAU package (Transplanting of 25 days old seedlings at 15 cm × 10 cm @ 2-3 seedlings hill ⁻¹)	82.9	7.0	8.3	2069	2.74
T ₂ : Transplanting of 12 days old seedlings at 20cm × 20 cm	84.9	9.1	8.7	2274	2.89
T ₃ : Transplanting of 12 days old seedlings at 25 cm × 25 cm	50.5	9.0	8.3	2128	2.82
T ₄ : Transplanting of 12 days old seedlings at 30 cm × 30 cm	48.5	8.6	8.2	2110	2.79
T ₅ : Transplanting of 15 days old seedlings at 20 cm × 20 cm	90.9	10.2	8.6	2323	2.91
T ₆ : Transplanting of 15 days old seedlings at 25 cm × 25 cm	53.3	8.5	8.4	2140	2.85
T ₇ : Transplanting of 15 days old seedlings at 30 cm × 30 cm	50.0	8.0	8.3	2116	2.80
T ₈ : Transplanting of 18 days old seedlings at 20 cm × 20 cm	84.7	9.0	8.8	2229	2.87
T ₉ : Transplanting of 18 days old seedlings at 25 cm × 25 cm	45.5	9.0	8.5	2184	2.76
T ₁₀ : Transplanting of 18 days old seedlings at 30 cm × 30 cm	43.1	8.6	8.1	2106	2.86
SEm±	2.9	0.6	0.11	12.30	0.05
CD (P=0.05)	8.7	NS	0.32	36.56	0.14

Table 2. Grain yield and straw yield including harvest index of finger millet as influenced by crop geometry and age of seedlings

Treatments	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	Harvest index
T ₁ : ANGRAU package (Transplanting of 25 days old seedlings at 15 cm × 10 cm @ 2-3 seedlings hill ⁻¹)	2361	6856	0.33
T ₂ : Transplanting of 12 days old seedlings at 20cm × 20 cm	2426	5041	0.43
T ₃ : Transplanting of 12 days old seedlings at 25 cm × 25 cm	2147	4610	0.35
T ₄ : Transplanting of 12 days old seedlings at 30 cm × 30 cm	2031	4165	0.34
T ₅ : Transplanting of 15 days old seedlings at 20 cm × 20 cm	2876	5752	0.44
T ₆ : Transplanting of 15 days old seedlings at 25 cm × 25 cm	2299	4858	0.40
T ₇ : Transplanting of 15 days old seedlings at 30 cm × 30 cm	2112	4100	0.41
T ₈ : Transplanting of 18 days old seedlings at 20 cm × 20 cm	2413	5306	0.42
T ₉ : Transplanting of 18 days old seedlings at 25 cm × 25 cm	1976	4550	0.39
T ₁₀ : Transplanting of 18 days old seedlings at 30 cm × 30 cm	1966	4010	0.37
SEm±	110	217	0.04
CD (P=0.05)	324	642	0.12

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TRENDS IN PRICES OF PULSES IN SELECTED MARKETS OF ANDHRA PRADESH

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ABSTRACT

The present study was conducted for bengalgram, blackgram, greengram, redgram in selected markets of Andhra Pradesh for a period of 2000-2014. The secondary data pertaining to monthly modal prices (Rs./qtl) of selected pulses was collected from respective Agricultural Market Committees for evaluation of trend analysis for the corresponding markets. In selected markets, with regard to prices of selected pulses in the long run all the markets showed an increasing trend. The extent of increase in prices varied from one market to another.

KEYWORDS: Bengalgram, Blackgram, Greengram, Redgram, Prices, Trend.

INTRODUCTION

India is one of the largest pulses producing countries in the world. It accounts for 32.24 per cent of global pulses area but only 23.46 per cent of the global pulse production. About 23.26 million hectares of land (17 per cent of the total cultivated area) is under cultivation of pulses with an annual production of about 18.34 million tonnes (2012-13). Pulses have been cultivated in rain fed conditions which are characterised by poor soil fertility and moisture stress. Among the pulses, chickpea and pigeon pea are the important crops accounting for 50 per cent of pulse area and 60 per cent of total production. Madhya Pradesh, Uttar Pradesh, Maharashtra, Rajasthan, Andhra Pradesh, Karnataka, Bihar, Chattisgarh, Gujarath and Tamil Nadu, Orissa account for about 95 per cent of production.

Pulses are the cheapest source of dietary proteins. The highest content of protein in pulses makes the diet more nutritive. Pulses occupy a unique position in Indian agriculture by virtue of their high protein content (up to 18-25%) and ability to convert atmospheric nitrogen into useful form. This makes pulses one of the cheap sources of protein for human consumption. Hence pulses are also called as poor man's meat. However, prices of pulses were highly flexible across the markets. Hence, the study was taken up to analyse the price trends of bengalgram, blackgram, greengram and redgram across the selected markets and to explore possible reasons.

MATERIAL AND METHODS

This study was undertaken with an overall objective of analysing the trends in prices of bengalgram, blackgram, greengram and redgram. Selection of the markets was done on the basis of maximum quantity of arrivals for the market. The top two markets were selected for each crop for the study are Koilakuntla, Kurnool, Tenali, Ponnur, Thandur, Suryapetamarkets. The secondary data collected for the study were monthly modal prices of bengalgram, blackgram, greengram and redgram at the respective Agricultural Market Committees of the selected markets for a period of 14 years (2000 to 2014).

Time Series Analysis

A time series is a complex mixture of four components namely, Trend (T_t), Seasonal (S_t), Cyclical (C_t) and Irregular (I_t). These four types of movements are frequently found either separately or in combination in a time series. The relationship among these components is assumed to be additive or multiplicative, but the multiplicative model is the most commonly used, which can be represented as

$$\text{Monthly data: } Y_t = T \times C \times S \times I$$

$$\text{Yearly data: } Y_t = T \times C \times I$$

where,

Y_t : Original observation at time period 't'

T_t : Secular trend at time period 't'

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S_t : Seasonal variations at time period 't'

C_t : Cyclical movements at time period 't'

I_t : Irregular fluctuations at time period 't'

x = Period

a = Intercept parameter

b = Slope parameter

e = Error

Analysis of long-term movements (trend)

For estimating the long run trend of arrivals and prices, the method of least squares estimate was employed. This method of ascertaining the trend in a series of annual arrivals of prices involves estimating coefficient of intercept (a) and slope (b) in the linear functional form. The equation adopted for this purpose was specified as follows

$$Y_t = a + bx + e$$

Y_t = Trend values at time t

Annual trends of prices for the selected markets were computed and compared. The goodness of fit of trend line to the data was tested by the coefficient of multiple determination which is denoted by R^2 .

RESULTS AND DISCUSSION

The trends are the changes over years and are associated with changes in technology of production, input supply, infrastructure etc. The study of trends enables us to indicate the general direction of change in prices in different markets.

Table 1. Trends in prices of bengalgram in the selected markets

Market	Equation	R^2	t
Koilakuntla	$782.777 + 15.3198*t$	0.77	12.3356**
Kurnool	$915.327 + 12.2841*t$	0.60	11.9574**

** Significant at 1% level of significance

Table 2. Trends in prices of blackgram in the selected markets

Market	Equation	R^2	t
Tenali	$1104.866 + 22.13379*t$	0.64	8.723041**
Ponnur	$846.3734 + 23.20199*t$	0.69	7.061094**

** Significant at 1% level of significance

Table 3. Trends in prices of greengram in the selected markets

Market	Equation	R^2	T
Suryapeta	$823.6617 + 22.85532*t$	0.66	6.644157**
Thandur	$731.5858 + 25.31653*t$	0.70	5.748414**

** Significant at 1% level of significance

Table 4. Trends in prices of redgram in the selected markets

Market	Equation	R^2	T
Thandur	$998.0815 + 20.01432*t$	0.78	12.28495**
Kurnool	$1113.5000 + 14.35965*t$	0.70	15.58149**

** Significant at 1% level of significance

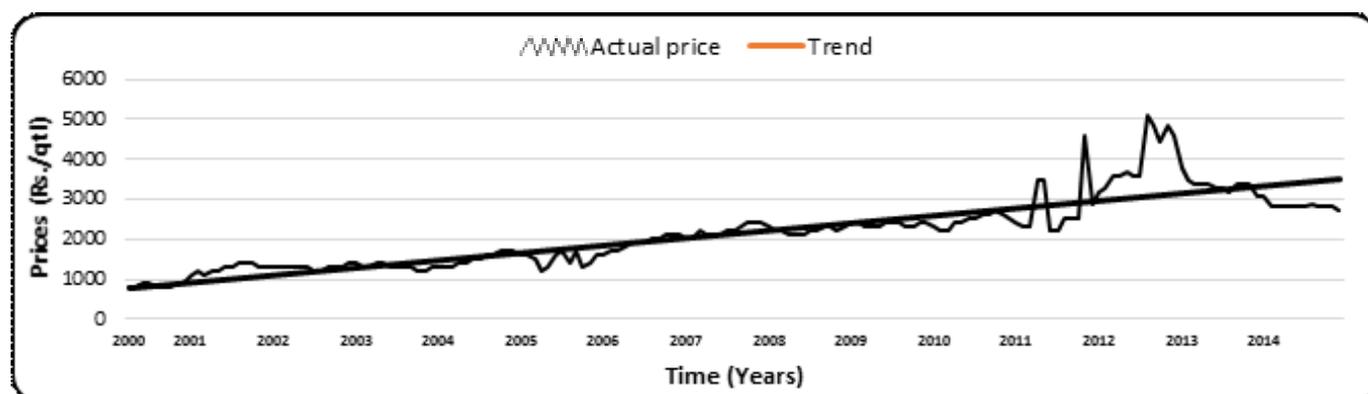


Fig. 1. Trends in prices of bengalgram in Koilakuntla market

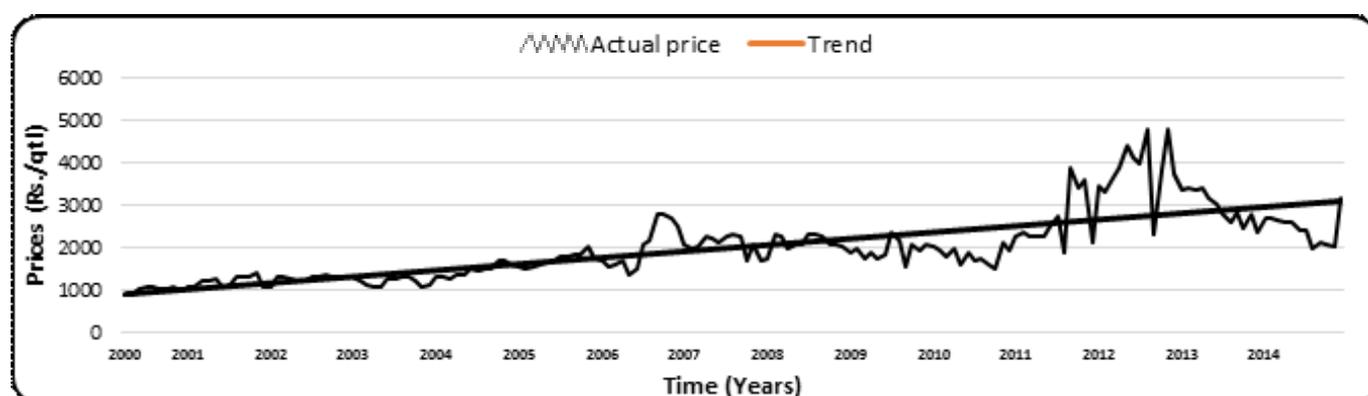


Fig. 2. Trends in prices of bengalgram in Kurnool market

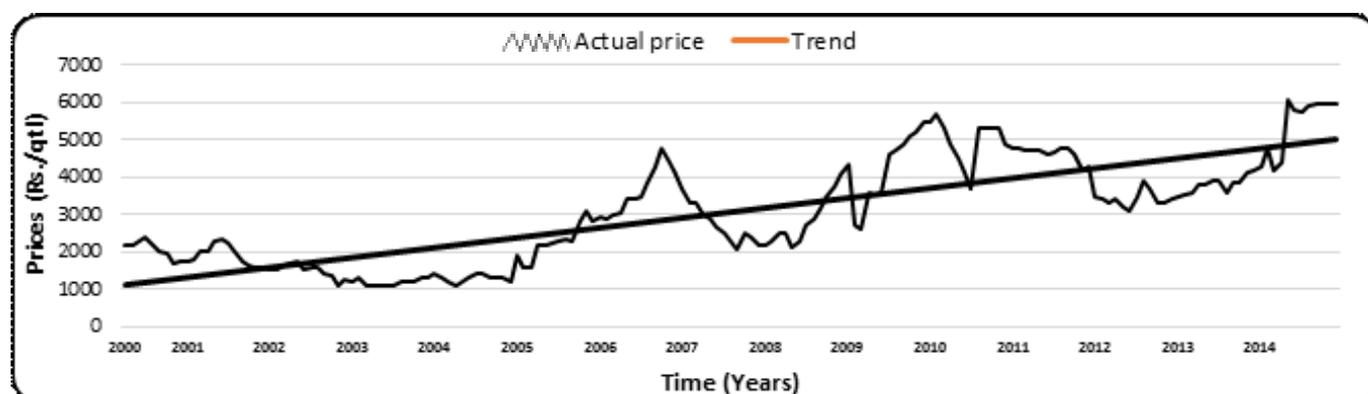


Fig. 3. Trends in prices of blackgram in Tenali market

Trends in the prices of bengalgram in selected markets

In order to ascertain, the long run movements of bengalgram prices in the selected markets, the data relating to prices of bengalgram were subjected to linear trend analysis.

The results presented in Table 1 revealed that there was an increasing trend in the prices of bengalgram in

both the selected markets (Figures 1 and 2) and were found to be highly significant.

The annual increase in prices of bengalgram was found to be highest in koilakuntla market (15.32 Rs./qtl) whereas lowest in Kurnool market (12.28 Rs./qtl) and were found to be statistically significant at 1 per cent level of significance. The contribution of independent variable time, to the changes in the prices was found to be lowest in

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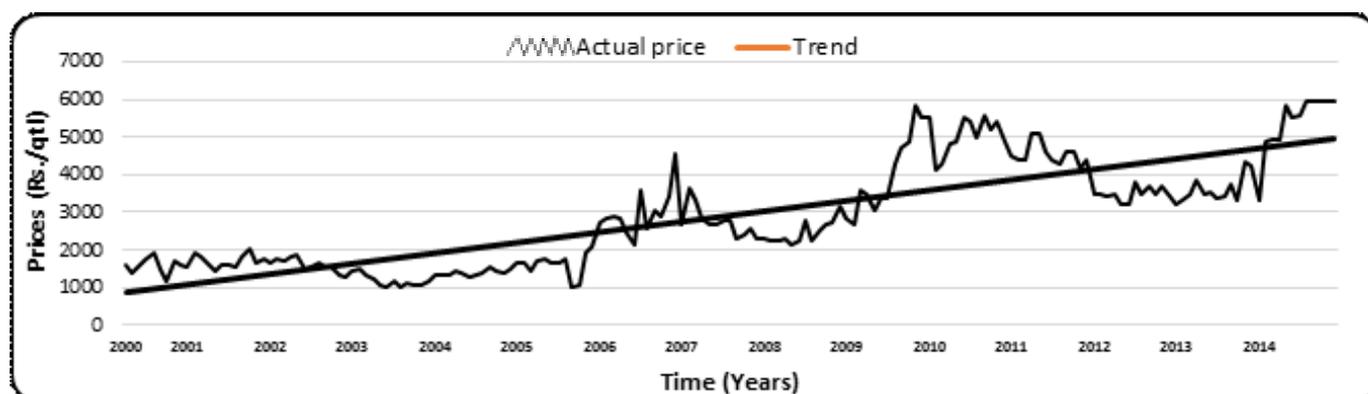


Fig. 4. Trends in prices of blackgram in Ponnur market

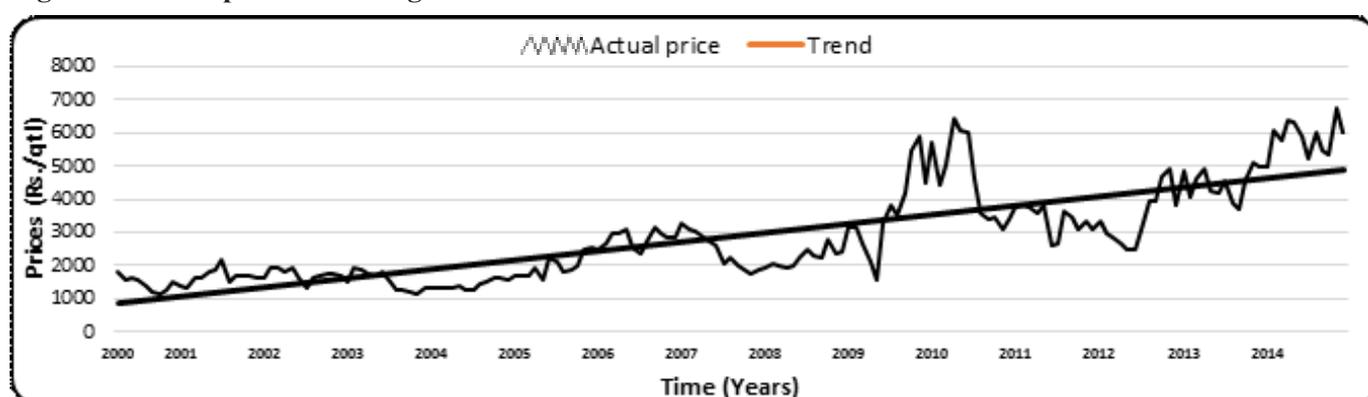


Fig. 5. Trends in prices of greengram in Suryapeta market

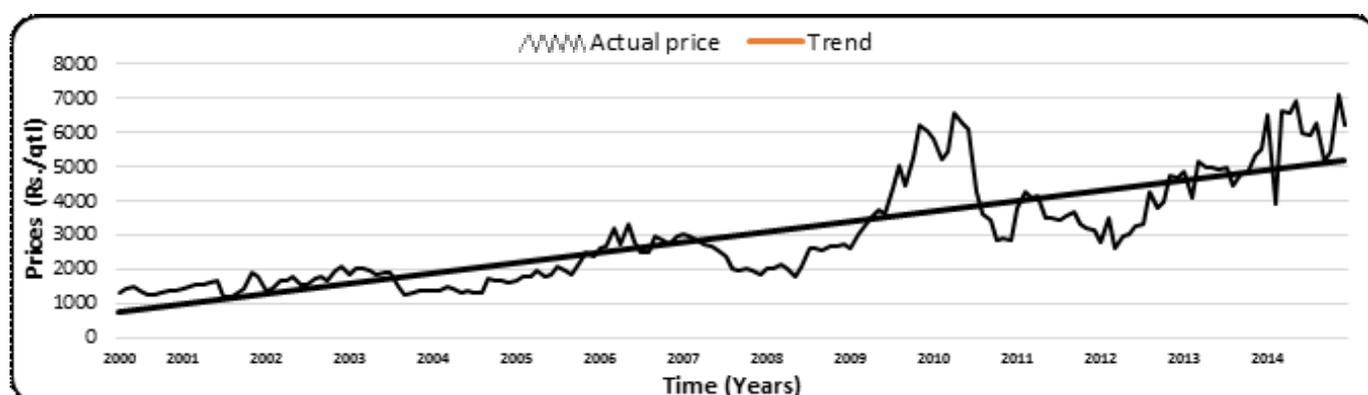


Fig. 6. Trends in prices of greengram in Thandur market

Kurnool market (60%) and highest in Koilakuntla market (77%).

Trends in the prices of blackgram in the selected markets

To study the long run movements of blackgram prices in the selected markets, the data relating to prices of blackgram were subjected to linear trend analysis. As noticed from Table 2 there was an increasing trend in the prices of blackgram (Figures 3 and 4) in all the selected markets and were found to be highly significant.

The annual increase in prices was relatively higher in Ponnur market (23.20 Rs./qtl), compared to Tenali market (22.13 Rs./qtl) and were found statistically significant at 1 per cent. The increasing trend in prices did not vary much from one market to another market.

Trends in the prices of greengram in the selected markets

As noticed from Table 3 there was an increasing trend in the prices of greengram (Figures 5 and 6) in all the selected markets and was found to be highly significant.

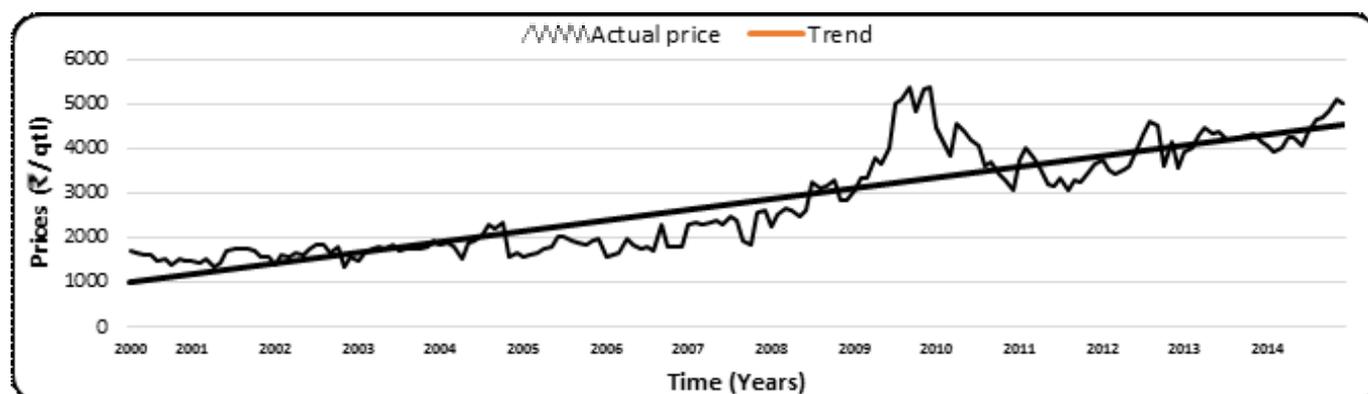


Fig. 7. Trends in prices of redgram in Thandur market

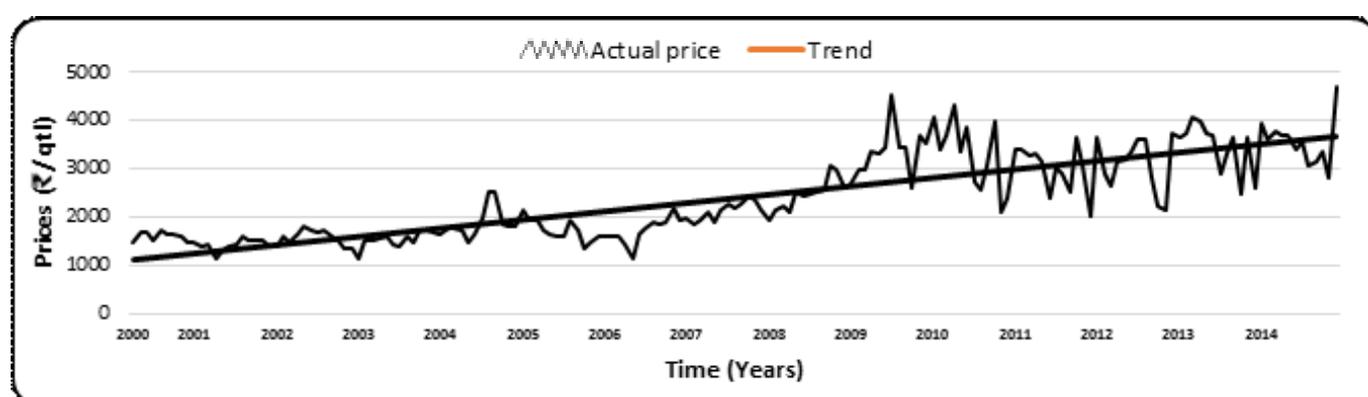


Fig. 8. Trends in prices of redgram in Kurnool market

The annual increase in prices was higher in Thandur market (25.31 Rs./qtl), whereas it was lowest in Suryapeta market (22.85 Rs./qtl) and were found statistically significant at 1 per cent. The increasing trend in prices varied from one market to another market.

Trends in the prices of redgram in the selected markets

As noticed from Table 4 there was an increasing trend in the prices of redgram (Figures 7 and 8) in all the selected markets and was found to be highly significant.

The annual increase in prices was distinctly higher in Thandur market (20.01 Rs./qtl), whereas it was lower in Suryapeta market (14.35 Rs./qtl) and were found statistically significant at 1 per cent. The increasing trend in prices varied from one market to another market.

CONCLUSION

The study has indicated that the prices of the pulses in the selected markets were on the rise during the period under study. There was not much of a difference in the price rise for bengal gram, blackgram and greengram across the markets. However there was distinct difference

in price rise of redgram between the selected markets. The probable reason for this might be the frequent movement of produce from the selected markets to neighbouring markets.

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STUDIES ON GENETIC VARIABILITY AND HERITABILITY FOR YIELD AND WATER USE EFFICIENT TRAITS IN GROUNDNUT (*Arachis hypogaea* L.) UNDER RAINFED CONDITIONS

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ABSTRACT

Fifty genotypes of groundnut were evaluated for their genetic variability, heritability and genetic advance for a set of 16 agronomic and physiological characters during *kharif*, 2014. Analysis of variance revealed presence of highly significant differences among the genotypes for all characters indicating sufficient variability in the material studied. High PCV and GCV were observed for dry matter per plant, number of sound mature kernels per plant, kernel yield per plant, pod yield per plant and number of primaries per plant. High heritability coupled with high genetic advance as per cent of mean was observed for dry matter per plant, number of sound mature kernels per plant, pod yield per plant, number of primaries per plant, number of pods per plant, SLA at 60 DAS, number of seeds per pod, shelling percentage and SLA at 80 DAS indicating that these traits were mainly governed by additive gene effects and response to selection could be effected for further improvement of pod yield and its attributes through simple selection.

KEYWORDS: Genetic advance, Groundnut, Heritability, Variability.

INTRODUCTION

Groundnut is one of the main oilseed and food legume crop of India. In India it is grown in 5.5 M ha with a production of 9.6 M t and productivity of 1750 kg ha⁻¹ (Annual report, NRCG 2014). Drought is the most important factor limiting the yield potential of the genotypes under rainfed conditions. Crop physiologists have identified number of traits that would help the breeder in development and identification of moisture stress tolerant genotypes with high yield potential. Development of high yielding pure line cultivars coupled with water use efficiency traits is the major breeding objective of groundnut genetic improvement in order to obtain high productivity under rainfed conditions.

There is a need to identify the groundnut genotypes possessing desirable yield and physiological attributes to drought tolerance under rainfed conditions. Heritability is an important parameter which determines the extent of expressivity of a trait in a set of environments or agro-climatic conditions. Therefore, heritability estimates are useful in predicting genetic advance under different intensities of selection. High heritability estimates together with high genetic advance are more valid for selection than heritability estimates alone (Johnson *et al.*, 1955).

Hence, considering these aspects, genetic variability studies were initiated with diverse groundnut genotypes involving both Spanish bunch and Virginia bunch botanical types in the present investigation.

MATERIAL AND METHODS

The material for the present study comprised of 50 groundnut genotypes, grown in a Randomised block design with three replications at Sri Venkateswara Agricultural College dry land farm, Tirupati during *kharif*, 2014. Each genotype was sown in single row of 3 m length by adopting a spacing of 30 × 10 cm. Observations were recorded on randomly chosen ten competitive plants for fourteen characters viz., number of primary branches per plant, number of pods per plant, number of seeds per pod, number sound mature kernels per plant, dry matter per plant (g), pod yield per plant (g), kernel yield per plant (g), shelling per cent, Specific Leaf Area (SLA) at 60 Days After Sowing (DAS), SLA at 80 DAS, SPAD chlorophyll meter (SCMR) at 60 DAS, SCMR at 80 DAS, leaf nitrogen (%) content at 60 DAS and leaf nitrogen (%) content at 80 DAS. The characters viz., days to 50% flowering and days to maturity were recorded on per plot basis. Leaf nitrogen (%) content values were transformed using arc-sine transformation. Analysis of variance was

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carried out as per the method suggested by Panse and Sukhatme (1961). The phenotypic and genotypic co-efficient of variation (Burton, 1952), heritability in broad sense (Allard, 1960) and genetic advance as per cent of mean (Johnson *et al.*, 1955) were also computed as per the standard procedure.

RESULTS AND DISCUSSION

The success of any crop improvement programme essentially depends upon the nature and magnitude of the genetic variability present in the gene pool of the crop. The knowledge of nature and magnitude of genetic variability in the breeding population is of immense value for planning efficient breeding programme to improve the yield potential of genotypes under rainfed conditions as mild to severe moisture stress conditions would always co-exist in the crop environment. The analysis of variance for 16 characters in 50 genotypes revealed that the genotypes differed significantly for all the characters indicating the existence of sufficient variability in the material studied (Table 1). The estimates of genetic parameters for sixteen characters are furnished in Table 2. A wider range of mean variation was noted for specific leaf area at 60 days after sowing from 122.09 to 255.34 ($\text{cm}^2 \text{g}^{-1}$), whereas the range was found to be least for leaf nitrogen (%) content at 80 days after sowing (3.2 to 3.9). The highest magnitude of genotypic and phenotypic variance were observed for specific leaf area at 60 days after sowing while least estimates were recorded for leaf nitrogen (%) content at 80 days after sowing. The phenotypic co-efficient of variation was of high magnitude than the genotypic co-efficient of variation for all the characters indicating the influence of environment in the expression of these traits (Table 2). Similar kind of observations were reported by Korat *et al.* (2009), Prasanna Rajesh *et al.* (2012) which corroborated the findings of present study.

High magnitude of PCV and GCV of about 31.50 per cent and 30.92 per cent, respectively for dry matter per plant followed by number of sound mature kernels per plant (24.76 and 24.11), kernel yield per plant (23.81 and 23.44), pod yield per plant (22.87 and 22.44) and number of primaries per plant (22.78 and 22.10) indicated that most of the characters had sufficient variability to effect selection for improvement of these characters. Further, moderate values of PCV and GCV were registered for number of pods per plant (20.35 and 18.84), SLA at 60 DAS (14.21 and 14.15), number of seeds per plant

(14.13 and 13.95), shelling percentage (13.51 and 13.18) and SLA at 80 DAS (10.79 and 10.77). On contrary, low estimates of PCV and GCV were recorded for days to 50% flowering (9.02 and 8.97), days to maturity (8.00 and 7.99), SCMR at 60 DAS (8.35 and 7.90), SCMR at 80 DAS (7.11 and 6.75), leaf nitrogen content at 60 DAS (2.22 and 1.99) and leaf nitrogen content at 80 DAS (1.80 and 1.71). Reports of high GCV and PCV by Kumar and Rajamani (2004) for number of sound mature kernels per plant and John *et al.* (2008), Nandini *et al.* (2011), Srivalli *et al.* (2013), Shukla and Rai (2014) and Ramana *et al.* (2015) for kernel yield per plant were in conformity with findings of the present study.

High heritability was recorded for all the traits ranging from 99.7% for days to maturity and specific leaf area at 80 days after sowing to 80.7% for leaf leaf nitrogen content at 60 days after sowing indicating least influence of environment on the genetic expression of the characters under study.

The estimates of heritability alone will not be of much value for selection and genetic gain should be considered in conjunction with heritability estimates (Johnson *et al.*, 1955) to estimate realized genetic improvement possible in the character through simple selection methods. High heritability and high genetic advance estimates were registered for dry matter per plant ($h^2(b) = 96.3\%$, $GAM = 62.51\%$), number of sound mature kernels per plant (94.9%, 48.38%), pod yield per plant (96.3%, 45.36%), number of primary branches per plant (94.1%, 44.16%), number of pods per plant (85.7%, 35.49%), SLA at 60 DAS (99.2%, 29.04%), number of seeds per pod (97.5%, 28.39%), shelling percentage (95.2%, 26.51%) and SLA at 80 DAS (99.7%, 22.6%) indicating additive gene effects in inheritance of these characters and simple selection would be effective to augment further genetic improvement of these traits. The reports of high heritability coupled with high GAM for number of sound mature kernels per plant by Kumar and Rajamani (2004), Venkateswarlu (2007) and Hiremath *et al.* (2011) were in conformity with findings of the present study.

High heritability coupled with moderate genetic advance as per cent of mean was observed for the traits days to 50% flowering (99.0%, 18.39%), days to maturity (99.7%, 16.44%), SCMR at 60 DAS (89.5%, 15.40%) and SCMR at 80 DAS (90.2%, 13.22%) indicating the role of both additive and non-additive gene effects in their

Table 1. Analysis of variance for sixteen quantitative characters in 50 genotypes of groundnut

S. No.	Characters	Mean sum of squares		
		Replications (df: 2)	Genotypes (df: 49)	Error (df: 98)
1.	Days to 50% flowering	3.14	23.34**	0.23
2.	Days to maturity	4.28*	232.00**	0.62
3.	No of primary branches per plant	0.54	4.17**	0.24
4.	No of pods per plant	17.16**	36.97**	5.28
5.	No of seeds per pod	0.01	0.20**	0.01
6.	No of sound mature kernels per plant	14.18**	59.76**	3.07
7.	Dry matter per plant (g)	9.22**	97.89**	3.59
8.	Pod yield per plant (g)	0.44	36.15**	1.34
9.	Kernel yield per plant (g)	1.79	17.66**	0.54
10.	Shelling percentage (%)	22.36**	250.83**	11.94
11.	SLA at 60 Days after sowing (cm ² g ⁻¹)	17.81**	1387.61**	11.56
12.	SLA at 80 Days after sowing (cm ² g ⁻¹)	2.00	672.95**	2.04
13.	SCMR at 60 Days after sowing	0.01	33.27**	3.50
14.	SCMR at 80 Days after sowing	1.95	26.06**	2.54
15.	Leaf Nitrogen (%) content at 60 Days after sowing	0.01	0.17**	0.03
16.	Leaf Nitrogen (%) content at 80 Days after sowing	0.01	0.11**	0.01

* Significant at 5% level; ** Significant at 1% level

genetic control and simple selection methods may not be rewarding to effect further genetic gain in these traits. Hybridization of selects followed by selection in later generations of segregating populations would be effective to capitalize both additive and non-additive gene effects observed in these traits. On contrary, high heritability and low GAM was observed for leaf nitrogen content at 60 DAS (80.7% and 3.69%) and 80 DAS (90.0% and 3.34%) indicating that high heritability was due to favourable influence of environment rather than genotypic effects and selection for such traits may not be rewarding.

From the foregoing discussion, it can be concluded that high GCV, heritability and genetic advance as per cent of mean were observed for dry matter per plant,

number of sound mature kernels per plant, pod yield per plant, number of primary branches per plant, number of seeds per pod and shelling percentage indicating that variation in above traits was most-likely due to additive gene effects, hence simple selection may be effective to isolate high yield potential groundnut genotypes with high water use efficiency traits for rainfed conditions.

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Table 2. Mean, coefficients of variation, heritability (broad sense) and genetic advance as percent of mean for sixteen characters in 50 groundnut genotypes

S. No.	Character	Mean		Range		Variance		Coefficient of Variation		Heritability (Broad sense) (%)	Genetic advance (GA) as percent of mean (%)
		Min	Max	Genotypic	Phenotypic	Genotypic	Phenotypic				
1.	Days to 50% flowering	30.92	25.67	37.67	7.70	7.78	8.97	9.02	99.0	5.68	18.39
2.	Days to maturity	109.85	91.67	123.67	77.12	77.33	7.99	8.00	99.7	18.06	16.44
3.	No of primary branches per plant	5.18	3.00	7.64	1.31	1.39	22.10	22.78	94.1	2.28	44.16
4.	No of pods per plant	17.25	10.00	30.67	10.56	12.32	18.84	20.35	85.7	6.19	35.94
5.	No of kernels per pod	1.86	1.50	2.91	0.06	0.06	13.95	14.13	97.5	0.52	28.39
6.	No of sound mature kernels per plant	18.03	4.67	26.67	18.89	19.92	24.11	24.76	94.9	8.72	48.38
7.	Dry matter per plant	18.13	8.33	32.17	31.43	32.63	30.92	31.50	96.3	11.33	62.51
8.	Pod yield per plant (g)	17.24	7.10	25.13	11.60	12.05	22.44	22.87	96.3	6.88	45.36
9.	Kernel yield per plant (g)	10.19	3.65	16.92	5.70	5.89	23.44	23.81	96.9	4.84	47.55
10.	Shelling percentage (%)	67.67	44.30	87.58	79.63	83.61	13.18	13.51	95.2	17.94	26.51
11.	SLA at 60 DAS (cm ² g ⁻¹)	151.27	122.09	255.34	458.68	462.54	14.15	14.21	99.2	43.93	29.04
12.	SLA at 80 DAS (cm ² g ⁻¹)	138.80	109.18	195.04	223.63	224.31	10.77	10.79	99.7	30.75	22.16
13.	SCMR at 60 DAS	39.85	34.07	46.93	9.92	11.09	7.90	8.35	89.5	6.13	15.40
14.	SCMR at 80 DAS	41.43	36.02	48.32	7.84	8.68	6.75	7.11	90.2	5.48	13.22
15.	Leaf Nitrogen (%) content at 60 DAS	3.7	3.2	3.9	0.04	0.06	1.99	2.22	80.7	0.40	3.69
16.	Leaf Nitrogen (%) content at 80 DAS	3.7	3.3	3.9	0.03	0.03	1.71	1.80	90.0	0.36	3.34

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STUDIES ON VARIABILITY AND HERITABILITY IN CLUSTERBEAN

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ABSTRACT

The experiment was conducted during *Kharif*, 2014 to estimate genetic variability and genetic parameters in 48 diverse genotypes of clusterbean for 16 quantitative characters. The analysis of variance revealed significant differences among all 48 genotypes for all the characters studied. The highest estimates of coefficients of variation were registered for number of branches per plant followed by number of clusters per plant, number of pods per cluster and seed yield per plant. High heritability coupled with high genetic advance was observed for number of branches per plant and number of clusters per plant indicating the presence of additive gene action in the expression of these characters. High estimates of genotypic coefficient of variation, heritability and genetic advance recorded for number of branches per plant and number of clusters per plant indicated that variation in these traits is high and these traits appear to be governed by additive gene action. Hence, simple directional selection may be effective to improve these traits.

KEYWORDS: Heritability, Variability, Clusterbean.

INTRODUCTION

Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub] ($2n = 14$) commonly known as guar is grown in *Kharif* season in arid and semi arid regions of India. It is a drought hardy and deep rooted annual legume. Guar is one of the most important and potential vegetable cum industrial crop grown for its tender pods for vegetable purpose and for endospermic gum. Like other legumes, guar is an excellent soil-building crop with respect to nitrogen fixation. Root nodules contain nitrogen-fixing bacteria and crop residues, when ploughed under, improves yields of succeeding crops.

In recent years guar has achieved the status of an industrial crop due to the water soluble natural polymer galactomannan gum. Now guar has become an alternative remunerative crop with high adaptability suited for growing in arid regions of the world. Gum having good binding properties is derived from the endosperm of the seed. Guar gum is an important ingredient in producing food emulsifier, food additive, food thickener and other guar gum products. Its usage as a thickening agent and emulsifier in the oil and gas extraction industry for hydraulic fracturing of sub-surface shale has made it a much sought after product in international market.

Despite its importance, only limited breeding work has been done and very little attention has been given for

clusterbean genetic improvement in the past. Hence, there is a need to enhance the productivity levels of cluster bean. Progress in breeding for economic characters depends largely on the magnitude and nature of the variability present in germplasm. An insight into the magnitude of variability present in a crop species and heritability of characters is essential to select potential genotypes from breeding populations as it provides the basis for effective selection. Hence, in the present study an attempt was made to elucidate information on the nature and magnitude of genetic variation observed for seed yield, yield components and quality traits in 48 clusterbean genotypes.

MATERIAL AND METHODS

The material for the present investigation comprising of 48 genotypes of clusterbean were obtained from Rajasthan Agriculture Research Institute, Durgapura, Rajasthan. The experiment was laid out in a randomized block design with three replications, during *Kharif*, 2014 at Dryland farm of S.V. Agricultural College, Tirupati. Each genotype was sown in a single row of 6 m length adopting recommended spacing of 45×30 cm. Fertilizers were applied at recommended dose of 20 Kg N and 40 Kg P_2O_5 per hectare in the form of urea and single super phosphate. Weeding and plant protection operations were taken up as and when needed during the crop growth period and life saving irrigation was given to raise a good crop.

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The data was recorded on five randomly selected plants per genotype per replication for 16 characters viz., days to 50% flowering, days to maturity, plant height, number of branches per plant, number of clusters per plant, number of pods per cluster, number of pods per plant, pod weight, pod length, number of seeds per pod, 100 seed weight, shelling percentage, endosperm percentage, gum percentage, pod yield per plant and seed yield per plant. The data was subjected to statistical analysis. Analysis of variance was worked according to the method outlined by Panse and Sukhatme (1961). The genotypic (GCV) and phenotypic (PCV) coefficient of variation was calculated by the formulae given by Burton (1952). Heritability in broad sense [$h^2(b)$] was calculated by the formula given by Lush (1940). Genetic gain as per cent of mean was calculated by the formula given by Johnson *et al.* (1955a).

RESULTS AND DISCUSSION

The analysis of variance showed significant differences among the genotypes for all the 16 characters studied (Table 1). The range, general mean, variance, heritability and GAM are presented in the Table 2. A wide range of variability was recorded for characters viz., plant height (116.00-191.33), number of branches per plant (0.00-11.67), number of clusters per plant (15.33-87.67), number of pods per plant (78.13-200.02), shelling percentage (31.76-53.42), pod yield per plant (32.18-77.38) and seed yield per plant (11.60-33.69).

In the present study, phenotypic variance was higher than genotypic variance for all the characters studied (Table 2). Phenotypic coefficient of variation ranged from 3.62 (days to maturity) to 41.16 (number of clusters per plant). Genotypic coefficient of variation ranged from 2.51 (endosperm percentage) to 38.36 (number of branches per plant). The estimates of heritability ranged from 30.26 (pod length) to 89.78 (days to maturity). Genetic advance expressed as percentage over mean ranged from 3.12% (pod length) to 73.76% (number of branches per plant).

The highest estimates of coefficients of variation were registered for number of branches per plant followed by number of clusters per plant, number of pods per cluster and seed yield per plant. Moderate estimates of genotypic coefficient of variation and higher estimates of phenotypic coefficient of variation were observed for number of pods per plant followed by pod yield per plant, pod weight, while shelling percentage and plant height registered

moderate estimates of both GCV and PCV, whereas low estimates of coefficient of variation were recorded for characters 100-seed weight, days to 50% flowering, days to maturity, number of seeds per pod, pod length, gum percentage and endosperm percentage.

The results indicated more scope of selection for improvement of characters viz., number of branches per plant, number of pods per cluster, number of clusters per plant and seed yield per plant which registered higher estimates of GCV and PCV. These results are in accordance with the findings of Singh *et al.* (2004), Saini *et al.* (2005) for number of branches per plant, number of clusters per plant and seed yield per plant. Anandhi and Oommen (2007) and Muthuselvi and Shanthi (2013) also observed high GCV and PCV for number of pods per cluster. On contrary, endosperm percentage, gum percentage, number of seeds per pod, days to maturity, pod length, days to 50% flowering and 100-seed weight recorded lower estimates of GCV and PCV indicating little scope for selection of these traits. Similar results were reported by Reddy and Gupta (1984) for endosperm percentage. Low GCV and PCV were earlier reported by Chaudhary and Singh (1976) and Singh *et al.* (2005) for days to 50% flowering and 100 seed weight.

In the present study, high heritability associated with high genetic advance as per cent of mean was observed for number of branches per plant and number of clusters per plant which indicated that the inheritance of these traits is most likely due to additive gene action. These results are in correspondence with the findings of Saini *et al.* (2010) and Muthuselvi and Shanthi (2013) for number of branches per plant and number of clusters per plant.

High heritability coupled with low genetic advance as per cent of mean was observed for days to 50% flowering and days to maturity indicating the non additive gene action hence, selection for days to 50% flowering and days to maturity may not be rewarding.

From the results obtained in present investigation, it is evident that number of branches per plant and number of clusters per plant had high genotypic coefficient of variation (GCV) and high heritability coupled with high genetic advance indicating that variation in these traits is high and most likely these traits are governed by additive gene effects.

Table 1. Analysis of variance for 16 characters in 48 Clusterbean genotypes

S. No.	Character	Mean sum of squares		
		Replications (df=2)	Genotypes (df=47)	Error (df=94)
1.	Days to 50% flowering	1.02	4.26**	0.48
2.	Days to maturity	1.58	33.20**	1.21
3.	Plant height (cm)	1244.91	1042.00**	359.03
4.	Number of branches per plant	2.84	25.25**	1.19
5.	Number of clusters per plant	36.92	534.20**	51.33
6.	Number of pods per cluster	0.80	2.60**	0.67
7.	Number of pods per plant	55.46	2260.07**	461.34
8.	Pod weight (g)	0.006	0.023**	0.0093
9.	Pod length (cm)	0.023	0.104**	0.045
10.	Number of seeds per pod	0.15	0.29**	0.10
11.	100-seed weight (g)	0.016	0.180**	0.054
12.	Shelling percentage (%)	4.29	87.62**	22.29
13.	Endosperm percentage (%)	1.07	4.46**	1.40
14.	Gum percentage (%)	0.82	4.50**	1.42
15.	Pod yield per plant (g)	136.64	329.00**	94.70
16.	Seed yield per plant (g)	16.01	79.14**	21.00

Ample variation was observed in the traits viz., number of pods per cluster and seed yield per plant as indicated by high GCV. Further, these traits registered moderate heritability coupled with high GAM suggesting that these traits are also governed by additive gene action and hence simple selection may be effective in the improvement of these traits also.

Moderate variability and moderate heritability was reported for the traits number of pods per plant, pod yield per plant, plant height, pod weight and shelling percentage. The high GAM indicated additive gene action for number of pods per plant and pod yield per plant. Whereas moderate GAM for plant height, pod weight and shelling percentage indicated the role of additive and non-additive gene action for these traits. These results

suggested that careful selection may be helpful in the improvement of these traits.

Low GCV values exhibited by pod length, number of seeds per pod, 100 seed weight, endosperm percentage, gum percentage, days to 50% flowering and days to maturity and the low GAM recorded for these traits suggested lesser scope of improvement of these traits by phenotypic selection as these traits are governed by non-additive gene action.

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Table 2. Mean, Range, variability and genetic parameters for 16 characters in clusterbean

S. No.	Character	Mean	Range		Variance		Coefficient of Variation		Heritability (Broad sense) (%)	Genetic advance (GA)	Genetic advance as percent of mean (%)
			Min	Max	Genotypic	Phenotypic	Genotypic	Phenotypic			
1.	Days to 50% flowering	27.46	25.00	30.67	1.26	1.74	4.09	4.81	72.35	1.97	7.17
2.	Days to maturity	95.17	88.33	100.00	10.66	11.88	3.43	3.62	89.78	6.37	6.70
3.	Plant height (cm)	144.19	116.00	191.33	227.65	586.69	10.46	16.80	38.80	19.36	13.43
4.	Number of branches per plant	7.38	0.00	11.67	8.02	9.20	38.36	41.11	87.10	5.45	73.76
5.	Number of clusters per plant	35.40	15.33	87.67	160.95	212.29	35.84	41.16	75.82	22.76	64.28
6.	Number of pods per cluster	3.84	2.83	6.90	0.64	1.31	20.92	29.85	49.13	1.16	30.21
7.	Number of pods per plant	132.91	78.13	200.02	599.58	1060.91	18.42	24.51	56.52	37.92	28.53
8.	Pod weight (g)	0.42	0.28	0.68	0.005	0.014	16.13	28.07	33.00	0.08	19.08
9.	Pod length (cm)	5.10	4.61	5.66	0.02	0.06	2.75	5.00	30.26	0.16	3.12
10.	Number of seeds per pod	7.48	6.68	8.17	0.06	0.16	3.35	5.43	38.09	0.32	4.26
11.	100 seed weight (g)	3.36	2.86	3.94	0.04	0.10	6.13	9.23	44.06	0.28	8.38
12.	Shelling percentage (%)	41.04	31.76	53.42	21.78	44.07	11.37	16.17	49.41	6.76	16.46
13.	Endosperm percentage (%)	40.24	37.53	43.82	1.02	2.42	2.51	3.87	42.05	1.35	3.35
14.	Gum percentage (%)	37.98	35.28	41.57	1.03	2.45	2.67	4.12	41.93	1.35	3.56
15.	Pod yield per plant (g)	52.50	32.18	77.38	78.10	172.80	16.83	25.04	45.20	12.24	23.31
16.	Seed yield per plant (g)	21.54	11.60	33.69	19.38	40.38	20.44	29.50	48.00	6.28	29.17

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TRENDS IN ECONOMICS OF TOBACCO AND ITS COMPETING CROPS IN NELLORE AND PRAKASAM DISTRICTS OF ANDHRA PRADESH

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ABSTRACT

The present study was conducted to know the trends in productivity, prices, cost of cultivation and net returns of FCV tobacco and non-tobacco crops from 2002-03 to 2011-12. Non – tobacco crops selected for the study were bengalgram, redgram and paddy. The results showed that, the productivity of all crops registered a negative growth, while paddy recorded a positive growth rate with mild fluctuations. Similarly, the prices and cost of cultivation of FCV tobacco and other crops showed a positive growth with an increasing trend, whereas net returns from all crops registered a negative growth rate except paddy crop, which recorded a positive growth with highly fluctuating trend.

KEYWORDS: Cost of cultivation, Net returns, Prices, Productivity, Trends.

INTRODUCTION

India has a prominent place in the production of tobacco in the world due to varied agro-climatic conditions and different types of tobacco it produces. Important among them, in terms of exports, is the flue-cured Virginia tobacco (FCV), the cultivation of which has been in vogue for the last 100 years. India stands third in production of tobacco, where as China and Brazil occupy the first and second positions respectively.

In exports, Brazil and USA are ahead of India. Presently, tobacco is being cultivated in an area of about 4.93 Lakh hectares (0.24 per cent of total arable land) in the country covering different styles / types of tobacco viz., cigarette tobacco, bidi tobacco, chewing tobacco, hookah tobacco, cheroot tobacco, cigar wrapper tobacco, cigar filler tobacco, oriental tobacco, dark fire cured tobacco, etc., with a production of 800 Million Kgs (M.Kgs). Out of the total production about 50 per cent is cigarette type and 50 per cent is non-cigarette type of tobacco. Out of this around 265 M. Kgs. is flue-cured Virginia tobacco (FCV) which is produced in an area of 2.17 Lakh hectares mainly in the states of Andhra Pradesh and Karnataka. Traditional growth zone is comprised Southern Black Cotton Soils (SBCS) and Southern Light Soils (SLS) and is one of the most important region among the different Flue Cured Virginia (FCV) growing regions in India. Tobacco is grown here in almost 958 villages of Prakasam and Nellore districts across 13 Tobacco Auction

Platforms (TAP). More than 35,000 farmers and 1,00,000 farm labourers are engaged in tobacco cultivation in this region, which makes it the most important commercial crop which influences the farm economy of the region. This study aims to assess the trends in farmers' economics between tobacco and other crops for the last ten years.

MATERIAL AND METHODS

For the purpose of the present study, two districts namely Nellore and Prakasam were selected. Data regarding productivity, prices, cost of cultivation and net returns from 2002-03 to 2011-12 were obtained from Directorate of Economic and Statistics (DES), Indiatat.com and Agmark.net websites.

Growth Model: The growth in productivity, prices, cost of cultivation and net returns of the tobacco and non-tobacco crops selected in the two districts were analysed using the exponential growth function of the form.

$$Y_t = ab^t e^{\dots\dots\dots} \quad (1)$$

where,

- Y_t : Dependent variable (Productivity in kg per hectare, Prices in Rs. Per tonne, Cost of cultivation in Rs. per hectare, Net returns in Rs. per hectare)
- t : Time period
- a : Intercept value (value of y when $t = 0$)
- b : Regression coefficient
- e : Error term

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Equation (1) was converted into the logarithmic form in order to facilitate the use of linear regression. Taking logarithms on both sides.

$$\ln Y_t = \ln a + t \ln b + u \dots\dots\dots(2)$$

$\ln a$ and $\ln b$ are obtained by application of Ordinary Least Squares (OLS) procedure to equation (2) and the growth rate CGR was derived using the relationship:

$$CGR = \text{Anti log } (b - 1) \times 100 \dots\dots\dots (3)$$

RESULTS AND DISCUSSION

Compound Growth Rates (CGR) for the productivity, prices, cost of cultivation and net returns were calculated and presented in the Tables 1, 2, 3 and 4 respectively. Trends for the same were worked out and portrayed in the Figures 1, 2, 3 and 4 respectively.

1. Trends in Productivity from Tobacco and other Crops

Table 1 presents the growth rates of productivity of FCV tobacco, bengalgram, redgram and paddy. It was evident from the table that only paddy crop registered a positive growth while rest of the crops recorded a negative growth. The growth rate in the productivity was highest in the case of paddy (0.84 per cent) followed by FCV tobacco (0.33 per cent), redgram (-1.64 per cent) and bengalgram (-3.98 per cent).

The Figure 1 depicts that the productivity of FCV tobacco, bengalgram, redgram, paddy ranges from 1,142 to 1,377 kg per hectare, 742 to 1790 kg per hectare, 550 to 1,420 kg per hectare and 4,970 to 5,600 kg per hectare respectively.

It was observed that productivity of FCV tobacco recorded lesser fluctuated growth trend, while the growth trends for other crops are with fluctuating passion. The trend reflects the lacunae of research to improve the productivity of FCV tobacco when compared to other crops.

2. Trends in Prices of Tobacco and other Crops

It was apparent from the Table 2 that there was a positive growth in prices of all the crops. It was highest in FCV tobacco (10.93 per cent) followed by redgram (9.64 per cent), bengalgram (7.80 per cent) and paddy (7.45 per cent).

Figure 2 illustrates that the prices of FCV tobacco, bengalgram, redgram and paddy, which ranged from ₹ 39,155 to ₹ 95,060, ₹ 12,160 to ₹ 29,400, ₹ 15,430 to ₹ 35,360 and ₹ 5,467 to ₹ 11,500 respectively.

It was clearly observed that there was an increasing trend in the prices of all the crops and it was also noticed that there was a sudden raise in the prices of FCV tobacco in 2008-09 and continued the increasing trend, while rest of the crops showed an increasing trend in fluctuated passion.

Trends in cost of Cultivation between Tobacco and other Crops.

Table 3 narrates that there was a positive growth in cost of cultivation of all the crops. The highest growth rate was seen in redgram (11.05 per cent), followed by bengalgram (10.88 per cent), paddy (9.50 per cent) and FCV tobacco (9.46 per cent).

The Figure 3 portrayed that there was an increasing trend of cost of cultivation in all crops. The cost of cultivation of FCV tobacco, bengalgram, redgram and paddy ranges from ₹ 47,156 to ₹ 1,02,850, ₹ 12,747 to ₹ 28,608, ₹ 12,201 to ₹ 33,990 and ₹ 28,570 to ₹ 58,105 respectively. It was conspicuous that there was two folds increase in the cost of cultivation of all the crops over a period of 10 years.

Figure 3 showed the increasing trends in cost of cultivation of all crops with a consistent growth indicating that the cost of input and input services in farm enterprise are increasing over year by year

4. Trends in Net Returns between Tobacco and Other Crops

A perusal of Table 4 revealed that, the net returns from paddy crop only registered a positive growth rate of 6.56 percent, whereas the net returns from bengalgram, redgram and FCV tobacco recorded negative growth rates.

Figure 4 showed that the net returns from FCV tobacco, bengalgram, redgram and paddy varied from ₹ 5,300 to ₹ 48,851, ₹ 17,63 to ₹ 10954, ₹ -1058 to ₹ 11610 and ₹ 2646 to ₹ 10652 respectively.

It was noticed that the net returns from all crops are in highly fluctuating trend. The net returns from FCV tobacco reached a peak of 48,851 in 2008-09 due to sudden raise in the price for FCV tobacco in the same period.

Table 1. CGR for productivity of tobacco and other competing crops

S. No.	Productivity	CGR (in percentage) (from 2002-03 to 2011-12)
1	FCV tobacco	-0.33
2	Bengalgram	-3.98
3	Redgram	-1.64
4	Paddy	0.84

Source: Agmark.net and Indiastat (2002-03 to 2011-12)

Table 2. CGR for prices of tobacco and other competing crops

S. No.	Prices	CGR (in percentage) (from 2002-03 to 2011-12)
1	FCV tobacco	10.93
2	Bengalgram	7.80
3	Redgram	9.64
4	Paddy	7.45

Source: Agmark.net and Indiastat (2002-03 to 2011-12)

Table 3. CGR for cost of cultivation of tobacco and other competing crops

S. No.	Prices	CGR (in percentage) (from 2002-03 to 2011-12)
1	FCV tobacco	10.93
2	Bengalgram	7.80
3	Redgram	9.64
4	Paddy	7.45

Source: Agmark.net and Indiastat (2002-03 to 2011-12)

Table 4. CGR for net returns from tobacco and other competing crops

S. No	Net returns	CGR (in percentage) (from 2002-03 to 2011-12)
1	FCV tobacco	-0.76
2	Bengalgram	-7.42
3	Redgram	-11.91
4	Paddy	6.56

Source: DES and Indiastat (2002-03 to 2011-12)

Trends in economics of tobacco crop

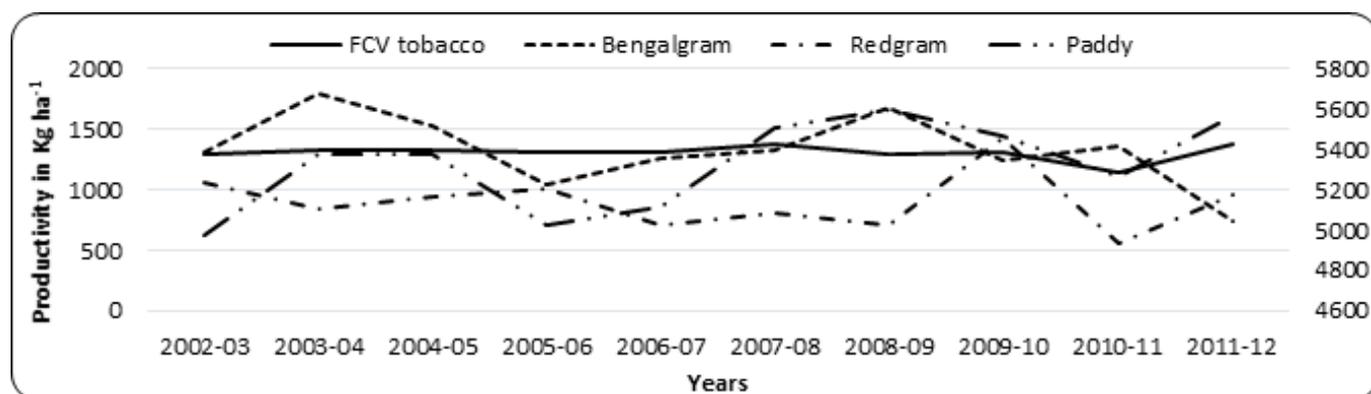


Fig. 1. Trends in Productivity of tobacco and other crops

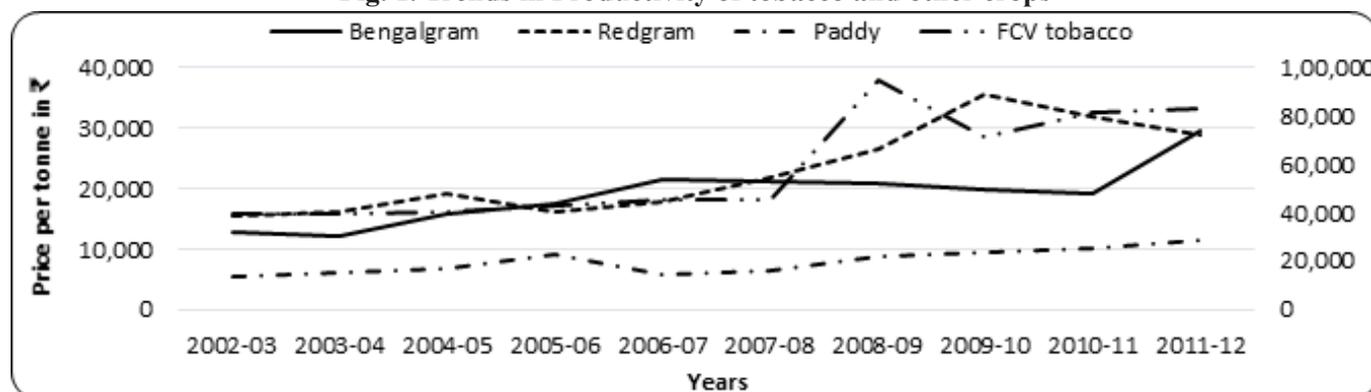


Fig. 2. Trends in prices of tobacco and other crop

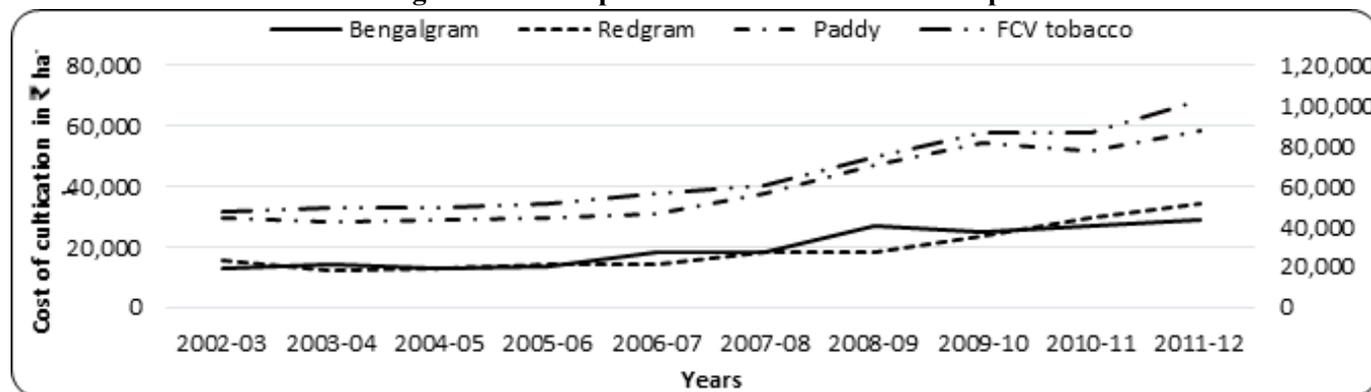


Fig. 3. Trends in cost of cultivation of tobacco and other crops

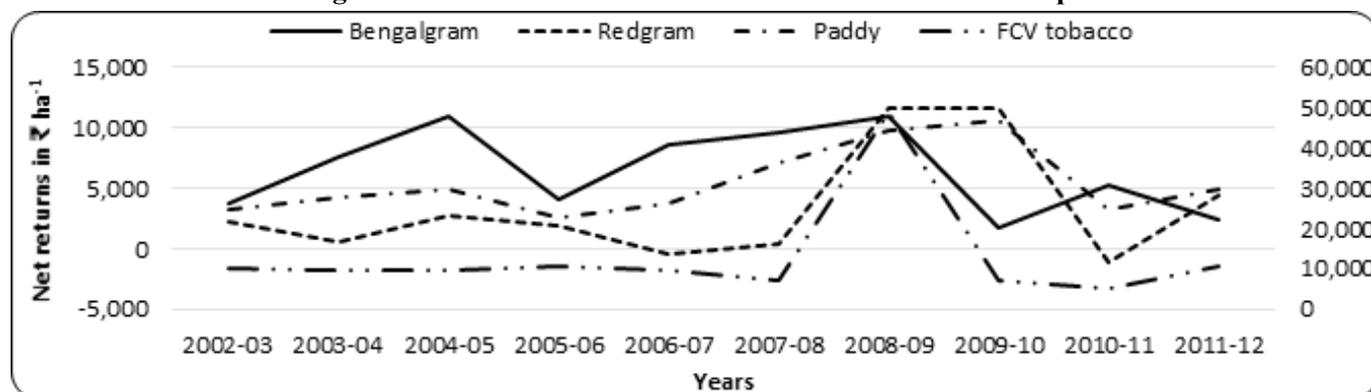


Fig. 4. Trends in net returns from tobacco and other crops

It was also observed that redgram had recorded negative net returns in 2006-07 and 2010-11. The overall scenario of these fluctuating trends of net returns indicate the need for research on the areas which curb the returns to farmers.

CONCLUSIONS

The growth rate in the productivity was highest in the case of paddy (0.84 per cent) followed by FCV tobacco (0.33 per cent), redgram (-7.64 per cent) and begalgram (-3.98 per cent). There was a positive growth in prices of all the crops. It was highest in FCV tobacco (10.93 per cent) followed by redgram (9.64 per cent), bengalgram (7.80 per cent) and paddy (7.45 per cent). Cost of cultivation too recorded positive growth for all the crops. The highest growth rate was seen in redgram (11.05 per cent), followed by bengalgram (10.88 per cent), paddy (9.50 per cent) and FCV tobacco (9.46 per cent). The net returns from FCV tobacco, bengalgram, redgram and paddy ranged from ₹ 5,300 to ₹ 48,851, ₹ 1,763 to ₹ 10,954, ₹ -1,058 to ₹ 11,610 and ₹ 2,646 to ₹ 10,652 respectively.

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PRODUCTIVE POTENTIAL OF FODDER MAIZE (*Zea mays* L.) AS INFLUENCED BY SOIL AND FOLIAR APPLICATIONS OF ZINC

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ABSTRACT

A field experiment was conducted during *kharif*, 2014 at S.V. Agricultural College Farm, Tirupati to find out the response of fodder maize to different soil and foliar applications of zinc. The twelve nutrient management practices consisted of RDF (120 kg N - 50 kg P₂O₅ - 40 kg K₂O ha⁻¹) without zinc and different combinations of soil and foliar applications of zinc were studied in a randomized block design with three replications. The results of the experiment revealed that among all the treatments, the maximum plant height (362.0 cm), leaf area index (4.972), leaf to stem ratio (0.304), dry matter production (6695 kg ha⁻¹) and green fodder yield (424 q ha⁻¹) were recorded with RDF + soil application of 50 kg ZnSO₄ ha⁻¹ along with foliar application of 0.2% ZnSO₄ at 30 and 45 DAS (T₁₂). All the above growth parameters and yield were statistically comparable with RDF + soil application of 50 kg ZnSO₄ ha⁻¹ along with foliar application of 0.2% ZnSO₄ at 45 DAS (T₁₁). Hence, it can be concluded that application of zinc had significant influence on the growth parameters and green fodder yield of fodder maize.

KEYWORDS: Fodder maize, Zinc Sulphate, Growth Parameters and Green Fodder Yield.

INTRODUCTION

Livestock production is the backbone of Indian agriculture contributing 7 per cent to national gross domestic product and a source of employment and ultimate livelihood for 70 per cent of the population in rural areas. The milk production to a large extent depends upon the availability of good quality fodder. At present, the country faces a net deficit of 61.1 per cent green fodder, 21.9 per cent dry crop residues and 64% concentrate feeds (www.apdoes.org). To meet out the needs of the ever increasing livestock population, the production as well productivity of fodder is to be increased.

Fodder maize is the most nutritious and palatable *kharif* fodder which is considered good for milch animals. It has an excellent growth characters, quick growing nature, excellent fodder quality, free from toxicants and can be safely fed to animals at all the growth stages. Nevertheless, the high fertilizer application and intensive cropping has lead to deficiency of micronutrients including zinc in most of the soils. Zinc deficiency not only adversely affects plant growth but also impairs health of milch animals. Therefore, a field study was undertaken to study the effect of zinc on growth and yield of fodder maize (*Zea mays* L.) variety 'African tall' through soil and foliar applications.

MATERIAL AND METHODS

A field experiment was carried out during *kharif*, 2014 at S.V. Agricultural College Farm, Tirupati. The experimental soil was sandy loam in texture, near neutral in soil reaction (pH 6.4), low in organic carbon (0.48 per cent), available nitrogen (174 kg ha⁻¹) and available zinc (0.49 ppm), high in available phosphorus (44 kg ha⁻¹) and medium in available potassium (165 kg ha⁻¹).

The experiment was laid out in a randomized block design with twelve treatments and replicated thrice. The treatment comprised of soil and foliar applications of zinc viz., Recommended dose of fertilizers (RDF) alone (120 kg N - 50 kg P₂O₅ - 40 kg K₂O ha⁻¹) without zinc application (T₁), RDF + soil application of 25 kg ZnSO₄ ha⁻¹ (T₂), RDF + soil application of 50 kg ZnSO₄ ha⁻¹ (T₃), RDF + foliar application of 0.2% ZnSO₄ at 30 days after sowing (DAS) (T₄), RDF + foliar application of 0.2% ZnSO₄ at 45 DAS (T₅), RDF + foliar application of 0.2% ZnSO₄ at 30 and 45 DAS (T₆), RDF + soil application of 25 kg ZnSO₄ ha⁻¹ along with foliar application of 0.2% ZnSO₄ at 30 DAS (T₇), RDF + soil application of 25 kg ZnSO₄ ha⁻¹ along with foliar application of 0.2% ZnSO₄ at 45 DAS (T₈), RDF + soil application of 25 kg ZnSO₄ ha⁻¹ along with foliar application of 0.2% ZnSO₄ at 30 and 45 DAS (T₉), RDF + soil application of 50 kg ZnSO₄

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ha⁻¹ along with foliar application of 0.2% ZnSO₄ at 30 DAS (T₁₀), RDF + soil application of 50 kg ZnSO₄ ha⁻¹ along with foliar application of 0.2% ZnSO₄ at 45 DAS (T₁₁), RDF + soil application of 50 kg ZnSO₄ ha⁻¹ along with foliar application of 0.2% ZnSO₄ at 30 and 45 DAS (T₁₂).

Fodder maize was sown on 12th July 2014 at a spacing of 45 × 10 cm and harvested on 29th September 2014. The recommended dose of fertilizers was applied to all the treatments. Nitrogen was applied through urea in two equal splits *viz.*, first half at the time of sowing as basal and remaining half as top dressing at 30 DAS. Entire quantity of phosphorous and potassium was applied as basal through single super phosphate and muriate of potash, respectively in furrows at 5 cm away from the seed rows. Zinc sulphate was applied as per the treatments (soil application of ZnSO₄ at two days after basal application of N, P and K and foliar application of 0.2 % ZnSO₄ at 30 and 45 DAS as per the treatments).

RESULTS AND DISCUSSION

Growth parameters

Growth parameters like plant height (362.0 cm), leaf area index (4.972), leaf to stem ratio (0.304) were recorded highest with RDF + soil application of 50 kg ZnSO₄ ha⁻¹ along with foliar application of 0.2% ZnSO₄ at 30 and 45 DAS (T₁₂), which was however, comparable with RDF + soil application of 50 kg ZnSO₄ ha⁻¹ along with foliar application of 0.2% ZnSO₄ at 45 DAS (T₁₁) and both of them were differed significantly over other nutrient management practices. The highest dry matter production (6695 kg ha⁻¹) at harvest was produced with the former nutrient management practice, which was significantly superior over other treatments (Table-1). The percentage increase in dry matter production of the treatments with zinc over RDF alone (T₁) ranged from 2-33 per cent. The lowest values of all the growth parameters were recorded with the treatment involving application of only RDF without zinc application (T₁), which differed significantly from other treatments.

This might be due to involvement of zinc in biosynthesis of plant hormones by activating tryptophan, which is a precursor of Indole acetic acid (auxin). IAA is a component of various enzymes, such as carbonic anhydrase and alcoholic dehydrogenase, which have a suggestive role in chlorophyll formation, photosynthesis and metabolic reactions in plants. It also involves in protein synthesis, cell division and cell elongation, which

inturn promotes the vertical growth of the plant, photosynthates accumulation and thereby improving the plant biomass production. The results are in accordance with those of Meena *et al.* (2010), Mahdi *et al.* (2012), Mohan and Singh (2014).

Green fodder yield (q ha⁻¹)

The highest green fodder yield of maize (424 q ha⁻¹) was recorded with soil application of ZnSO₄ @ 50 kg ha⁻¹ + foliar application of ZnSO₄ @ 0.2 % twice at 30 and 45 DAS along with RDF (T₁₂), which was however comparable with soil application of either 25 or 50 kg ZnSO₄ ha⁻¹ + foliar application of 0.2 % ZnSO₄ once or twice at 30 and 45 DAS along with RDF (T₁₁, T₁₀, T₉, T₈ and T₇). The percentage increase in green fodder yield under these treatments over T₁ (no zinc application) ranged from 13.5 to 30 per cent. Application of only RDF without zinc application (T₁) resulted in significantly the lowest green fodder yield (324 q ha⁻¹).

The increase in green fodder yield might be due to the role of zinc in various growth processes like photosynthesis, nitrogen metabolism, protein synthesis, hormone production and regulation of auxin concentration in the plants. These favourable impacts of zinc resulted in taller plants, increase in leaf area, leaf to stem ratio and dry matter production which might have reflected in terms of higher green fodder yields. These results are inline with those of Patel *et al.* (2007), Koushik *et al.* (2010), Kumar *et al.* (2012).

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Table 1. Influence of soil and foliar applications of zinc on growth parameters and green fodder yield of fodder maize at harvest

Treatments	Plant height (cm)	Leaf area index (LAI)	Leaf to stem ratio	Drymatter production (kg ha ⁻¹)	Green fodder yield (q ha ⁻¹)
T ₁ : Recommended dose of fertilizers (120 kg N - 50 kg P ₂ O ₅ - 40 kg K ₂ O ha ⁻¹)	253.0	3.841	0.161	5016	324
T ₂ : T ₁ + Soil application of 25 kg ZnSO ₄ ha ⁻¹	260.9	4.122	0.182	5451	368
T ₃ : T ₁ + Soil application of 50 kg ZnSO ₄ ha ⁻¹	268.7	4.4514	0.192	5607	380
T ₄ : T ₁ + Foliar application of 0.2% ZnSO ₄ at 30 DAS	276.6	3.994	0.169	5150	354
T ₅ : T ₁ + Foliar application of 0.2% ZnSO ₄ at 45 DAS	280.8	4.043	0.172	5233	356
T ₆ : T ₁ + Foliar application of 0.2% ZnSO ₄ at 30 and 45 DAS	289.1	4.062	0.175	5272	360
T ₇ : T ₂ + Foliar application of 0.2% ZnSO ₄ at 30 DAS	302.1	4.241	0.199	5749	406
T ₈ : T ₂ + Foliar application of 0.2% ZnSO ₄ at 45 DAS	308.9	4.322	0.206	5805	408
T ₉ : T ₂ + Foliar application of 0.2% ZnSO ₄ at 30 and 45 DAS	317.3	4.434	0.214	5822	411
T ₁₀ : T ₃ + Foliar application of 0.2% ZnSO ₄ at 30 DAS	330.9	4.511	0.235	6028	417
T ₁₁ : T ₃ + Foliar application of 0.2% ZnSO ₄ at 45 DAS	355.2	4.923	0.264	6283	421
T ₁₂ : T ₃ + Foliar application of 0.2% ZnSO ₄ at 30 and 45 DAS	362.0	4.972	0.304	6695	424
SEm±	2.62	0.019	0.002	41.7	8.85
CD (P=0.05)	7.7	0.05	0.007	122	26

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EFFECT OF IRRIGATION AND SULPHUR ON GROWTH, YIELD, NUTRIENT UPTAKE AND MOISTURE USE IN CHICKPEA (*Cicer arietinum* L.)

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ABSTRACT

A field experiment was carried out during *rabi*, 2010-11 to study the growth, yield, moisture extraction pattern and nutrient uptake in chickpea as influenced by irrigation and sulphur levels. Scheduling irrigation based on IW/CPE ratio and application of sulphur significantly influenced the growth, yield, moisture extraction pattern, nutrient uptake and quality of chickpea. Higher values for all these parameters along with net return and B : C ratio were obtained with scheduling irrigation at IW/CPE ratio of 0.9 which was statistically at par with 0.7 IW/CPE ratio. The study revealed that higher amount of moisture was extracted from surface layers irrespective of irrigation schedule and depletion of soil moisture by the crop increased with increasing frequency of irrigation. The highest water use efficiency was recorded under farmer's practice of irrigation schedule, while the lowest was recorded with IW/CPE ratio of 0.9. Among the three levels of sulphur *i.e.* 0, 20 and 40 kg ha⁻¹, application of 40 kg S ha⁻¹ being at par with 20 kg S ha⁻¹ recorded higher grain yield, net return and B : C ratio. But interaction of irrigation scheduled at 0.7 IW/CPE ratio with application of 20 kg S ha⁻¹ recorded 32 % higher grain yield and higher B : C ratio over other treatment combinations.

KEYWORDS: B : C ratio, Chickpea, Chickpea, Irrigation, IW/CPE ratio, Sulphur.

INTRODUCTION

Bengalgram or chickpea (*Cicer arietinum* L.) is the most important pulse crop of India accounting 34.6 per cent area and 48.4 per cent production of total pulses with a productivity of 841 kg ha⁻¹. Considering the climatic change, limited water resources and replacement of new varieties with earlier ones along with changing cropping patterns calls urgent need for application of water at an appropriate critical stage of the crop for ensuring better water use efficiency. In spite of this, recent studies on soil fertility across the country showed that long term application of N, P and K fertilizers alone resulted in imbalance of nutrient ratios and led to sulphur deficiency in most of the states including the districts of Saurashtra region of Gujarat (Singh, 1999) and further, sulphur was known to increase the yield and quality in chickpea (Narendra Kumar *et al.*, 2003). Due to very limited information regarding appropriate irrigation interval and optimum sulphur dose for chickpea crop in recent years in South Saurashtra region, the present investigation was carried out.

MATERIAL AND METHODS

The field experiment was conducted at the Instructional Farm, Department of Agronomy, College of

Agriculture, Junagadh Agricultural University, Junagadh during *rabi*, 2010-11. The soil was clayey in texture, rich in organic carbon (0.76%), low in available nitrogen (178.75 kg ha⁻¹), potassium (112.90 kg ha⁻¹) and sulphur (8.15 ppm), medium in available phosphorus (38.40 kg ha⁻¹) and alkaline in reaction with pH of 7.9. The field capacity, permanent wilting point and bulk density of the soil were 28.4%, 12.8% and 1.36 Mg m⁻³, respectively.

The experiment was laid out in split-plot design comprising four levels of irrigation based on IW/CPE ratios [I₁=0.5, I₂=0.7, I₃=0.9 and I₄=farmer's practice (1st irrigation immediately after sowing, 2nd irrigation at 10-12 DAS and rest of the three at an interval of 18-20 days)] were allotted to main plot and three levels of sulphur (S₁=0, S₂=20 and S₃=40 kg S ha⁻¹) allotted to sub plot treatments and replicated thrice comprising 36 plots each having a size of 5.0 m X 3.6 m. Sowing of chickpea (var. JG-16) was done using 60 kg seed ha⁻¹ at a spacing of 45 cm x 10 cm. Irrigation was scheduled as per the treatments each at 50 mm depth measured with parshall flume of 7.5 mm throat width placed at the head irrigation channel based on cumulative pan evaporation readings. Besides initial two common irrigations (1st immediately after sowing and 2nd at 10-12 DAS) a total of three (41, 60 and

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82 DAS), four (33, 52, 68 and 80 DAS), five (29, 47, 57, 70 and 79 DAS) and three (29, 47 and 68 DAS) irrigations were given to I₁, I₂, I₃ and I₄ treatments, respectively. The quantity of water received by I₁, I₂, I₃ and I₄ treatments was 250 mm, 300 mm, 350 mm and 250 mm, respectively. Sulphur was applied to soil as per the treatments at 10 days prior to sowing in elemental form. Recommended dose of both nitrogen (25 kg ha⁻¹) and phosphorus (50 kg ha⁻¹) was supplied through Urea and DAP, respectively at the time of sowing. Depth wise moisture extraction and consumptive use of water by crop were studied by gravimetric method (Dastane, 1972). Observations on growth parameters, yield attributes, yield and quality were recorded.

RESULTS AND DISCUSSION

Effect of irrigation on growth and yield

Scheduling seven irrigations to chickpea (including two common irrigations) at IW/CPE ratio of 0.9 resulted in significantly higher plant height, plant spread, branches/plant, dry matter accumulation at harvest, number of nodules and nodule dry weight/plant, pods/plant, seeds/pod, test weight, grain and stover yield (Table.1). This was due to the availability of adequate moisture throughout crop growth and development contributing to luxurious uptake of nutrients, favourable physiological processes and active cell division. Increased frequency of irrigation from 0.5 to 0.9 IW/CPE ratio significantly delayed the flowering and maturity of the crop due to prolonged vegetative growth compared to farmer's practice. The extent of increase in grain and stover yields of chickpea at 0.9 IW/CPE ratio was to the tune of 16.88 and 30.68% over farmer's practice, respectively, and it remained at par with 0.7 IW/CPE ratio. The irrigation schedule of 0.9 IW/CPE ratio was exactly coincided with that of farmer's practice and further provided two more irrigations one at peak vegetative stage and another at the time of maturity thus, resulted in more number of well filled pods with large sized seeds. This finally resulted in higher grain and stover yield. The results obtained by Patel (1988), Parihar (1990) and Dixit *et al.* (1993a) were in corroborative with the above results. Increasing frequency of irrigation from 0.5 to 0.9 IW/CPE ratio significantly increased the nutrient uptake by the crop.

Effect of irrigation on nutrient uptake

Scheduling irrigation to chickpea at 0.9 IW/CPE ratio significantly increased the uptake of N, P, K and S by 20, 22, 18 and 27% and 41, 30, 37 and 43% by grain and

stover respectively over the farmers practice (Table.2). Continuous availability of adequate moisture resulting in more available nutrients in soil solution, active root and shoot growth, increased biomass accumulation, luxurious growth of root nodules along with synergetic effect between moisture, soil microorganisms and nutrients may boosted nutrient availability and resulted in higher uptake by chickpea crop at 0.9 IW/CPE ratio. These results were in close agreement with findings of Reddy and Ahlawat (1998) and Singh *et al.* (2004).

Effect of irrigation on moisture use pattern

With increasing depth of soil, per cent moisture extracted by the crop gradually decreased. It was also revealed that about 60-64 per cent of moisture was extracted from top 0-30 cm soil depth and around 90-95 per cent moisture was extracted from 0-60 cm depth (Table 3). With increasing frequency of irrigation, the per cent moisture extracted from the upper layers increased. However, at lower IW/CPE ratios the moisture extracted from deeper layers was increased. The present study further revealed that increasing IW/CPE ratio from 0.5 to 0.9 increased total consumptive use of water and decreased water use efficiency (Table.4). This was due to more consumption of water resulting in higher vegetative growth and decreasing trend of yield increase per unit water available from lower to higher IW/CPE ratios. Same trend in moisture extraction, CUW and WUE were observed by Prabhakar and Saraf (1991) and Dixit *et al.* (1993b).

Effect of sulphur on growth and yield

Application of 20 kg S ha⁻¹ recorded significantly higher plant height and plant spread at harvest and was at par with 40 kg S ha⁻¹. Whereas, dry matter accumulation at harvest, number of nodules and nodule dry weight per plant were significantly higher when chickpea fertilized with 40 kg S ha⁻¹ and at par with 20 kg S ha⁻¹ (Table.1). Increase in growth parameters with increased levels of sulphur was due to its higher availability and uptake as well as its active involvement in synthesis of amino acids, regulation of various metabolic and enzymatic processes along with enhanced nitrogen fixation and biomass accumulation. Similar results were reported by Singh *et al.* (2004) and Srinivasa Rao *et al.* (2010). Application of sulphur @ 40 kg ha⁻¹ resulted in significantly higher number of pods per plant followed by 20 kg S ha⁻¹ (Table 1). Joseph and Verma (1994) and Singh *et al.* (2004) reported

Table 1. Growth and yield attributes of chickpea as influenced by different irrigation and sulphur levels

Treatments	Plant height at harvest (cm)	Plant spread at harvest (cm)	Dry matter per plant at harvest (g)	Days to 50% flowering	Days to maturity	No. of nodules per plant	Nodule dry weight (g)	No. of pods per plant	Grain yield per hectare (kg)	Stover yield per hectare (kg)	Test weight (g)	Harvest index (%)
Irrigation: (IW/CPE ratios)												
I ₁ : 0.5	33.5	18.8	14.8	52.8	86.4	20.8	0.197	53.1	1744	2503	17.05	41.28
I ₂ : 0.7	38.2	22.8	19.7	55.4	93.3	26.6	0.303	58.4	2199	3472	17.74	38.69
I ₃ : 0.9	42.2	23.4	20.9	57.4	95.9	31.1	0.342	61.0	2243	3791	19.03	37.27
I ₄ : Farmer's practice	34.7	18.5	16.3	50.9	85.8	22.9	0.214	54.9	1919	2901	16.45	40.02
S.Em.±	1.02	0.94	0.88	0.15	0.23	1.23	0.015	1.34	103.20	209.47	0.28	1.24
C.D. at 5%	3.53	3.24	3.06	0.51	0.81	4.25	0.053	4.63	357.15	724.88	0.95	NS
C.V.%	8.24	13.47	14.78	0.81	0.78	14.51	17.53	7.06	15.28	19.84	4.71	9.47
Sulphur levels (kg ha⁻¹)												
S ₁ : 0	35.7	19.63	16.7	54.2	90.3	22.6	0.244	52.5	1919	2965	16.62	39.65
S ₂ : 20	38.3	21.45	18.2	54.0	90.5	25.2	0.263	58.0	2035	3291	18.65	38.28
S ₃ : 40	37.5	21.52	18.8	54.3	90.3	28.3	0.286	60.1	2124	3245	17.44	40.00
S.Em.±	0.61	0.42	0.51	0.25	0.26	0.91	0.009	1.0	46	71	0.2	0.81
C.D. at 5%	1.8	1.3	1.5	NS	NS	2.74	0.028	2.8	137	212	0.5	NS
C.V.%	5.7	7.0	9.8	1.6	1.0	12.5	12.3	5.7	8.0	7.8	3.5	7.1
Interaction (I X S)												
S.Em.±	1.23	0.84	1.02	0.51	0.53	1.83	0.019	1.86	91.51	141.74	0.35	1.62
C.D. at 5%	NS	NS	NS	NS	NS	5.48	NS	5.57	274.37	NS	1.05	NS
C.V.%	5.7	7.0	9.8	1.6	1.0	12.5	12.3	5.7	7.8	7.8	3.5	7.1

Table 2. N, P, K and S uptake (kg ha^{-1}) by chickpea grain and stover as influenced by different irrigation and sulphur levels

Treatments	Uptake (kg ha^{-1}) of															
	N				P				K				S			
	Grain	Stover	Total	Grain	Stover	Total	Grain	Stover	Total	Grain	Stover	Total	Grain	Stover	Total	
Irrigation schedules																
I ₁ : 0.5	50.1	46.1	96.2	16.5	7.6	24.1	8.1	6.9	15.0	4.7	6.8	11.5				
I ₂ : 0.7	71.2	65.8	137.0	20.0	10.7	30.6	10.3	10.2	20.5	6.4	10.6	17.0				
I ₃ : 0.9	71.5	77.7	149.3	20.8	11.7	32.5	10.5	11.8	22.2	6.6	12.0	18.7				
I ₄ : Farmer's practice	59.6	55.1	114.8	17.1	9.0	26.1	8.9	8.6	17.6	5.2	8.4	13.6				
S.Em.±	4.0	4.8	8.3	1.2	0.6	1.6	0.5	0.7	1.2	0.3	0.6	0.8				
C.D. at 5%	13.7	16.8	28.7	NS	1.9	5.6	1.7	2.3	4.0	1.2	1.9	2.9				
C.V.%	18.9	23.7	20.0	19.2	17.2	17.3	15.8	21.5	18.3	17.9	17.8	16.3				
Sulphur levels (kg ha^{-1})																
S ₁ : 0	58.8	56.9	115.7	17.0	8.9	25.9	8.9	8.6	17.5	5.3	8.4	13.6				
S ₂ : 20	63.6	63.2	126.8	18.9	10.2	29.1	9.5	9.8	19.3	5.7	9.9	15.7				
S ₃ : 40	67.0	63.5	130.5	19.8	10.2	30.0	10.0	9.7	19.7	6.2	10.1	16.3				
S.Em.±	1.6	1.9	2.5	0.5	0.3	0.6	0.2	0.3	0.3	0.2	0.3	0.3				
C.D. at 5%	4.9	5.6	7.4	1.6	0.8	1.7	0.7	0.8	0.9	0.5	0.8	0.8				
C.V.%	9.0	10.5	6.9	9.8	9.5	6.9	8.8	9.7	5.3	9.8	9.8	6.3				
Interaction (I X S)																
S.Em.±	3.3	3.7	4.9	1.1	0.5	1.1	0.5	0.5	0.6	0.3	0.5	0.6				
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS				
C.V.%	9.0	10.5	6.9	16.5	7.6	24.1	8.8	9.7	5.3	9.8	9.8	6.3				

Table 3. Depth wise moisture extraction pattern (%) by chickpea as influenced by different irrigation and sulphur levels

Treatments	Soil depth (cm)				
	0-15	15-30	30-45	45-60	60-75
Irrigation: (IW/CPE ratios)					
I ₁ : 0.5	31.83	29.00 (60.83)	16.73 (77.56)	12.46 (90.02)	9.98 (100.00)
I ₂ : 0.7	32.63	29.55 (62.18)	18.74 (80.92)	13.47 (94.39)	5.61 (100.00)
I ₃ : 0.9	34.01	30.55 (64.56)	21.20 (85.76)	11.51 (97.27)	2.73 (100.00)
I ₄ : Farmer's practice	33.78	29.12 (62.90)	17.88 (80.78)	10.67 (91.45)	8.55 (100.00)
Sulphur levels (kg ha⁻¹)					
S ₁ : 0	33.64	30.83 (64.47)	18.59 (83.06)	10.07 (93.13)	6.87 (100.00)
S ₂ : 20	31.97	29.27 (61.24)	18.86 (80.10)	13.13 (93.23)	6.77 (100.00)
S ₃ : 40	33.57	28.56 (62.13)	18.47 (80.60)	12.88 (93.48)	6.52 (100.00)

Note: Data in parentheses indicates cumulative moisture extraction percentage up to that depth

Table 4. Consumptive use of water, water use efficiency, net realisation and benefit cost ratio of chickpea as influenced by different irrigation and sulphur levels

Treatments	Consumptive use of water (mm)	Water use efficiency (kg ha ⁻¹ mm ⁻¹)	Gross realization (₹/ha)	Net realization (₹/ha)	B:C ratio
Irrigation: (IW/CPE ratios)					
I ₁ : 0.5	211	6.98	40241	14483	1.56
I ₂ : 0.7	248	7.33	50866	24826	1.95
I ₃ : 0.9	282	6.41	51984	25661	1.97
I ₄ : Farmer's practice	224	7.67	44338	18580	1.72
Sulphur levels (kg ha⁻¹)					
S ₁ : 0	238	6.75	44364	19349	1.77
S ₂ : 20	239	7.10	47104	21134	1.81
S ₃ : 40	246	7.44	49088	22165	1.82

Table 5. Economics of chickpea production as influenced by different irrigation schedules and sulphur levels in different treatment combinations

Treatment	Yield (kg ha ⁻¹)		Gross realization (₹/ha ⁻¹)	Total expenditure (₹/ha ⁻¹)	Net realization (₹/ha ⁻¹)	Benefit : cost ratio
	Seed	Stover				
I ₁ S ₁	1860	2338	42775	24804	17971	1.72
I ₁ S ₂	1636	2639	37861	25758	12103	1.47
I ₁ S ₃	1736	2531	40075	26711	13364	1.50
I ₂ S ₁	1914	3272	44364	25086	19278	1.77
I ₂ S ₂	2353	3657	54414	26041	28373	2.09
I ₂ S ₃	2330	3488	53826	26993	26833	1.99
I ₃ S ₁	2122	3457	49126	25369	23757	1.94
I ₃ S ₂	2276	3904	52777	26323	26454	2.00
I ₃ S ₃	2330	4012	54035	27276	26759	1.98
I ₄ S ₁	1782	2793	41221	24804	16417	1.66
I ₄ S ₂	1875	2963	43373	25758	17615	1.68
I ₄ S ₃	2099	2948	48401	26711	21690	1.81

the same results. Maximum test weight recorded with the application of 20 kg S ha⁻¹ followed by 40 kg S ha⁻¹ (Table 1). Mishra *et al.* (2001) observed the same results at Raipur. Sulphur @ 40 kg ha⁻¹ resulted in significantly higher grain yield and was statistically at par with 20 kg S ha⁻¹. Whereas, maximum stover yield was obtained with 20 kg S ha⁻¹ being on same bar with 40 kg S ha⁻¹ (Table 1). This potential increase of grain and stover yields with increasing level of sulphur was due to its contribution on growth and yield attributes. Hariram and Dwivedi (1992) and Joseph and Verma (1994) reported higher grain yields in chickpea with 40 kg S ha⁻¹. Significant increase in stover yields of chickpea with 20 kg S ha⁻¹ was also reported by Srinivasa Rao *et al.* (2010).

Effect of sulphur on nutrient uptake

Increasing levels of sulphur from 0 to 40 kg ha⁻¹ significantly increased nitrogen, phosphorus, potassium and sulphur uptake by the crop. Application of 40 kg S ha⁻¹ resulted in 12.4, 15.8, 12.6 and 19.8 per cent higher uptake of N, P, K and S by the crop, respectively over control and was at par with 20 kg S ha⁻¹ (Table 2). This increase in nutrient uptake with successive increase in sulphur up to 40 kg ha⁻¹ could be attributed to increased availability of sulphur to plants which in turn might have resulted in more number of effective root nodules, profuse shoot and root growth contributing to higher biomass production, higher photosynthetic activity as well as synergistic effect of N-S and S-P may boosted their availability and absorption from the soil. These findings were in accordance with those of Kaprekar *et al.* (2003) and Singh *et al.* (2004).

Effect of sulphur on moisture use pattern

Significant trend in moisture extraction pattern was not observed with the application of sulphur. But it was showed that application of 40 kg S ha⁻¹ markedly increased the WUE in chickpea (Table 3 and Table 4).

Interaction effect of irrigation and sulphur

Significant interaction between irrigation and sulphur was observed in number of nodules, pods and grain yield per plant, test weight and grain yield per ha (Table 1). Irrigating chickpea at 0.7 IW/CPE ratio along with the application of 20 kg S ha⁻¹ resulted in maximum yield (Table.5). Interaction between irrigation and sulphur was also reported by Patel and Patel (2005) in chickpea.

Economics

Irrigating chickpea at 0.9 IW/CPE ratio resulted in higher net realisation as well as benefit cost ratio. Dixit *et al.* (1993a) also recorded higher net returns and B:C ratio at higher IW/CPE ratios. Fertilizing chickpea with 40 kg S ha⁻¹ recorded maximum net returns and B:C ratio (Table 4). Results obtained by Singh *et al.* (2005) are also in conformity with the above results. But the present investigation revealed that combination of irrigating chickpea at 0.7 IW/CPE ratio along with the application of 20 kg S ha⁻¹ resulted in maximum B : C ratio of 2.09 (Table 5).

CONCLUSION

The present investigation revealed that chickpea (cv JG-16) should be irrigated at IW/CPE ratio of 0.7 along with the application of 20 kg S ha⁻¹ including recommended dose of fertilizers for higher grain yield in chickpea, net realization and higher B:C ratio under clayey soils of South Saurashtra agro-climatic zone.

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GROWTH AND YIELD OF WHITE GRAIN FINGER MILLET (*Eleusine coracana* (L). Gaertn) UNDER VARIED NITROGEN LEVELS AND TIME OF NITROGEN APPLICATION

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ABSTRACT

A field experiment was conducted during *rabi*, 2014-15 to study the effect of different nitrogen levels and time of nitrogen application on growth and yield of white grain finger millet. The experiment was laid out in split - plot design and replicated thrice. The four nitrogen levels *i.e.* 60, 80, 100 and 120 kg ha⁻¹ were assigned to main plots time of nitrogen application *i.e.* 50% basal + 50% top dressing at 30 DAT, 50% basal + 25% top dressing at 30 DAT + 25% top dressing at 45 DAT and 25% basal + 50% top dressing at 30 DAT + 25% top dressing at 45 DAT were assigned to sub plots. The results revealed that the highest nitrogen level 120 kg ha⁻¹ resulted in higher growth stature and yield, while these parameters were found to be at their lowest with 60 kg N ha⁻¹. Nitrogen applied as 25% basal + 50% top dressing at 30 DAT + 25% top dressing at 45 DAT markedly improved the crop growth, yield attributes and yield, while these were found to be at their lowest with two splits of nitrogen application as 50% basal + 50% top dressing at 30 DAT.

KEYWORDS: Growth parameters, Nitrogen, Time of nitrogen application, White grain finger millet and Yield.

INTRODUCTION

In India, finger millet (*Eleusine coracana* (L). Gaertn) accounts for 60 per cent area and 75 per cent of total small millets production, which is grown over an area of 1.3 million hectares with an annual production of 1.9 million tonnes and a productivity of 1480 kg ha⁻¹. In Andhra Pradesh, it is cultivated in 44,000 hectares with a production of 54,000 tonnes and a productivity of 1175 kg ha⁻¹ (Ministry of Agriculture, 2012).

Finger millet is a versatile cereal crop which offers plausible health benefits with an ideal nutrient profile *i.e.* 100 grams of finger millet grain contains 6-8 g protein, 1.3 g fat, 70-76 g carbohydrates along with 370 mg of calcium and 3.9 mg iron. But the brown coloured grains have been reported to contain higher amounts of tannins (360 mg / 100g) and poly phenols, (Ramachandra *et al.*, 1977), which affects the *in vitro* protein digestibility and the zinc as well as iron availability and adsorption. In contrast, white grain varieties have lower levels of tannins (0.05 mg/100g) and higher protein content (10-12%) with wider acceptability among the consumers. Nitrogen is a unique mobile nutrient in soil – plant system and the crop requires nitrogen throughout the crop growth period. Therefore, Split application of nitrogen in precise amounts

synchronizing with peak demand periods of crop might be a promising agro-technique to enhance its use efficiency along with realization of maximum possible productivity. Keeping all the above points in view, it is pertinent to evolve the best nitrogen management practice for higher yield and quality of white grain finger millet.

MATERIAL AND METHODS

A field experiment was carried out during *rabi*, 2014 - 15 at S.V. Agricultural College Farm, Tirupati. The experimental soil was sandy loam in texture, low in organic carbon (0.39%) and available nitrogen (132 kg/ha), medium in available phosphorus (27.3 kg/ha) and medium in potassium (147.6 kg/ha). The experiment was laid out in split - plot design and replicated thrice. The main plots comprised of four nitrogen levels 60, 80, 100 and 120 kg N ha⁻¹ and sub plots consisted of varied times of nitrogen application *i.e.* 50% basal + 50% top dressing at 30 DAT; 50% basal + 25% top dressing at 30 DAT + 25% top dressing at 45 DAT and 25% basal + 50% top dressing at 30 DAT + 25% top dressing at 45 DAT. Uniform dose of 45 kg ha⁻¹ P₂O₅ through single super phosphate and 30 kg ha⁻¹ K₂O through muriate of potash were applied basally at the time of transplanting. Nitrogen was applied through urea as per the prescribed treatments

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and accordingly to the time of nitrogen application. The variety of finger millet used in the experiment was Hima (VR 936). The other agronomic management practices were followed excluding nitrogen management as per the recommendation of the ANGRAU.

RESULTS AND DISCUSSION

Effect of nitrogen

Varied nitrogen levels exerted significant effect on growth and yield of white grain finger millet. The application of nitrogen @ 120 kg ha⁻¹ produced elevated stature of growth parameters, *viz.*, LAI, plant height and dry matter production. The application of 100 kg N ha⁻¹ was the next best level of nitrogen to white grain finger millet. The lowest values of growth parameters were obtained with 60 kg ha⁻¹. The increase in number of tillers m⁻² with each successive level of nitrogen might be owing to its role in cytokinin synthesis, which promoted the growth and development of tiller buds, present at each node of the shoot. Nitrogen regulates the synthesis of photosynthetic carboxylating enzymes, which results in greater light interception, enhancing canopy photosynthesis and eventually higher dry matter accumulation. Therefore, increase in growth attributes with higher levels of nitrogen application might be due to adequate supply of nitrogen associated with higher photosynthetic activity and vigorous shoot growth. These results are in conformity with the findings of Chavan *et al.* (1995), Roy *et al.* (2002).

The highest grain yield of white grain finger millet was obtained with the application of nitrogen @ 120 kg ha⁻¹, which was significantly higher than with rest of the N levels tried. The lowest grain yield of white grain finger millet was obtained with application of 60 kg N ha⁻¹ which was significantly lesser than rest of the nitrogen levels tried. The better availability of nitrogen with 120 kg ha⁻¹ might have fulfilled the plant requirement, enhanced the total biomass accrual and its efficient translocation from source to sink for the production of elevated yield stature *i.e.* number of productive tillers /m², grain weight ear⁻¹ and consequently increased the grain yield of white grain finger millet. The linear increase in grain yield with increased supply of nitrogen was also reported by Rao *et al.* (1986) and Ramesh Singh and Singh (2005).

Effect of time of nitrogen application

Application of nitrogen in three splits as 25% basal + 50% top dressing at 30 DAT + 25% top dressing at 45

DAT registered the highest growth parameter continuous and adequate supply of nitrogen in commensurate with the growth stages *viz.*, early vegetative, active tillering, panicle initiation, flowering and grain filling of the crop and maintained the photosynthetic capacity for longer period, resulting in higher dry matter accrual. Application of nitrogen in two splits of nitrogen *i.e.* 50% basal + 50% top dressing at 30 DAT resulted in reduced growth attributes.

The yield attributes *viz.*, productive tillers m⁻², grain weight ear⁻¹ and grain yield were recorded to be the highest with the application of nitrogen as 25% basal + 50% top dressing at 30 DAT + 25 % top dressing at 45 DAT, which might be ascribed due to continuous adequate availability of nitrogen synchronizing with its peak crop requirements of critical stages of the crop growth, This is crucial in determination of sink capacity as well as the maintenance of functional sink throughout the seed development. Another positive effect of nitrogen as top dressing at 45 DAT might have enhanced the LAD of older leaves with increased photosynthetic activity particularly from flag leaf during reproductive and ripening periods. The larger proportion of nitrogen have applied in two splits with application of N as 50% basal + 50% top dressing at 30 DAT might have not been efficiently utilized at the early stages of crop growth and lost from the soil in various forms, and leading to nitrogen starvation at later critical stages of crop growth for nitrogen nutrition *i.e.* post flowering period . The results of the present investigation are in agreement with the findings of Tahir *et al.* (2008) and Jakhar *et al.* (2011).

In conclusion, the present study has revealed that application of nitrogen @120 kg ha⁻¹ in three splits as 25% basal + 50% top dressing at 30 DAT + 50% top dressing at 45 DAT was the best nitrogen management practice for obtaining higher productivity of white grain finger millet.

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Table 1. Growth parameters at harvest, yield attributes and yield of white grain finger millet as influenced by nitrogen levels and time of nitrogen application

Treatments	Leaf area index	Number of tillers m ⁻²	Dry matter production (kg ha ⁻¹)	Productive tillers m ⁻²	Grain weight ear ⁻¹ (g)	Grain yield (kg ha ⁻¹)	B:C ratio
Nitrogen levels (kg ha⁻¹)							
60	2.13	69.3	3958	60	2.13	1560	1.14
80	3.05	80.2	4540	74	3.37	1908	1.37
100	3.53	87.2	5395	83	4.38	2123	1.53
120	4.05	99.2	7157	89	5.20	2604	1.87
SEm±	0.072	1.49	110	1.44	0.08	60.1	0.041
CD (P=0.05)	0.24	5.1	381	5	0.29	207	0.14
Time of nitrogen application							
T ₁ : 50 % basal + 50 % top dressing at 30 DAT	2.91	81.1	4929	72	3.48	1908	1.39
T ₂ : 50 % basal + 25 % top dressing at 30 DAT + 25% top dressing at 45 DAT	3.35	91.1	5331	75	3.88	2104	1.52
T ₃ : 25 % basal + 50 % top dressing at 30 DAT + 25% top dressing at 45 DAT	3.4	92.8	5528	76	3.96	2135	1.54
SEm±	0.050	0.93	90.1	0.56	0.09	55.2	0.031
CD (P=0.05)	0.15	2.8	270	2	0.28	165	0.11

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ACADEMIC, PERSONAL AND SOCIO-PSYCHOLOGICAL VARIABLES OF AGRICULTURAL POST GRADUATE STUDENTS

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ABSTRACT

This research study was undertaken at College of Agriculture, Pune and Post Graduate Institute, of MPKV, Rahuri of Maharashtra state during the year 2011-12. Expost-facto research design was followed for the study. The results indicated that slightly more than half (55.83%) of the post graduate students had secured 'First class' at XII standard. Nearly three-fourth (73.33%) of them had secured 'First class' at Under-Graduation, majority (84.17%) of them belonged to nuclear family. Slightly less than two-fifth (38.33%) of the respondents' fathers' were graduates. Majority (91.67%) of the respondents' fathers' had medium level of annual income.

KEYWORDS: Agricultural education, Academic, Personal, Socio-Psychological Variables, Post graduate students.

INTRODUCTION

Agricultural education today has become highly complex and specialized and offers many opportunities to plan and choose careers to its recipients. The participation of post graduate students had been constantly increasing which reflects the raising interest of students on research in different disciplines of agriculture offered by Central and State Agricultural Universities. Agricultural post graduate students do have some aspirations and plans to pursue a specific career after getting their degree. Aspiration means a strong desire to do or get something. Indeed, aspiration can be said to be the desired future state of being with respect to standards of living, social status, marriage and family, education and career. The present research paper focuses on the academic, personal and socio-psychological variables actually studied in the main research study. The study would provide better insight into the suggestions of the post graduate students which would help in improvement of educational programme and strategies for vocational guidance not only to them but also students willing to seek admission in the agricultural colleges.

MATERIAL AND METHODS

The present study was conducted in College of Agriculture, Pune and Post Graduate Institute, Rahuri which are under Mahatma Phule Krishi Vidyapeeth of

Maharashtra state during the academic year 2011-12. Expost facto research design was followed for the study. The sample constituted 93 post graduate students of Post Graduate Institute, Rahuri and 27 post graduate students of College of Agriculture, Pune with a total of 120 students by following Proportionate Stratified Random Sampling. The data were collected with the help of structured interview schedule. The statistical tools used in this study were frequency, percentage, mean and standard deviation.

RESULTS AND DISCUSSION

The independent variables used in the study were academic performance of post graduate students at XII standard and under-graduation, type of family, family education status, size of land holding, parents occupation and family annual income which were assumed to influence the aspirations of post graduate students. The results of these variables are presented as follows.

1.a. Academic performance of Post graduate students at XII standard

It is seen from table 1(a) that slightly more than half (55.83%) of the post graduate students had secured 'First class' at XII standard, while 31.67 per cent post graduate students had secured 'First class with Distinction' at XII standard. Only 12.50 per cent post graduate students had secured 'Second class' at XII standard. The mean percentage of marks obtained by the post graduate students at XII standard was 70.38.

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It can be concluded that the academic performance of the post graduate students at XII standard was good. In other words, these students, who had good academic performance at XII standard, had opted for career in agriculture sector. The findings were similar with the findings of the study conducted by Iswalkar (2001).

1.b. Academic performance of Post graduate students at Under-Graduation level

The academic performance of the students at Under Graduation level is measured on the basis of Cumulative Grade Point Average (CGPA). It is seen from the table 1(b) that nearly three-fourth (73.33%) of the Post graduate students had secured 'First class', while 14.67 per cent of the Post graduate students had secured 'First class with Distinction'. Only 12.50 per cent of the Post graduate students had secured 'Second class'. The average CGPA of the Post graduate students at Under-Graduation was 7.98.

It can be concluded that the academic performance of the post graduate students at under-graduation was good but the mean C.G.P.A is 7.98 only which comes under first class. The findings were similar with the findings of the study conducted by Waman *et al.* (2000) and Iswalkar (2001).

2. Type of Family

It is observed from the table 2 that majority (84.17%) of the post graduate students' belonged to nuclear family and only few (15.83%) of post graduate students' belonged to joint family. This indicates that most of the post graduate students' came from nuclear family.

Nuclear family gives scope to children to utilize the facilities to a maximum extent as the number of members will be less when compared to joint family. The parents can concentrate more on their children's future and could provide them what they need to a maximum extent in nuclear families. Thus nuclear family may contribute to higher level of aspirations by the respondent students.

3. Family Education Status

Family education Status is operationally defined as the formal education completed by both the parents of post graduate students'. Education has a profound impact on every aspect of life.

The data from the table 3 revealed that slightly less than two-fifth (38.33%) of the post graduate students' fathers' were graduates. Also 21.67 per cent of the post graduate students' fathers' were educated up to secondary

level and 12.50 per cent of them were educated up to higher secondary level, whereas 17.00 per cent of them studied up to primary level. Only 10.00 per cent of them were post graduates and very few (3.33%) of them were illiterate.

Regarding mothers' education around 41.66 per cent were educated up to secondary level. About 31.66 per cent were educated up to primary level, whereas 12.50 per cent of them were graduates and 5.00 per cent of them studied up to higher secondary level. Only 1.66 per cent of them were post-graduates. The percentages of illiterates were 7.50. This indicated that majority of the parents of the post graduate students' were well educated. The findings were similar with the study conducted by Saritha (2000).

4. Size of Land holding

It refers to the total number of hectares of land owned, by the respondents' parents. Larger the size of land holding, more is the income, which in turn changes the standard of living which may possibly influence the educational aspirations or play a role in crystallizing the professional aspirations of the respondents'.

The data from table 4 indicated that a slightly more than one-fourth (27.50%) of the parents of the respondents' students has semi medium sized land holding i.e. between 2.01 to 4.0 hectare. However 22.50 per cent each of them had marginal and small sized land holding i.e. up to one hectare and between 1.01 to 2.0 hectare respectively. About 8.33 per cent and 7.50 per cent of the respondents' parents' had medium sized land holding between 4.01 to 6.0 hectare and more than 6.01 hectare respectively, whereas 11.67 per cent of the respondents' parents' had no land at all. This indicated that most (88.33%) of the respondents' parents' possessed some land holding that contribute to farming.

5. Parents Occupation

Occupation refers to the work activity performed by the respondents' parents. The parents are classified on the basis of their main occupation. The main occupation contributes more than 50 per cent of the total earnings.

The data from table 5 revealed that slightly more than half (55.83%) of the respondents' father had involved in service sector as main occupation followed by 35.83 per cent of them had involved in farming. 5.00 per cent respondents' father had dairy farming as subsidiary

Table 1.a. Distribution of Post graduate students according to their academic performance at XII standard

S. No.	Academic Performance at XII standard	Respondents (n=120)	
		Frequency	Percentage
1.	First class with Distinction (75.00 per cent and above)	38	31.67
2.	First class (60 .00 to 74.99 percent)	67	55.83
3.	Second class (45.00 to 59.99 per cent)	15	12.50
	Total	120	100.00
	Mean (Percentage)	70.38	

Table 1.b. Distribution of Post graduate students according to their academic performance at Under Graduation level

S. No.	Academic Performance at Under-graduation	Respondents (n=120)	
		Frequency	Percentage
1.	First class with Distinction (above 8.50 CGPA)	17	14.67
2.	First class (7.50 to 8.49 CGPA)	88	73.33
3.	Second class (6.00 to 7.49 CGPA)	15	12.50
4.	Pass(5.50 to 5.99 CGPA)	0	0.00
	Total	120	100.00
	Mean	7.98	

Table 2. Distribution of Post graduate students according to their type of family

S. No.	Family Type	Respondents (n=120)	
		Frequency	Percentage
1.	Nuclear	101	84.17
2.	Joint	19	15.83
	Total	120	100.00

Table 3. Distribution of Post graduate students according to their parents' education

S. No.	Education	Respondents (n=120)	
		Frequency	Mother
1.	Illiterate (No Formal Education)	4 (3.33)	9 (7.50)
2.	Primary (Up to 4 th Std.)	17 (14.17)	38 (31.67)
3.	Secondary (5 th to 10 th Std.)	26 (21.67)	50 (41.67)
4.	Higher Secondary (11 th to 12 th Std.)	15 (12.50)	6 (5.00)
5.	Graduation (Degree or Diploma.)	46 (38.33)	15 (12.50)
6.	Post-Graduation (Above Degree.)	12 (10.00)	2 (1.66)
	Total	120 (100.00)	120 (100.00)
	Mean	12.28	8.73

(Figures in the parenthesis represent percentages)

Table 4. Distribution of Post graduate students according to their parents' size of land holding

S. No.	Category	Respondents (n=120)	
		Frequency	Percentage
1.	No Land	14	11.67
2.	Marginal (below 1.00 ha)	27	22.50
3.	Small (1.01 to 2.0 ha)	27	22.50
4.	Semi medium (2.01 to 4.0 ha)	33	27.50
5.	Medium (4.01 to 6.0 ha)	10	8.33
6.	Big (6.01 ha and above)	9	7.50
	Total	120	100.00
	Mean	4.20 ha	

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Table 5. Distribution of Post graduate students according to their parents Occupation

S. No.	Occupation	Respondents(n=120)	
		Frequency	Mother
1.	No Occupation	0	85 (70.84)
2.	Farming	43 (35.83)	13 (10.84)
3.	Service	67 (55.83)	22 (18.33)
4.	Farming+ Dairy farming	6 (5.00)	0
5.	Service + Farming	4 (3.34)	0
Total		120 (100.00)	120 (100.00)

(Figures in the parenthesis represent percentages)

Table 6.a. Distribution of the Post graduate students according to their Fathers' annual income

S. No.	Annual income	Respondents (n=120)	
		Frequency	Percentage
1.	Low (Up to ₹ 17,066/-)	5	4.16
2.	Medium (₹ 17,067/- to ₹ 5,52,216/-)	110	91.68
3.	High (₹ 5,52,217/- and above)	5	4.16
Total		120	100.00
Mean		₹ 2,84,641/-	

Table 6.b. Distribution of the Post graduate students according to their Mothers' annual income

S. No.	Annual income	Respondents (n=120)	
		Frequency	Percentage
1	Low (No income)	85	70.83
2	Medium (0.01 to ₹ 76,805/-)	25	20.84
3	High (₹ 76,806/- and above)	10	8.33
Total		120	100.00
Mean		₹ 22,983/-	

occupation and 3.34 per cent of them had farming as subsidiary occupation.

The data regarding mothers' occupation indicated that majority (70.84%) of the respondents' mothers were house wives followed by 18.33 per cent of respondents' mother had involved in service sector and 10.84 per cent of the mothers of respondents do farming.

6. Family Annual Income

It is operationally defined as the yearly income received from all the sources, of the parents of respondent students. It is shown under two subheadings i.e. Fathers' annual income and Mothers' annual income.

6.a. Fathers' annual income

The data pertaining to respondents' Fathers' annual income is given in the table 6(a)

The data from table 6(a) indicated that large majority (91.68%) of the respondents' fathers' earning between ₹ 17,067/- to ₹ 5,52,216/- which come under medium level of annual income, whereas only 4.16 per cent had low and high level of annual income i.e. up to ₹ 17,067/- and ₹ 5,52,217/- and above respectively. The average annual income of the fathers' of the respondents is ₹ 2,84,641/- This indicated that majority of respondents' fathers' has medium level of annual income i.e. between ₹ 17,065/- to ₹ 5,52,217/-. Hence it also contributed to the high aspirations of the respondent students. The findings of the present study were in conformity with the findings of Ingle *et al.* (1999) and Iswalkar (2000).

6.b. Mothers' annual income

The data from table 6(b) indicated that majority (70.83%) of the respondents' mother do not earn any income where as 20.84 per cent had medium level of annual income i.e. 0.01 to ₹ 76,805/- While only 8.33 per cent had high level of annual income i.e. ₹ 76,806/- and above.

The average annual income of the Mothers' of the respondents is ₹ 22,983/-. Hence the mothers' annual income had non-significant and also negative relationship with the aspirations of the post graduate students. The findings were similar with the study conducted by Saritha (2000).

CONCLUSION

It was observed that there was varied distribution of respondents with respect to their academic, personal and socio-psychological variables. Hence it is imperative to focus on these variations among the post graduate students while designing appropriate strategies to strengthen the selected variables of the post graduate students.

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ASSOCIATION STUDIES BETWEEN YIELD AND DROUGHT RELATED TRAITS IN MUNGBEAN (*Vigna radiata* L. Wilczek)

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ABSTRACT

An experiment was carried out to know the nature and magnitude of association among various yield and drought related traits using thirty one mungbean genotypes. Estimates of correlations revealed that seed yield had positive and significant correlation with number of pods per plant, number of clusters per plant, number of seeds per pod, days to 50% flowering, days to maturity, plant height and SLA. Whereas, seed yield showed non-significant but positive association with SCMR, RI and CSI. From the present study it is evident that improvement in seed yield and drought tolerance in green gram could be brought through selection of component characters like number of pods per plant, number of clusters per plant, number of seeds per pod, days to 50% flowering, days to maturity, plant height, SLA, SCMR, RI and CSI.

KEYWORDS: Mungbean, Correlation, Seed yield.

INTRODUCTION

Mungbean (*Vigna radiata* (L.) Wilczek) is an important pulse legume and ranks third after chickpea and pigeon pea in India. It is a cheap and rich source of vegetable protein and therefore, commonly used as a supplement to the normal diet of many people. Mungbean occupies an important position due to its high seed protein content (22 to 24%) and ability to restore the soil fertility through symbiotic nitrogen fixation. It is rich in essential amino acids specially lysine, which is deficient in most of the cereal grains. Despite of its importance, greengram production and productivity levels are low in India as this crop is mainly grown in marginal lands and are affected by various biotic and abiotic stresses. Among the stresses, drought is considered as the most important factor to reduce the productivity level. Since seed yield and drought tolerance are the most complex traits and expression of these traits largely depends upon the interplay of a number of their component traits. Being this intricacy, the direct selection is never effective for genetic enhancement and knowledge of correlation is always helpful in the short listing of desirable component traits. Correlation studies provide reliable information on nature and extent of relationship between different characters and is of great value to plant breeders as it will helps in assessing the scope of simultaneous improvement of two or more

characters at a time. Hence, the present investigation is aimed to study the correlation coefficients of a number of yield and drought related components in mungbean, in order to design the selection criteria to improve yield coupled with drought tolerance in mungbean.

MATERIAL AND METHODS

Thirty one mungbean genotypes belonging to varied geographical regions were collected and sown in a randomized block design (RBD) with three replications during *rabi*, 2013-14 at wet land farm of Sri Venkateswara Agricultural College, Tirupati. The inter and intra- row spacing adapted was 30cm x 10cm. Each genotype was sown in three rows of 3m length and observations were recorded on five randomly selected plants in each replication for characters *viz.*, plant height, number of clusters per plant, number of pods per cluster, number of pods per plant, number of seeds per pod, hundred seed weight, harvest index, SPAD Chlorophyll Meter Reading(SCMR), Relative Water Content (RWC), Relative Injury (RI), Chlorophyll Stability Index (CSI), Specific Leaf Area (SLA), chlorophyll content and seed yield per plant. However, the data for days to 50% flowering and days to maturity were recorded on plot basis. Recommended cultural practices and plant protection measures were followed to raise a healthy crop.

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Table 1. Mean performance of thirty one genotypes of mungbean for sixteen quantitative characters

Sl. No.	Genotype	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of clusters/plant	No. of pods/cluster	No. of seeds/pod	100 seed weight (g)	Harvest index (%)	SCMR	Relative water content (%)	Relative injury (%)	Chlorophyll stability index	Specific leaf area (cm ² g ⁻¹)	Chlorophyll content (mg g ⁻¹)	Seed yield/plant (g)
1.	AKM 9904	40.67	64.67	47.40	10.67	3.11	32.73	12.47	3.75	51.20	87.92	67.37	63.61	188.77	2.40	10.70
2.	Asha	39.00	63.00	48.47	7.93	3.21	25.73	11.73	3.99	52.23	84.71	38.17	52.98	140.26	2.42	8.47
3.	COGG 974	36.67	62.00	56.67	8.20	3.19	26.00	11.87	3.89	53.40	86.76	62.87	62.40	198.57	2.91	8.76
4.	EC 396117	31.00	56.67	33.93	6.20	3.48	20.07	11.07	6.34	55.57	90.39	64.79	61.29	153.14	1.68	8.35
5.	GVIT 203	36.67	63.67	57.07	9.87	3.32	33.00	11.83	3.56	51.77	84.40	60.22	58.20	182.38	2.28	10.94
6.	IPM- 02-03	32.67	57.33	43.33	8.20	3.41	27.47	12.60	4.08	54.63	88.07	54.48	61.82	123.41	2.98	9.02
7.	IPM- 02-19	33.00	57.67	47.13	6.00	3.30	20.60	11.53	4.40	51.67	87.70	51.25	61.00	194.96	2.20	7.82
8.	KM- 8-657	34.67	59.67	53.93	7.93	3.21	25.47	11.57	3.82	50.97	83.26	50.55	56.51	179.09	3.21	9.04
9.	KM 122	36.67	62.00	52.60	10.87	3.69	39.60	12.37	3.48	51.43	88.07	70.48	60.39	191.61	2.18	12.39
10.	LGG 407	36.33	61.67	46.87	10.07	3.16	31.87	12.10	3.79	50.17	86.64	85.39	71.46	183.24	2.40	9.86
11.	LGG 410	39.33	62.00	52.73	9.20	3.45	31.60	11.90	3.98	51.07	87.36	69.60	54.95	152.63	2.41	9.77
12.	LGG 450	39.67	65.67	49.20	12.00	3.87	43.53	12.80	3.61	50.17	86.60	62.40	69.04	208.84	2.28	14.02
13.	LGG 460	40.00	65.00	51.80	8.87	3.19	28.33	11.93	3.79	52.87	86.65	68.12	64.29	178.75	2.53	10.32
14.	LGG 528	36.33	62.33	57.13	9.07	3.17	28.67	12.13	3.94	53.50	81.73	64.76	55.53	163.19	3.07	9.60
15.	MGG 295	38.67	60.00	43.93	8.67	2.85	27.53	11.90	3.93	50.77	83.36	69.32	70.38	156.74	1.58	9.27
16.	MGG 347	37.33	61.67	49.27	8.40	3.43	28.80	12.43	4.01	54.77	88.74	50.53	54.50	156.61	2.55	8.80
17.	MGG 350	35.00	64.00	52.47	11.40	3.13	35.60	12.00	3.74	55.20	79.26	60.02	76.08	176.01	2.10	10.76
18.	MH-3-18	39.00	62.00	48.07	8.73	3.32	29.00	11.37	3.95	54.70	86.45	72.55	52.72	172.86	1.60	9.79
19.	MH 565	33.33	58.67	33.07	7.13	3.58	25.20	11.17	4.00	46.80	88.74	83.35	72.05	205.77	1.61	8.03
20.	ML 145	34.67	60.00	48.53	9.27	3.43	31.20	11.77	3.88	51.83	86.89	52.14	69.89	175.41	1.12	9.60
21.	ML 267	33.67	63.33	42.33	8.53	3.49	29.67	12.93	3.68	53.97	83.04	72.59	54.37	166.24	3.22	9.18
22.	PM 110	38.67	61.67	46.07	7.87	3.70	28.33	11.73	4.03	49.23	85.95	74.37	71.73	196.41	2.29	10.50
23.	PUSA 9531	36.00	62.33	53.67	9.73	3.17	30.40	11.07	3.46	41.57	85.65	56.99	38.87	184.23	2.54	9.34
24.	PUSA VISHAL	36.00	60.33	55.00	7.13	3.48	27.13	11.43	3.54	52.13	81.43	55.70	64.10	218.42	2.53	6.87
25.	RMG 492	34.33	59.67	46.33	7.67	3.80	29.20	11.63	3.60	51.20	87.44	78.19	74.35	185.52	2.27	9.88
26.	TLM 7	32.33	58.00	41.40	7.93	3.44	27.00	11.40	4.24	49.67	81.44	87.57	71.14	185.57	1.77	10.09
27.	TM 96-2	37.67	59.33	49.80	10.60	3.02	32.00	12.13	4.17	53.07	84.73	56.60	60.91	188.27	1.97	10.93
28.	VG-6197A	34.67	59.67	49.67	8.47	3.85	30.20	12.43	4.09	48.70	83.74	83.54	67.49	198.01	2.12	10.02
29.	VG-7098A	32.67	58.67	44.87	7.00	3.47	24.27	11.00	3.83	48.13	85.15	70.31	69.81	177.73	1.89	7.89
30.	WGG 2	35.67	66.67	54.07	7.93	3.24	25.53	12.63	3.89	55.83	92.21	73.47	66.89	171.50	2.49	7.78
31.	WGG 37	36.67	63.67	52.20	8.47	3.78	31.93	12.20	3.95	50.97	79.11	65.95	75.15	203.86	2.49	9.81
General Mean		36.10	61.39	48.68	8.71	3.39	29.28	11.91	3.95	51.71	85.60	65.60	63.35	179.29	2.29	9.60
S.Ed.		0.90	1.19	3.46	0.88	0.25	2.65	0.49	0.22	2.01	2.43	4.88	4.38	12.52	0.19	0.91
CD at 5%		1.80	2.39	6.94	1.76	0.49	5.32	0.98	0.44	4.02	4.87	9.78	8.78	25.11	0.37	1.82
CD at 1%		2.39	3.17	9.21	2.33	0.65	7.06	1.30	0.58	5.34	6.46	12.97	11.65	33.31	0.49	2.42
C.V.(%)		3.05	2.38	8.71	12.31	8.86	11.10	5.05	6.80	4.75	3.47	9.10	8.47	8.55	9.91	11.58

Table 2. Phenotypic (r_p) and genotypic (r_g) correlation coefficients among sixteen characters in thirty one genotypes of greengram

Character	Days to maturity	Plant height (cm)	No. of clusters/plant	No. of pods/cluster	No. of seeds/pod	No. of pods/plant	100 seed weight (g)	Harvest index (%)	Relative water content (%)	Specific leaf area (cm ² g ⁻¹)	SCMR	Relative injury (%)	Chlorophyll Stability Index	Chlorophyll II content	Seed yield/plant (g)
Days to 50% Flowering	r_g	0.6857**	0.5376**	0.6348**	-0.2941**	0.4751**	-0.4617**	-0.1868	0.0124	0.0669	0.0471	-0.151	-0.1954	0.0951	0.5563**
	r_p	0.6722**	0.4539**	0.5452**	-0.2131*	0.3164**	-0.4159**	-0.1744	-0.0031	0.0751	0.0101	-0.1345	-0.1656	0.0925	0.4542**
Days to maturity	r_g	0.6784**	0.7236**	0.795**	-0.1693	0.6339**	-0.553**	-0.2077	-0.0854	0.1385	0.3047**	-0.0423	-0.1004	0.3436**	0.5261**
	r_p	0.5543**	0.5797**	0.5201**	-0.0839	0.5469**	-0.5094**	-0.1967	-0.0455	0.1293	0.2456*	-0.0321	-0.0827	0.3218**	0.4006**
Plant height (cm)	r_g	0.4635**	0.4635**	0.4149**	-0.2431*	0.4329**	-0.628**	-0.4213**	-0.282**	0.2336*	0.099	-0.3868**	-0.3078**	0.509**	0.2476*
	r_p	0.3944**	0.3944**	0.2458*	-0.1965	0.3585**	-0.5588**	-0.3619**	-0.2818**	0.1758	0.1191	-0.3447**	-0.2783**	0.4553**	0.1888
No. of Clusters/plant	r_g	0.6454**	0.6454**	0.6454**	-0.1386	0.9578**	-0.5488**	0.0345	-0.1313	0.1127	0.2124*	-0.0459	-0.0206	0.0476	0.9035**
	r_p	0.5082**	0.5082**	0.5082**	-0.1299	0.9139**	-0.4782**	0.0274	-0.1703	0.1058	0.1561	-0.0127	-0.0218	0.0313	0.8238**
No. of Pods/ cluster	r_g	0.186	0.186	0.186	0.186	0.272**	0.0761	-0.036	0.0922	0.544**	-0.607**	0.4255**	0.4049**	-0.0884	0.329**
	r_p	0.1103	0.1103	0.1103	0.1103	0.244*	0.0158	0.0011	0.0565	0.3579**	-0.3625**	-0.3083**	0.3045**	-0.0651	0.2342*
No. of Seeds/ pod	r_g	0.7097**	0.7097**	0.7097**	0.1422	0.7097**	-0.3908**	0.1422	-0.0055	-0.2605*	0.5492**	0.061	0.0631	0.6479**	0.5793**
	r_p	0.5372**	0.5372**	0.5372**	0.1265	0.5372**	-0.2909**	0.1265	0.0351	-0.1193	0.3175**	0.0068	0.0694	0.4318**	0.4393**
No. of Pods/ plant	r_g	-0.5856**	-0.5856**	-0.5856**	-0.0286	-0.5856**	-0.0286	-0.0286	-0.1503	0.2943**	-0.0981	0.0595	0.0863	0.0118	0.9455**
	r_p	-0.5389**	-0.5389**	-0.5389**	-0.0051	-0.5389**	-0.0051	-0.0051	-0.189	0.2614*	-0.0401	0.0756	0.102	0.0118	0.8708**
100 seed weight (g)	r_g	0.3077**	0.3077**	0.3077**	0.072	0.3077**	0.072	0.072	0.3077**	-0.3374**	0.3951**	-0.0272	0.0213	-0.3159**	-0.3644**
	r_p	0.2791**	0.2791**	0.2791**	0.0557	0.2791**	0.0557	0.0557	0.2791**	-0.2995**	0.2878**	-0.0067	0.024	-0.2901**	-0.2723**
Harvest index (%)	r_g	-0.1431	-0.1431	-0.1431	-0.1689	-0.1431	-0.1689	-0.1689	-0.1431	-0.1869	0.0681	0.4977**	0.274**	0.0485	0.2153*
	r_p	0.0578	0.0578	0.0578	0.0578	0.0578	0.0578	0.0578	0.0578	-0.1267	0.0578	0.4222**	0.2465*	0.0359	0.2734**
Relative water content (%)	r_g	-0.2839**	-0.2839**	-0.2839**	0.0733	-0.2839**	0.0733	0.0733	-0.1628	0.4447**	0.4447**	0.0733	-0.1628	-0.1767	-0.1006
	r_p	-0.207*	-0.207*	-0.207*	0.0488	-0.207*	0.0488	0.0488	-0.1491	-0.207*	0.2567*	0.0488	-0.1491	-0.1432	-0.1041
Specific leaf area (cm ² g ⁻¹)	r_g	-0.6382**	-0.6382**	-0.6382**	0.378**	-0.6382**	0.378**	0.378**	-0.6382**	-0.6382**	-0.6382**	0.3007**	0.3548**	-0.1211	0.2462*
	r_p	-0.607**	-0.607**	-0.607**	0.3007**	-0.607**	0.3007**	0.3007**	0.3007**	-0.607**	-0.607**	0.3007**	0.3548**	-0.1247	0.2027
SCMR	r_g	-0.4312**	-0.4312**	-0.4312**	-0.2983**	-0.4312**	-0.2983**	-0.2983**	-0.4312**	-0.4312**	-0.4312**	-0.4312**	-0.4699**	0.2089*	0.0601
	r_p	-0.2983**	-0.2983**	-0.2983**	-0.3439**	-0.2983**	-0.3439**	-0.3439**	-0.2983**	-0.2983**	-0.2983**	-0.2983**	-0.3439**	0.2006	0.0552
Relative injury (%)	r_g	0.5037**	0.5037**	0.5037**	0.1443	0.5037**	0.1443	0.1443	0.5037**	0.5037**	0.5037**	0.5037**	0.5037**	-0.2603*	0.1443
	r_p	0.4586**	0.4586**	0.4586**	0.1552	0.4586**	0.1552	0.1552	0.4586**	0.4586**	0.4586**	0.4586**	0.4586**	-0.2294*	0.1552
Chlorophyll Stability Index	r_g	-0.4264**	-0.4264**	-0.4264**	0.1303	-0.4264**	0.1303	0.1303	-0.4264**	-0.4264**	-0.4264**	-0.4264**	-0.4264**	-0.4264**	0.1303
	r_p	-0.3813**	-0.3813**	-0.3813**	0.1278	-0.3813**	0.1278	0.1278	-0.3813**	-0.3813**	-0.3813**	-0.3813**	-0.3813**	-0.3813**	0.1278
Chlorophyll content	r_g	-0.0734	-0.0734	-0.0734	-0.0691	-0.0734	-0.0691	-0.0691	-0.0734	-0.0734	-0.0734	-0.0734	-0.0734	-0.0734	-0.0734
	r_p	-0.0691	-0.0691	-0.0691	-0.0691	-0.0691	-0.0691	-0.0691	-0.0691	-0.0691	-0.0691	-0.0691	-0.0691	-0.0691	-0.0691

Genotypic and phenotypic correlations were calculated as per the procedure described by Johnson *et al.*, (1955).

RESULTS AND DISCUSSION

The results based on analysis of variance revealed that the genotypes differed significantly for all the characters indicating the existence of considerable amount of variation among the genotypes studied. Based on mean performance, the genotypes LGG 450, KM 122, GIVT 203, TM 96-2 and MGG 350 showed superior performance for yield and yield contributing traits (Table 1). For drought tolerance parameters, the genotypes WGG 2, MGG 347, EC 396117, MGG 350 and Asha showed better performance (Table 1). The phenotypic and genotypic correlation coefficients between all pairs of characters were presented in Table 2. Genetic correlation between different characters of plant could arise because of linkage, pleiotropy or developmentally induced functional relationships. For a rational approach towards the improvement of yield and drought tolerance, selection has to be made for their components traits since both of these traits are complex in nature. The genotypic correlations were greater than the corresponding phenotypic correlations in all most all the cases, indicating the preponderance of genetic variance in expression of different characters (Table 2). Seed yield per plant possessed highly significant positive correlation with number of pods per plant, number of clusters per plant and number of seeds per pod. This indicates that selection based on these characters may result in improved yield. Similar kind of results were also reported by Narasimhulu *et al.*, (2013), Srikanth *et al.*, (2013) and Singh and Kumar (2014). Seed yield per plant also showed significant positive correlation with days to 50% flowering, days to maturity, pods per cluster, plant height and SLA. Whereas, seed yield showed non-significant but positive association with SCMR, RI and CSI. On contrary, seed yield per plant exhibited non-significant negative correlation with relative water content and chlorophyll content. Similar results were also reported by Hossain *et al.*, (2010) and Swathi (2013) for RWC.

The inter-se correlations among yield and drought related traits revealed that, days to 50% flowering showed positive association with days to maturity, plant height, clusters per plant, seeds per pod and pods per plant. Similarly, days to maturity with plant height, clusters per plant, seeds per pod, pods per plant, SCMR and chlorophyll content; plant height with clusters per plant,

seeds per pod and pods per plant; clusters per plant with seeds per pod and pods per plant; pods per cluster with SLA, RI and CSI; seeds per pod with pods per plant, SCMR and chlorophyll content; pods per plant with SLA; 100 seed weight with RWC and SCMR; harvest index with RI and CSI; SLA with RI and CSI and RI with CSI, showed positive and significant association suggesting the interdependency of these characters on each other.

Days to 50% flowering had positive and significant association with days to maturity at both genotypic and phenotypic levels which is of an important component in identifying and deciding the duration of the crop. Thus, it indicated that flowering time was an important indicator of maturity. Both these traits *i.e.* days to 50% flowering and days to maturity were also found to have positive and significant correlations with plant height, clusters per plant, seeds per pod and pods per plant and negative associations with number of pods per cluster. These results are in accordance with the earlier findings of Sirohi *et al.*, (2007) and Singh and Kumar (2014).

In case of drought related traits, RWC showed significant positive association with SCMR and negative association with SLA. Similarly, SCMR also showed negative association with SLA. SLA showed significant positive association with RI and CSI and negative association with SCMR and chlorophyll content. Similar results were also observed by Swathi (2013). Hence, for selecting drought tolerant genotypes the traits *viz.*, RWC, SLA, SCMR and CSI may be effective.

In conclusion, from the present study it is evident that improvement in seed yield and drought tolerance in green gram could be brought through selection of component characters like number of pods per plant, number of clusters per plant, number of seeds per pod, days to 50% flowering, days to maturity, plant height, SLA, SCMR, RI and CSI.

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SOIL-SITE SUITABILITY EVALUATION FOR THE MAJOR CROPS GROWN IN PAKALA MANDAL OF CHITTOOR DISTRICT, ANDHRA PRADESH

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ABSTRACT

A Survey was undertaken in Pakala mandal of Chittoor district to evaluate the suitability of soils for rice, groundnut, sorghum, pigeonpea and sugarcane crops. These soils were classified as to Entisols and Inceptisols. Pedons 1 and 6 (Typic Ustorthent), showed organic carbon and shallow depth as major limitations. Organic carbon and pH are the major limitations in pedon 3 (Typic Haplustept). Pedons 4, 5 and 7 (Typic Haplustept) exhibited organic carbon and poor nutrient status were the major limitation whereas pedon 2 (Typic Ustifluvents) had texture, erosion and organic carbon as major limitations. The limitation levels of the land characteristics varied from crop to crop. The soil-suitability classes can be improved if the correctable limitations were altered through soil amelioration measures. On the basis of soil potentials and constraints, suitable management practices were suggested to achieve sustainable yields in crops grown on these soils.

KEY WORDS: Crop suitability, Land Evaluation, Limitations, Potentials.

INTRODUCTION

The performance of any crop was largely dependent on soil parameters (depth, texture, drainage *etc.*) as conditioned by climate and topography. Soil-site characterization for predicting the crop performance of an area forms land evaluation. The yield influencing factors for important crops have to be evaluated and the results obtained may be applied for higher production of these crops through proper utilization of similar soils occurred elsewhere in the same agro-climatic sub-region under scientific management practices (Khadse and Gaikwad, 1995). Studies on soil-site suitability evaluation is not available for crops in Pakala mandal, in particular and Chittoor district of Andhra Pradesh, in general. Hence, an attempt has been made to evaluate the soil suitability for five major crops *viz.*, rice, groundnut, sorghum, redgram and sugarcane grown on Entisols and Inceptisols in Pakala mandal of Chittoor district in Andhra Pradesh.

MATERIAL AND METHODS

Study area

The study area comprising of 26,786 ha lies in between 13°27' and 13.46' North latitudes and 79°07' and 79°12' East longitudes with an altitude ranging from 320 to 461m. The soils have been developed from granite-gneiss parent material. The area qualifies for semi-arid

monsoonic climate with distinct summer, winter and rainy seasons. The area experienced mean annual precipitation recorded for the last ten (2005-2014) years was 990.35 mm. The mean annual temperature was 28.54°C with mean summer temperature 33.92°C and the mean winter temperature of 23.12°C. The soil moisture regime has been computed as ustic regime as isohyperthermic (Soil Survey Staff, 1999). The natural vegetation comprises of *Parthenium hysterophorus*, *Calotropis gigantia*, *Tridax procumbens*, *Croton* species, *Pongamia pinnata*, *Lantana camera*, *Cyprus rotundus*, *Prosopis julifera*, *Achyranthus* species, *Cynodon dactylon*, *Azadiracta indica*, *Acacia nelotica*, *Tephrosia purpurea* *etc.*,

Methodology

Seven typical pedons were studied on different landforms (plains and uplands) for their morphological characteristics following the procedure given by Soil Survey Staff (1951). Horizon-wise soil samples were collected from the typifying pedons and analyzed for their physical, physico-chemical and chemical properties following the standard procedures (Table 2). Soils were classified according to keys to Soil Taxonomy (Soil Survey Staff, 2014). These pedons were selected for evaluation and their suitability assessed using limitation method regarding number and intensity of limitations (Sys *et al.*, 1991).

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Soil-site suitability evaluation for major crops

The land scape and soil requirements for these crops (Sys *et al.*, 1991) were matched with generated data at different limitation levels: no (0), slight (1), moderate (2), severe (3) and very severe (4). The number and degrees of limitations suggested the suitability of class of each soil for a particular crop (Sys *et al.*, 1991). The potential land suitability (Table 3) sub-classes were determined after considering the improvement measures to correct these limitations (Sys *et al.*, 1993). The present suitability classes can be improved if the correctable limitations such as pH, organic carbon and fertility status are corrected / altered through soil amelioration measures.

RESULTS AND DISCUSSION

Soil characteristics were given in table 1 and the site and weighted means of soil characteristics were given in table 2. These soils were developed from granite-gneiss parent material. The kind and degree of limitations for the five commonly growing crops were presented in table 3. Soils with more than four slight limitations, and / or with more than three moderate limitations were grouped under moderately suitability class (S2); the soil with more than three moderate limitations, and / or one or more severe limitation (s) was grouped under marginally suitability (S3) class; the soils with very severe limitations which can be corrected was categorized as N1 (temporarily not suitable); the soils with very severe limitations which cannot be corrected grouped under unsuitable class N2 (Sys *et al.*, 1991). This method also identifies the dominant limitation that restricts the crop growth in the sub-class symbol such as climatic (c), topographic (t), wetness (w), physical soil characteristics (s), soil fertility (f) and soil salinity / alkalinity (n). The suitability classes and sub-classes were decided by the most limiting soil characteristics. The soils vary in their suitability for different crops according to the criteria for the determination of the land suitability classes (Table 3).

Pedons 1 and 6 were grouped under Typic Ustorthents. Pedon 1 was highly suitable (S1) for rice and sorghum, moderately suitable (S2) for sugarcane and marginally suitable (S3) for groundnut and pigeonpea. Pedon 6 was highly suitable (S1) for rice, groundnut and sugarcane, moderately suitable (S2) for sorghum and marginally suitable (S3) for pigeonpea. (Table 4). Soil fertility characteristics *viz.*, pH and organic carbon and soil physical characteristics like texture, improper drainage and shallow depth were the moderate limitations for all five crops in both the pedons. Further, erosion is the major limiting factors for growing of all these crops in pedon 1.

Soil pH (slightly alkalinity) can be corrected by application of organic manures and application of suitable amendments. Organic carbon in these soils can be improved by the application of farm yard manure and green manuring and inclusion of legumes in rotation. Shallow depth in these soils can be increased by adopting ploughing or breaking up of soil, texture can be improved by addition of tank silt year after year and erosion can be controlled by suitable soil and water conservation practices. Kumar and Naidu (2012) reported that Typic Ustorthents were marginally suitable for growing rice crop in Vadamalapeta mandal of Chittoor district in Andhra Pradesh.

Pedons 3, 4, 5 and 7 were grouped under Typic Haplustepts. Pedons 3 and 4 were highly suitable (S1) for sorghum and sugarcane, moderately suitable (S2) for groundnut. Pedon 4 was moderately suitable (S2) for rice and pigeonpea. Pedons 5 and 7 were moderately suitable (S2) for sugarcane, where as pedon 5 was moderately suitable (S2) and pedon 7 was highly suitable (S1) for growing of sorghum crop. Pedon 7 was highly suitable (S1) and pedon 5 was moderately suitable (S2) for growing of rice, groundnut and pigeonpea crops. Pedon 3 was marginally suitable (S3) for crops like rice and pigeonpea (Table 4).

Soil Physico-chemical characteristics *viz.*, pH and organic carbon and soil physical characteristics like texture were the moderate limitations (Pedons 3, 4, 5 and 7) for all five crops. Besides these, depth and improper drainage were major limitations for growing of pigeon pea in all the pedons. Erosion is the major limitation for pedons 4 and 7 for all five crops. Organic carbon in these soils can be improved by the application of farm yard manure, green manuring and inclusion of legumes in rotation. Shallow depth in these soils can be increased adopting deep ploughing or breaking up of soil and erosion can be controlled by practicing conservations techniques. Texture can be improved by addition of tank silt year after year in these soils. These results were in accordance with the findings of Sekhar *et al.*, (2014). Leelavathi *et al.* (2010) reported that Typic Haplustepts were marginally suitable (S3) for growing paddy crop in Yerpedu mandal of Chittoor district in Andhra Pradesh.

Pedon 2 which is grouped under Typic Ustifluvents was highly suitable (S1) for sorghum, moderately suitable (S2) for rice, groundnut and pigeonpea and marginally suitable (S3) for sugarcane (Table 4). These soils showed

Table 1. Landscape characteristics of pedons

Pedons	Villages	Location	Elevation above mean sea level (m)	Physiography	Slope	Drainage	Parent material
P1	Srinivasapuram	13°26'46.7" N 79°09'30.4" E	361	Upland	3-5%	Moderately well drained	Weathered gneiss
P2	Adannapalli	13°26'50.0" N 79°09'39.2" E	357	Upland	3-5%	Moderately well drained	Weathered gneiss
P3	Suryanarayanapalli	13°27'42.9" N 79°06'13.2" E	389	Plain	0-1%	Moderately well drained	Weathered gneiss
P4	Maddinayanapalli	13°30'40.3" N 79°07'54.3" E	459	Upland	3-5%	Moderately well drained	Weathered gneiss
P5	Kavetigaripalli	13°30'42.2" N 79°07'45.8" E	461	Plain	0-1%	Moderately well drained	Weathered gneiss
P6	Sankampalli	13°26'45.1" N 79°07'07.2" E	360	Upland	1-3%	Somewhat poorly drained	Weathered gneiss
P7	Nantragunta	13°26'45.1" N 79°07'07.2" E	320	Upland	3-5%	Moderately well drained	Weathered gneiss

Table 2. Depth wise soil characteristics used in assessing crop suitability

Pedon No.	Location	Horizon	Depth (m)	Soil physical characteristics (s)				Fertility characteristics (f)						Salinity and alkalinity (n)	
				Texture				CEC [cmol (p+) kg ⁻¹ soil]	Sum of basic cations [cmol (p+) kg ⁻¹ soil]	BSP	pH (1:2.5 H ₂ O)	OC (%)	EC (dSm ⁻¹)	ESP	
				Sand (2-0.05%)	Silt (0.05 - 0.002)	Clay (<0.002)	CaCO ₃ (%)								
— % of <2 mm soil —															
1	Srinivasapuram	Ap	0.00-0.20	52.40	22.30	25.30	14.50	10.40	5.55	53.46	7.70	0.64	0.10	0.09	
		A1	0.20-0.39	53.25	20.63	26.12	17.00	10.24	5.43	53.32	7.74	0.48	0.09	0.29	
		A2	0.39-0.50	90.10	5.75	4.15	11.00	8.48	4.31	51.06	7.47	0.17	0.04	0.24	
		Cr	0.50+	Weathered gnesis mixed with lime											
2	Adannapalli	Ap	0.00-0.20	53.35	20.33	26.32	14.00	9.54	6.23	65.72	7.47	0.57	0.16	0.42	
		A1	0.20-0.37	52.10	19.95	27.95	13.00	9.67	5.30	55.43	7.69	0.46	0.15	0.62	
		A2	0.37-0.67	53.55	20.23	26.22	15.50	9.26	5.32	57.99	7.80	0.37	0.05	0.54	
		A3	0.67-0.89	50.30	21.35	28.35	13.50	9.87	6.49	65.96	7.72	0.39	0.05	0.20	
		2A4	0.89-1.17	90.00	6.30	3.70	6.00	6.50	3.81	59.53	7.54	0.16	0.16	0.92	
		2A5	1.17-1.50	92.50	5.00	2.50	6.50	4.60	2.88	62.83	7.43	0.14	0.15	0.22	
		Cr	1.50+	Weathered gnesis											
3	Suryanarayanapalli	Ap	0.00-0.18	55.40	19.30	25.30	7.50	15.22	10.75	70.83	7.37	0.52	0.10	0.19	
		Bw1	0.18-0.48	53.60	19.80	26.60	9.50	17.94	11.57	64.54	7.39	0.47	0.12	0.06	
		Bw2	0.48-0.77	40.00	28.00	32.00	13.20	18.80	13.13	70.05	7.61	0.40	0.11	0.21	
		Bw3	0.77-1.10	36.00	28.00	36.00	12.90	16.30	11.47	70.49	7.56	0.35	0.12	0.12	
		Cr	1.10+	Weathered gnesis											

Cont...

Table 2. Cont...

Pedon No.	Location	Horizon	Depth (m)	Soil physical characteristics (s)			Fertility characteristics (f)						Salinity and alkalinity (n)		
				Texture			CaCO ₃ (%)	CEC [cmol (p+) kg ⁻¹ soil]	Sum of basic cations [cmol (p+) kg ⁻¹ soil]	BSP	pH (1:2.5 H ₂ O)	OC (%)	EC (dSm ⁻¹)	ESP	
				Sand (2-0.05%)	Silt (0.05 - 0.002)	Clay (<0.002)									
— % of <2 mm soil —															
4	Maddinayanapalli	Ap	0.00-0.16	54.00	16.50	29.50	7.40	12.52	9.76	78.27	7.30	0.54	0.15	0.32	
		Bw1	0.16-0.37	52.90	20.70	26.40	8.80	10.70	8.24	77.57	7.52	0.50	0.17	0.09	
		Bw2	0.37-0.68	50.70	22.65	26.65	6.20	10.22	7.53	77.10	7.56	0.49	0.12	0.49	
		Bw3	0.68-0.97	49.40	23.30	27.30	4.90	9.80	7.41	75.82	7.50	0.25	0.11	0.20	
		Bw4	0.97-1.53	51.80	23.10	25.10	3.10	7.33	5.52	75.57	7.40	0.15	0.10	0.27	
		Cr	1.53+	Weathered gneiss											
5	Kavetigaripalli	Ap	0.00-0.20	54.80	23.40	21.80	3.20	9.50	6.65	70.11	7.75	0.62	0.11	0.11	
		Bw1	0.20-0.43	53.00	21.90	25.10	8.00	9.20	6.82	74.35	7.72	0.50	0.11	0.22	
		Bw2	0.43-0.66	49.50	24.25	26.25	9.50	9.13	7.19	78.86	7.31	0.47	0.12	0.11	
		Bw3	0.66-0.94	48.00	26.50	25.50	3.50	8.41	6.27	75.03	7.48	0.38	0.17	0.48	
		Bw4	0.94-1.10+	50.20	27.40	22.40	4.50	7.41	5.46	73.95	7.43	0.14	0.12	0.27	
6	Sankampalli	Ap	0.00-0.16	39.15	26.43	34.42	12.00	10.30	7.32	71.26	7.45	0.65	0.13	0.19	
		A1	0.16-0.35	28.70	38.65	32.65	13.50	10.60	6.97	65.85	7.32	0.53	0.15	0.09	
		A2	0.35-0.50	91.50	5.25	3.25	6.50	8.80	4.89	55.68	7.70	0.23	0.13	0.11	
		Cr	0.50+	Weathered gneiss											
		Ap	0.00-0.17	49.50	24.25	26.25	7.00	11.80	7.94	68.05	7.40	0.66	0.14	0.76	
7	Nantragunta	Bw1	0.17-0.35	51.50	21.25	27.25	7.50	21.60	14.93	50.27	6.67	0.63	0.98	0.32	
		Bw2	0.35-0.70	17.10	48.50	34.40	5.50	15.00	11.37	73.60	6.71	0.58	0.14	0.53	
		Bw3	0.70-0.85	18.20	48.40	33.40	12.00	16.20	11.94	67.65	7.65	0.45	0.15	0.12	
		Bw4	0.85-1.20	19.60	47.80	32.60	10.50	21.00	16.50	50.29	7.83	0.37	0.73	0.43	
		Cr	1.20+	Weathered gneiss mixed with feldspars											

Table 3. Limitation levels of the land characteristics and land suitability classes

Soil	Crop	Wetness (w)			Soil Physical characteristics (s)			Soil fertility characteristics (f)				Alkalinity (n)		Actual land suitability sub-class	Potential land suitability sub-class
		drainage	Texture	Coarse fragments (Vol. %)	Soil depth (cm)	CaCO ₃ (%)	Sum of basic cations (p+) kg ⁻¹ soil	pH 1:2.5	OC (%)	Esp	(n)				
Typic Ustorthents	Rice	1	2	0	2	2	0	1	2	0	0	0	S1wsf	S2s	
	Ground nut	1	0	0	3	1	0	2	2	0	0	0	S3wsf	S3s	
	Sugar cane	1	1	0	2	1	0	2	1	0	0	0	S2wsf	S2s	
	Sorghum	1	1	0	1	0	0	1	1	0	0	0	S1wsf	S1	
Typic Ustifluvents	Pigeon pea	2	1	0	3	1	0	2	2	0	0	0	S3wsf	S3ws	
	Rice	1	2	0	0	2	0	1	2	0	0	0	S2wsf	S2ws	
	Ground nut	1	0	0	0	1	0	1	2	0	0	0	S2wf	S1	
	Sugar cane	0	1	0	0	1	0	2	3	0	0	0	S3sf	S1s	
Typic Haplustepts	Sorghum	1	1	0	0	0	0	1	1	0	0	0	S1sf	S1s	
	Pigeon pea	2	1	0	1	1	0	2	2	0	0	0	S2wsf	S2ws	
	Rice	1	0	0	1	2	0	1	3	0	0	0	S3wsf	S2s	
	Ground nut	1	0	0	1	0	0	1	2	0	0	0	S2wsf	S1	
Typic Haplustepts	Sugar cane	1	1	0	1	0	0	1	1	0	0	0	S1ws	S1	
	Sorghum	1	1	0	1	0	0	1	1	0	0	0	S1ws	S1	
	Pigeon pea	2	1	0	3	0	0	1	2	0	0	0	S3wsf	S3ws	
	Rice	1	2	0	0	2	0	1	2	0	0	0	S2wsf	S2s	
Typic Haplustepts	Ground nut	1	0	0	0	0	0	2	2	0	0	0	S2wf	S1	
	Sugar cane	1	1	0	1	0	0	1	2	0	0	0	S2wsf	S1s	
	Sorghum	1	1	0	0	0	0	1	1	0	0	0	S1wsf	S1	
	Pigeon pea	2	1	0	0	0	0	1	1	0	0	0	S1ws	S1	
Typic Ustorthents	Rice	2	1	0	1	0	0	1	2	0	0	0	S2wf	S1w	
	Ground nut	1	2	0	0	1	0	1	2	0	0	0	S2wsf	S2s	
	Sugar cane	1	1	0	0	0	0	2	2	0	0	0	S2wf	S1	
	Sorghum	1	1	0	1	0	0	2	1	0	0	0	S2wsf	S1s	
Typic Haplustepts	Pigeon pea	1	1	0	0	0	0	1	1	0	0	0	S1wsf	S1s	
	Rice	2	1	0	1	0	0	2	2	0	0	0	S2wsf	S1ws	
	Ground nut	0	1	0	2	1	0	1	2	0	0	0	S2sf	S2s	
	Sugar cane	0	1	0	2	0	0	2	2	0	0	0	S2sf	S2s	
Typic Haplustepts	Sorghum	0	0	0	1	0	0	1	1	0	0	0	S1sf	S1s	
	Pigeon pea	1	1	0	3	0	0	1	2	0	0	0	S3wsf	S3s	
	Rice	1	2	0	0	1	0	1	2	0	0	0	S2sf	S2s	
	Ground nut	1	0	0	0	0	0	1	2	0	0	0	S2wsf	S1	
Typic Haplustepts	Sugar cane	1	1	0	1	0	0	1	1	0	0	0	S1ws	S1s	
	Sorghum	1	1	0	0	0	0	1	1	0	0	0	S1ws	S1s	
	Pigeon pea	2	1	0	1	0	0	1	2	0	0	0	S2wsf	S1ws	
	Rice	2	1	0	1	0	0	1	2	0	0	0	S2wsf	S1ws	

Table 4. Soil-site suitability for growing major crops

Pedon/Village	Crops				
	Rice	Groundnut	Pigeonpea	Sorghum	Sugarcane
P1 / Srinivasapuram	S1	S3	S3	S1	S2
P2 / Adannapalli	S2	S2	S2	S1	S3
P3 / Suryanarayanapalli	S3	S2	S3	S1	S1
P4 / Maddinayanapalli	S2	S2	S2	S1	S1
P5 / Kavetigaripalli	S2	S2	S2	S1	S2
P6 / Sankampalli	S1	S1	S3	S2	S1
P7 / Nantragunta	S2	S2	S2	S1	S1

S1: Very suitable, S2: Moderately suitable, S3: arginally suitable.

limitations *viz.*, Soil physical characteristics (texture and drainage), soil physic-chemical characteristics (organic carbon). The texture can be improved by mixing with tank silt year after year. So the organic carbon status in these soils can be improved by the application of farm yard manure, green manuring and inclusion of legumes in rotation. Selvaraj and Naidu (2013) stated that Typic Ustifluvents were moderately (S2) suitable for rice and groundnut crops in Renigunta mandal of Chittoor district in Andhra Pradesh.

CONCLUSION

The soil-site suitability for different crops like rice, groundnut, sorghum, pigeon pea and sugarcane revealed that all the pedons (1, 2, 3, 4, 5, 6 and 7) exhibited low organic carbon as a severe limitation. Shallow depth was a major limitation for pedons 1 and 6, Erosion is moderate limitation for pedons 1, 2, 4 and 7 whereas texture was a moderate limitation for growing rice crop in pedon 1, 2, 3 and 4. pH is a slight limitation in all pedons. Organic carbon status in these soils can be improved by the application of farm yard manure, green manuring and inclusion of legumes in rotation and pH can be controlled by application of organic manures and suitable amendments. Soil texture can be improved by mixing with tank silt year after year. Shallow depth in these soils can be improved by deepening of soil. Erosion can be controlled by adopting suitable conservation techniques. By correcting the above limitations sustainable yields can

be achieved in rice, groundnut, sorghum, pigeonpea and sugarcane crops. Hence, green manuring, addition of crop residues and organic manures in combination with chemical fertilizers in balanced form not only helps to achieve sustainable yields of crops but also sustains the soil health.

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MASS CULTURING OF CIGARETTE BEETLE, *Lasioderma serricorne*

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ABSTRACT

The cigarette beetle, *Lasioderma serricorne* (Fabricius) is an omnivorous insect pest that feeds and breeds successfully on a variety of processed food commodities in storage. Development of the cigarette beetle is influenced greatly by the diet and the ability of the insect to utilize the diet. An experiment was conducted at Post Harvest Technology Centre, Bapatla to identify an effective and cheaper culture medium for rearing of cigarette beetle to ensure regular supply of different stages of test insect for conducting various experiments in the laboratory. Wheat and maize were used as base food material in combination with yeast and/or vitamin supplements. Both maize and wheat in combination with yeast + B- complex, resulted in higher number of adult emergence (1076.3 and 1026.3 respectively) when compared to wheat alone or maize alone as culture media indicating that maize or wheat in combination with yeast and vitamin mix can be used as food source for getting good supply of different stages of cigarette beetle.

KEYWORDS: Cigarette beetle, culture media, wheat, maize

INTRODUCTION

The cigarette beetle, *Lasioderma serricorne* (Fabricius) (Coleoptera: Anobiidae) is ubiquitous of all stored-product insect pests as it occurs throughout the tropical and subtropical regions and in warm storage godowns of the temperate regions. It is known to feed and breed successfully on a variety of commodities during storage, processing and at the retail level. In addition to tobacco, these beetles infest various products such as castor beans (Chatterjee, 1963), coconut meal, mushrooms, pet feed (Gahukar, 1975), ginger, dried yeast, chilli powder, red pepper, paprika, turmeric (Ashworth, 1993), herbarium, insect museum, book binding (Kawamura, 2000), chocolates (Begum *et al.*, 2007), dried bee pollen (Julio *et al.*, 2013), cayenne pepper, opium and even pyrethrum powder (Mahroof and Phillips, 2015). Larval feeding causes most of the damage to stored commodities, while adults are known to cause damage by making holes to packages (Highland, 1991). Development of the cigarette beetle is influenced greatly by the diet and the ability of the insect to utilize the diet. Completion of the life cycle of *L. serricorne* required typically 18–20 d longer in tobacco (55 d) than in yeast (36 d) under similar conditions (Powell, 1931). Based on the time required for development and fresh body weights of cigarette beetles, Lecato, (1978) reported that cayenne pepper and paprika were the most favorable diets among the different spices tested.

For conducting various experiments on such an important omnivorous insect pest in laboratory, ensuring regular supply of different stages of test insect is very important. Imai and Harada (2009) maintained the cigarette beetle culture on yeast (10%) added corn flour while, Krishna and Bhargava (2009) mass cultured *L. serricorne* on a mixture of wheat flour and turmeric powder (4:1) to get a regular supply of different developmental stages of test insect for experiments. Chun (2008) reared cigarette beetle on the poultry diet composed ground corn and soybean meal. Thus, several researchers cultured cigarette beetles on various food sources. In view of this, an experiment was conducted at Post Harvest Technology Centre, Bapatla to identify an effective and cheaper culture medium for rearing of cigarette beetle.

MATERIALS AND METHODS

Wheat and maize were used as base food material in this experiment in combination with yeast and/or vitamin supplements. Wheat and maize grains were obtained from the market and disinfested by fumigation with Aluminium phosphide (celphos 3 g) tablets @ 1 per half quintal for seven days to eliminate existing infestation, if any. Later, the grains were milled to make suji and their moisture content before the experiment was determined by gravimetric method. The sample was prepared in triplicate portions of 30 g and was oven-dried at 70°C. After

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achieving constant weight *i.e.*, ensuring that there is no moisture retained in the sample, the moisture content (w/w) was determined and found to be 14.23 per cent in wheat and 14.16 per cent in maize. Yeast was procured from the commercial bakery while B-complex vitamin capsules (Becosules^R) were obtained from local pharmacy. Different compositions of media *viz.*; wheat alone, wheat + yeast (5%), wheat + B-complex vitamin powder (60 µg/kg), wheat + yeast (5%) + B-complex vitamin powder (60 µg/kg), maize alone, maize + yeast (5%), maize + B-complex vitamin powder (60 µg/kg) and maize + yeast (5%) + B-complex vitamin powder (60 µg/kg) were tested for rearing cigarette beetles for two successive generations. Thus, seven different media were prepared by thoroughly mixing the ingredients and 100 g of each medium was taken separately in plastic jars of 250 ml capacity. Insect culture required for the experiment was obtained from infested turmeric rhizomes collected at store houses of Agricultural Market Committee yard, Duggirala, Guntur district, Andhra Pradesh. Sex of the pupae were determined based on the morphological differences of the genital papillae *i.e.*, globular in male and protuberant, three segmented and distinctly divergent in female (Halstead, 1963). Ample numbers of male and female pupae were kept in separate containers to obtain sufficient number of adults of both sexes required for the experiment. Five pairs of freshly emerged adult beetles were introduced into the culture medium and the jars were secured with perforated lids. These jars were maintained in the laboratory at 28 ± 2 °C and 70 per cent RH. The experiment was replicated thrice. Data on adult emergence was recorded at 40 and 100 days after release (DAR) of the insects and analysed statistically.

RESULTS AND DISCUSSION

The highest number of adult emergence was recorded in maize + yeast + B- complex treatment (175.7) at 40 DAR followed by wheat + yeast + B- complex (156.3) which was significantly different from other treatments (Table 1). A progeny of 138.0 adults were recorded in maize + B- complex treatment which was on par with wheat + B- complex (137.3), maize + yeast (136.3) and wheat + yeast (132.0). The numbers of adults emerged from the culture media of wheat alone and maize alone were only 118.3 and 117.3, respectively. At 100 DAR, also similar trend was observed in emergence of cigarette beetle adults from different culture media. The highest number of adult emergence was observed in maize + yeast + B- complex treatment (900.7) which was on par with

wheat + yeast + B- complex (847.0). A progeny of 608.7 adults was recorded in maize + B- complex treatment followed by maize + yeast (546.3), wheat + B- complex (518.7) which was on par with wheat + yeast (499.7). Wheat alone and maize alone as culture media resulted only in less number of adults (411.7 and 426.3 respectively). Overall, both wheat and maize in combination with yeast + B- complex resulted in higher number of adult emergence (1026.3 and 1076.3 respectively) when compared to wheat alone or maize alone as culture media which resulted in less number of adults (537.7 and 579.3 respectively).

The results are in conformity with Mahroof and Phillips (2015) who observed the highest fecundity (52.4 ± 4.8 eggs/female) and adult survival rate ($91.0 \pm 2.7\%$) of cigarette beetles on wheat flour at 28°C compared to tobacco and processed almonds. Ali *et al.* (1972) also reported that the development of the cigarette beetle varies greatly on its natural diets, as the insect requires certain balance between the main classes of nutrients, proteins, carbohydrates and fats, which differ widely in various diets. The pupal period, longevity and egg production are influenced by the ability of the insect to utilize protein. The ability of *L. serricornis* to utilize toxin-rich hosts as food may be correlated to its association with a yeast-like symbiont, *Symbiotaphrina kochii* which is transmitted to the next generation superficially on the eggs and carried internally in larvae and adults in the mycetome of the gut (Patric and Samuel, 1990). Broad spectrum detoxification abilities of these symbionts help the insect to utilize host materials which are rich in plant allelochemicals and convert these to nutrients and carbon sources (Shen and Dowd, 1991).

However, variation in the total number of adults emerged from different culture media tested show that larval and pupal development is influenced by the specific food source. Cornell and Hoveling, (1998) indicated that wheat flour is nutritionally rich in valuable proteins, complex carbohydrates, vitamins and minerals necessary for growth and development of *L. serricornis*, and wheat flour also lack the defensive chemicals present in other hosts. Apart from the anobiid specific symbionts, addition of yeast and vitamin mix also supplemented to the nutrition of the beetles and resulted in more number of insects in this experiment. Hence, maize or wheat in combination of yeast and vitamin mix can be used as food source for getting good supply of different stages of cigarette beetle.

Table.1. Adult emergence of cigarette beetle, *L. serricornis* from different media

Treatment	Number of adults emerged		
	at 40 DAR	at 100 DAR	Total
Wheat	118.3 (10.87) ^c	411.67 (20.26) ^d	537.67 (22.99) ^d
Wheat + yeast @ 5%	132.0 (11.48) ^{bc}	499.67 (22.27) ^{bcd}	614.33 (25.07) ^{bcd}
Wheat + B- complex @ 60 µg kg ⁻¹	137.7 (11.71) ^{bc}	518.67 (22.62) ^{bcd}	646.33 (25.54) ^{bc}
Wheat + yeast @ 5% + B- complex @ 60 µg kg ⁻¹	156.3 (12.50) ^{ab}	847.00 (29.09) ^a	1026.33 (31.67) ^a
Maize	117.3 (10.83) ^c	426.33 (20.62) ^{cd}	579.33 (23.30) ^{cd}
Maize + Yeast @ 5%	136.3 (11.65) ^{bc}	546.33 (23.34) ^{bc}	647.00 (26.11) ^b
Maize + B-complex @ 60 µg kg ⁻¹	138.0 (11.73) ^{bc}	608.67 (24.66) ^b	725.00 (27.32) ^b
Maize+ Yeast @ 5%+ B- complex @ 60 µg kg ⁻¹	175.7 (13.22) ^a	900.67 (30.00) ^a	1076.33 (32.79) ^a
SEm ±	0.38	0.92	0.84
CD	1.13	2.77	2.51
CV %	5.54	6.63	5.41

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PREPARATION OF SOIL NUTRIENT STATUS THEMATIC MAPS OF NANDYAL MANDAL OF KURNOOL DISTRICT BY GEOGRAPHIC INFORMATION SYSTEM

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ABSTRACT

The present study is an attempt to assess the spatial variability by generating thematic maps of available soil fertility status of Nandyal mandal in Kurnool District by GIS technique. Two hundred and forty three geo-referenced soil samples were collected from sixteen villages at random and analysed for soil fertility adopting standard procedures and mapped by Geographic information system. The pH of the soil samples was neutral to highly alkaline in reaction. Available nitrogen was generally low to medium whereas Phosphorous and potassium are available in all the three ranges i.e. low, medium and high. The available micronutrient viz., Iron, copper, zinc and manganese were deficit in 13.54 per cent, 18.76 per cent, 31.22 per cent and 16.83 per cent area respectively in these soils. The spatial variability of the various soil parameters helps the farmers to take up sustained crop management practices.

KEYWORDS: Soil fertility, Spatial variability, Nutrient mapping, Geographic information system.

INTRODUCTION

The general recommendation/management practices for crop production are based on the assumption that fields are homogeneous areas. Soil fertility management is one such practice where the fertilizer requirements are recommended on whole field basis. Bouma and Finke (1993) reported that spatial variability can occur on a variety of scales, between regions, between fields or within fields. Variation in soil components can sometimes be discerned on a sub millimeter scale. However since 70 years it has been reported that the fields are not homogeneous and several sampling techniques have been recommended to cover the field variability. GIS is a powerful tool for collecting, storing, retrieving, transforming and displaying spatial data (Burrough, 1993). GIS can be used in producing soil fertility map of an area which helps to understand the status of soil fertility spatially and temporally. Such maps help in formulating balanced fertilizer recommendation, precision farming, crop suitability analysis and other sustainable crop management decisions. Therefore an appropriate understanding of the spatial variability of soil fertility at field level is essential. It is possible through generation of nutrient status thematic maps through spatial interpolation of point based measurements of soil properties. Therefore the present investigation was taken up for the assessment and mapping of soil fertility status

of Nandyal mandal in Kurnool district of Andhra Pradesh. The major cropping pattern of this area is rice followed by rice and fallow followed by bengalgram.

MATERIALS AND METHODS

The study area comprising of Nandyal mandal in Kurnool district lies between 15°37'01.9" to 15°58'11.4"N latitude and 78°25'54.8" to 78°63'48.3"E longitude (Fig. 1). It falls under scarce rainfall zone of agricultural zone of Andhra Pradesh. The area receives mean annual rainfall of 670 mm received mainly during June to September.

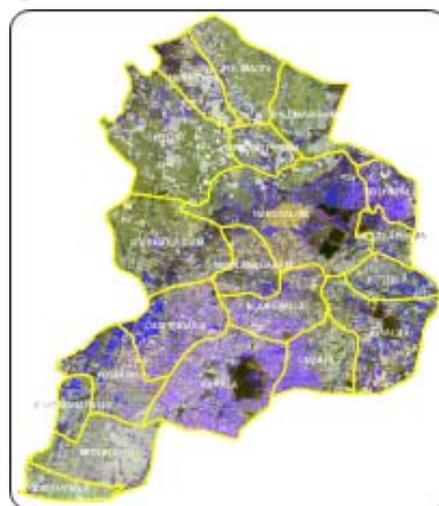


Fig. 1. Location map of study area

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Preparation of soil nutrient status thematic maps

Geo-referenced surface soil samples were collected at an average of fifteen samples per village from the study area representing different soil units and cropping systems as per the soil map prepared by NBSS & LUP were collected randomly at 0-15 cm depth by adopting the standard procedures of soil sample collections. A total of 233 samples were collected from all 15 villages of the mandal. The total geographical area of the study area is 23458.12 ha.

Soil samples collected were air dried under shade, ground with mortar and pestle, passed through a 2 mm sieve and then were used for laboratory analysis after proper labeling. These soil samples were analysed for estimating physical, physio-chemical and chemical properties of the soil using the standard methods. The pH of the soil in 1:2.5 soil water suspension was determined by glass electrode pH meter (Jackson, 1967). The available nitrogen was determined by alkaline permanganate method outlined by Subbaih and Asija (1956) and the results are expressed in kg ha^{-1} . The available phosphorus content was determined by extracting the soil with 0.5 M NaHCO_3 (Olsen *et al.*, 1954) and estimated by developing blue colour using ascorbic acid as reductant on calorimeter (Olsen and Watanabe, 1965). Available potassium in the soils was extracted by neutral normal ammonium acetate and determined by the flame photometer (Jackson, 1973). The available micronutrients *viz.*, Fe, Cu, Zn and Mn were determined in the DTPA extract of soil (pH 7.3) using Atomic Absorption Spectrophotometer as outlined by Lindsay and Norwell (1978). Fertility status of N,P,K are interpreted as low, medium and high and that of sulphur, iron, copper, zinc and manganese are interpreted as deficit and sufficient.

Arc Map 10.0 with spatial analyst function of Arc GIS software was used to prepare soil fertility maps. Interpolation method employed was kriging. Then map was reclassified according to the ratings of respective nutrients and estimated the area under different standard ratings.

RESULTS AND DISCUSSION

The data pertaining to fertility status of Nandyal mandal are presented in Table 1 for the soil Ph, major and micronutrients.

The soil pH plays an important role in crop productivity. It is the pattern of the soil reaction which decides the corresponding solubility and availability of

the nutrients causing the soil suitable for a particular cropping pattern. In the study area the soils were neutral to highly alkaline reaction (6.48 to 9.32) with low soluble salts. The major portion of the area is occupied by pH range of more than 8.4 with highly alkaline reaction in an area of 13906 ha (59 %) and the zone represented by pH range of 6.5 to 7.5 (1.58 %) occupies minimum area 371 ha (Fig. 2). The highly alkaline reaction of the soils may be due to efficient recycling of basic cations and also due to presence of sodium as dominant cation on exchangeable complex (Thangaswamy *et al.*, 2005).

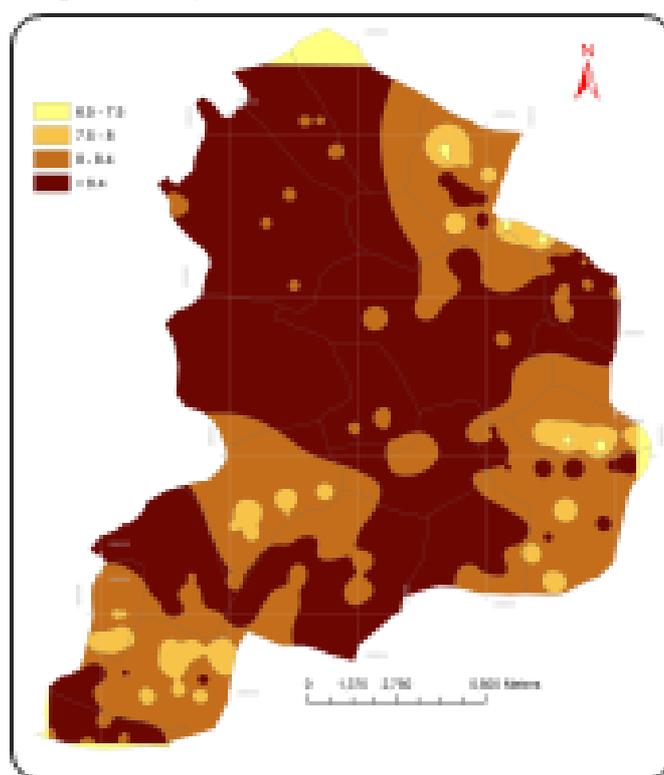


Fig. 2. Spatial distribution of soil pH

The available nitrogen content of villages of study area ranged from 60 to 626 kg ha^{-1} with a mean value of 230.38 and standard deviation of 15.25. out of the total study area, the largest area of 14640.5 ha (62.48 % of the area of the mandal) falls under low available nitrogen range while the medium nitrogen content of range occupies an area of 8793.4 ha (37.52 % of the area of the mandal) (Fig. 3). The major portion of the nitrogen content in soils is contributed by organic matter. The total nitrogen content in the soils is dependent on temperature, rainfall and altitude. Nitrogen variation may be related to soil management, application of FYM and fertilizer to previous crop (Ashok Kumar, 2000). The low organic

Table 1. Soil characteristics of Nandyal mandal

S. No.	Mandal	No. of Samples	pH	N	P	K	S	Iron	Copper	Zinc	Manganese
1	Ayyalur	20	7.15-8.97 (8.19)	204-268 (231.5)	5-30 (15.1)	235-475 (388.25)	8-18 (13.4)	7-12 (8.53)	0.3-0.5 (0.35)	0.3-1.0 (0.77)	3-4 (3.25)
2	Bheemavaram	14	8.1-8.92 (8.5)	204-274 (236.3)	4-19 (13.9)	225-500 (367.15)	8-15 (12.1)	4.5-9.0 (6.30)	0.3-0.5 (0.40)	0.4-1.0 (0.83)	3-4 (3.2)
3	Brahmanapalle	10	7.03-8.1 (7.78)	198-274 (211.8)	8-24 (17.6)	165-370 (240.5)	11-17 (12.5)	7-10 (7.6)	0.3-0.4 (0.38)	0.4-0.8 (0.6)	3-3 (3)
4	Chabolu	14	7.49-8.27 (7.74)	198-276 (247.15)	11-34 (17.43)	135-500 (387.5)	7-14 (11.43)	4-9 (6.21)	0.3-0.6 (0.4)	0.5-0.9 (0.76)	3-3 (3)
5	Chapirevula	9	7.1-8.6 (7.9)	204-212 (207.78)	8-30 (17.44)	225-495 (358.3)	7-19 (15.44)	8-10 (9.33)	0.4-0.5 (0.41)	0.7-0.8 (0.73)	3-4 (3.11)
6	Gunthanala	19	7.14-8.95 (7.88)	204-626 (262.32)	5-31 (16.2)	125-490 (230.52)	6-18 (13)	4-10 (6.26)	0.3-0.5 (0.39)	0.3-1.0 (0.76)	3-4 (3.05)
7	Kanala	15	7.08-9.32 (8.13)	60-272 (241.47)	5-31 (16.2)	100-400 (235.67)	7-16 (11.47)	8-12 (8.5)	0.3-0.5 (0.39)	0.4-0.9 (0.75)	3-3 (3)
8	Kothapalli	20	6.8-9.24 (8.15)	200-278 (234.1)	4-17 (9.1)	110-380 (246.75)	6-17 (12.05)	6-12 (8.6)	0.4-0.5 (0.425)	0.5-1 (0.81)	3-4 (3.05)
9	Kottala	4	7.15-7.8 (7.45)	198-278 (234)	8-20 (14)	115-1250 (163.75)	18-20 (19.25)	6-8 (7)	0.3-0.5 (0.4)	0.7-0.9 (0.85)	3-4 (3.5)
10	Mitnala	19	6.48-8.93 (8.04)	178-270 (232.7)	6-31 (12.73)	85-475 (268.68)	7-19 (13.31)	6-12 (9.05)	0.3-0.6 (0.47)	0.3-1.0 (0.75)	3-4 (3.1)
11	Moolasagaram	10	8.1-9.01 (8.65)	228-274 (244.8)	5-13 (8.7)	220-500 (325.5)	6-18 (13)	3-7 (4.45)	0.3-0.5 (0.44)	0.7-0.9 (0.79)	3-3 (3)
12	Munagala	19	8-8.95 (8.59)	184-274 (222)	4-22 (9.4)	230-650 (424.74)	9-20 (14.58)	4-9 (7.89)	0.4-0.6 (0.44)	0.4-0.9 (0.71)	3-4 (3.26)
13	Nandyal(M)	20	7.9-8.96 (8.39)	188-274 (2227.2)	4-23 (10.85)	215-500 (348.5)	7-21 (15.55)	7-9 (8)	0.1-0.4 (0.32)	0.4-0.9 (0.705)	3-4 (3.75)
14	Polur	20	7.85-8.26 (8.06)	166-262 (213.5)	7-38 (19.3)	150-495 (299)	6-15 (10.95)	6-12 (9.1)	0.1-0.6 (0.41)	0.4-1.0 (0.63)	3-4 (3.1)
15	Pusulur	20	8-9.25 (8.49)	130-278 (213.5)	2-30 (11.65)	140-500 (327.88)	8-19 (14.9)	4-12 (8.65)	0.2-0.6 (0.47)	0.4-0.9 (0.72)	3-4 (3.05)
	Mean		8.13	230.38	13.97	307.51	13.53	7.7	0.41	0.74	3.14
	Range		6.48-9.32	60-626	2-38	85-650	6-21	3-12	0.1-0.6	0.3-1	3-4
	SD		0.35	15.25	3.44	74.03	2.15	1.38	0.04	0.07	0.21
	CV		4.27	6.62	24.63	24.07	15.89	18.01	9.91	9.05	6.72

Preparation of soil nutrient status thematic maps

matter content in the soils due to low rainfall and low vegetation results in faster degradation and removal of organic matter leading to low nitrogen content in the soils may be one of the reason. The observations are in accordance with Patil *et al.* (2011).

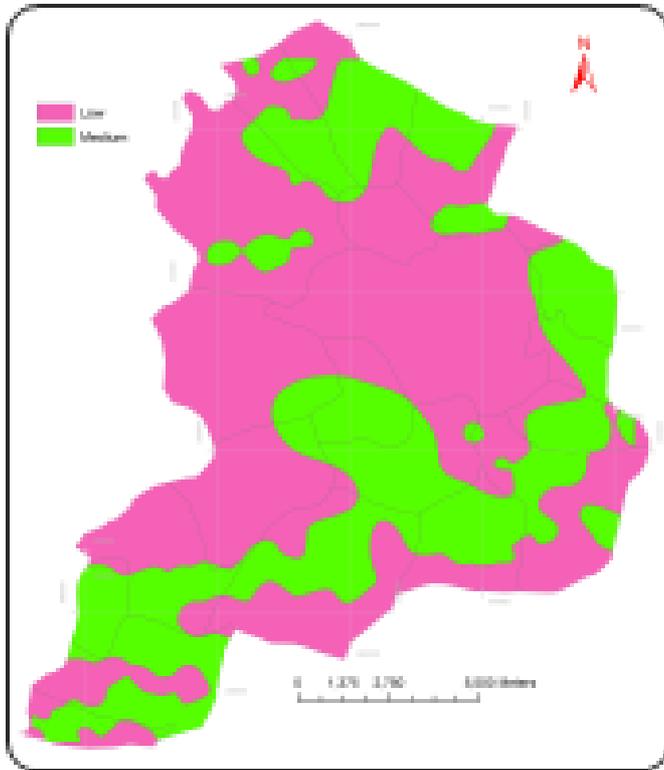


Fig. 3. Spatial distribution of Nitrogen

The available phosphorous status of soils of in the study area ranged from 2.0 to 38kg ha⁻¹ with a mean value of 13.97 kg ha⁻¹. The map (Fig. 4) shows that 16% (3751.5 ha) and 64.6% (15129.7 ha) of the soils in the mandal is characterized by low and medium phosphorous content respectively and whereas 19.4 % area (4552.7 ha) by high range. The low content of phosphorous may be due to low CEC and clay content. The results are in conformity with the findings of Bopathi and Sharma (2006) and Madan Mohan (2008).

The soils in the study area were found to be low to high in available potassium status ranging from 85 to 650 kg ha⁻¹ with a mean value of 307.51 kg ha⁻¹. The spatial variability map of study area (Fig. 5) shows that the maximum area of 15356.72 ha (65.53 %) is occupied by the high range of available potassium, 6059.95 ha (25.86%) with medium range of available potassium whereas 8.61 per cent (2017.26 ha) of the mandal is occupied by low potassium range. Binita *et al.* (2009)

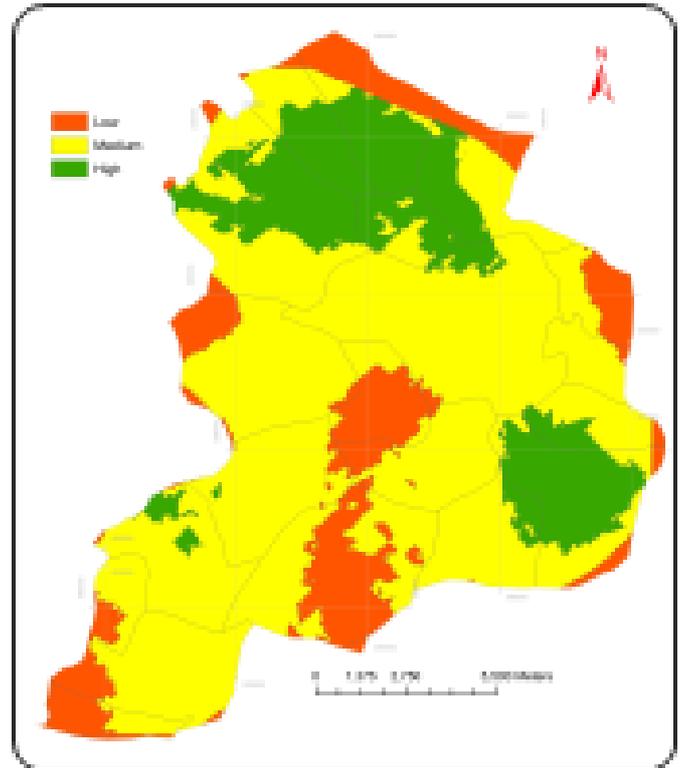


Fig. 4: Spatial distribution of Phosphorus

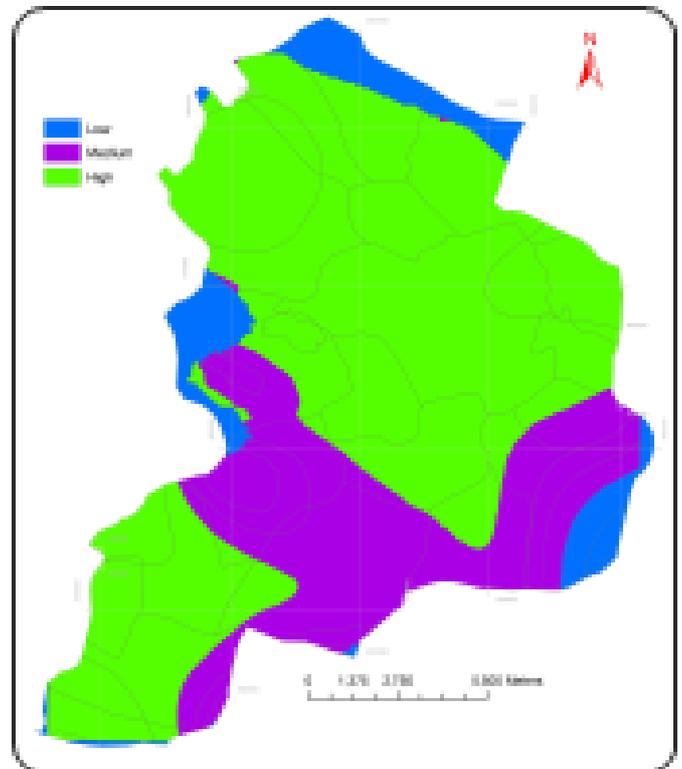


Fig. 5. Spatial distribution of Potassium

reported high K in study area with black soils. Soils of the study area may be predominantly rich in K containing micaceous and feldspars minerals in parent material leading to major portion of study area with high K availability (Ravi Kumar, 2006).

The availability of sulphur in study area ranged from 6 to 21 kg ha⁻¹, with a mean value of 13.53 kg ha⁻¹. About 76.23 per cent (17864.57 ha) of the area is characterized by sufficient sulphur content range (Fig.6). Similar results were reported by Deveraj (1994) where he observed that fine texture soils are generally well supplied with sulphur.

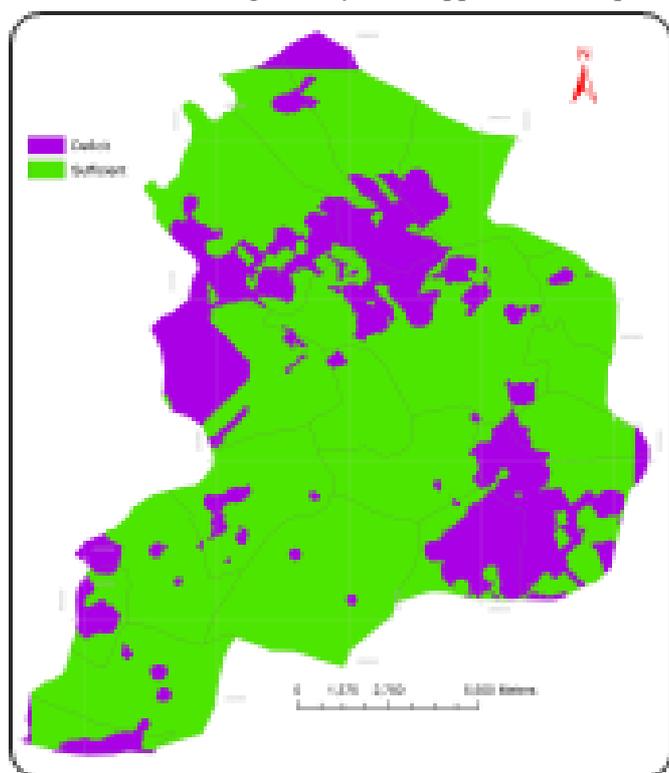


Fig. 6. Spatial distribution of Sulphur

The iron content ranged from 3 to 12 mg kg⁻¹ with mean value of 7.7 mg kg⁻¹. The area of 13.54 % (3171.95 ha) of the mandal comes under deficit iron content whereas 86.46 per cent (20261.98 ha) area by sufficient iron content (Fig. 7). The deficit iron content in certain portions of the area may be due to precipitation of iron by caco3 and resulting in decrease of its availability (Thampatti and Jose, 2006).

The major portion of the study area had sufficient quantity of copper available in an area of 81.24 per cent (19036.90 ha) of the mandal whereas in an area of 18.76 per cent (4397.03 ha) deficit content is recorded (Fig. 8).

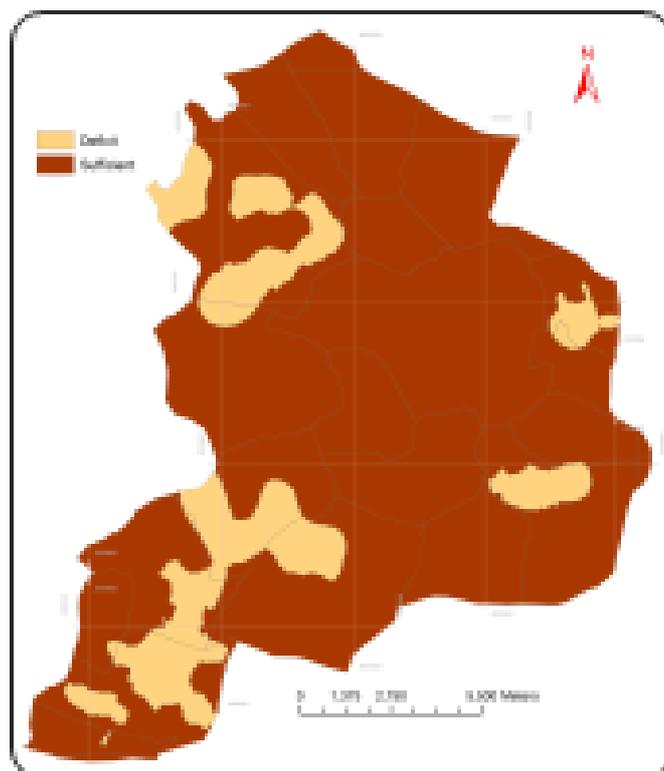


Fig.7. Spatial distribution of Iron

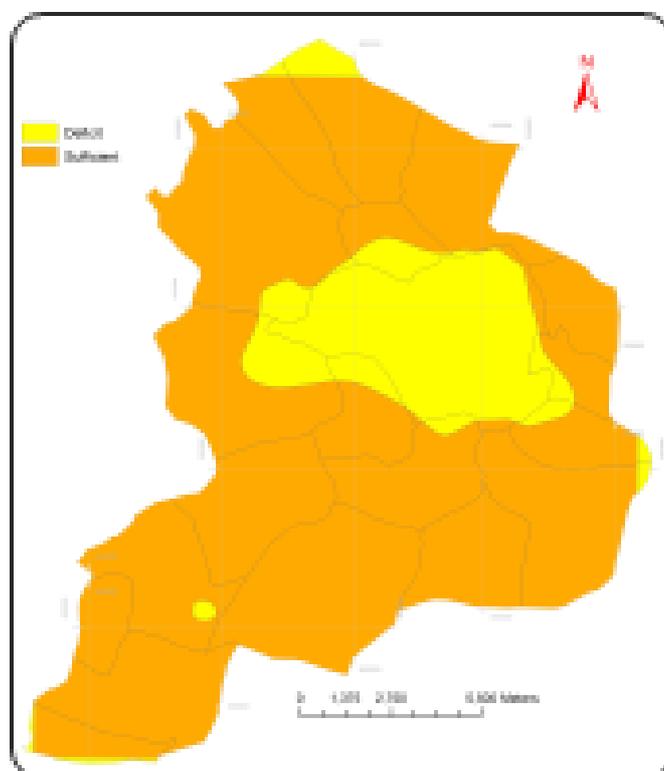


Fig. 8. Spatial distribution of Copper

Preparation of soil nutrient status thematic maps

On the whole the Cu content ranged from 0.10 to 0.60 mg kg⁻¹ with mean value of 0.41 mg kg⁻¹.

Available zinc status in the mandal ranged from 0.30 to 1 mg kg⁻¹ and an area of 68.78 per cent (16118.3 ha) is characterized by sufficient zinc content range and 31.22 per cent (7315.63) with deficit zinc status in the study area (Fig. 9). In alkaline pH range zinc forms negatively charged zincate ions and alter stability of soluble and insoluble organic complexes of zinc (Singh and Singh, 1996).

In the study area sufficient quantity of manganese content is available in an area of 83.17 per cent (19490 ha) of the mandal whereas 16.83 per cent (3943 ha) area by deficit manganese content (Fig. 10) due to neutral to low pH and nature of the parent material as reported by Prasad and Sahi (1989), while Arora and Shekon (1981) observed that high pH decreases the availability by converting in to unavailable for (Mn⁺⁺⁺). Vijayshekhar et al (2000) reported that sufficient quantity of Mn is due to high organic matter.

The coefficients of variation (Table 1) of soil fertility status shows that it ranged from 4.27 to 24.63, the large values of CV shows that soil fertility in the study area is not homogeneous in distribution. This may be due to several natural factors such as geology, topography and manmade factors as land use and land management practices.

CONCLUSIONS

The soils of Nandyal mandal in Kurnool district show considerable spatial variability in respect to the soil fertility status. The generation of such soil fertility maps helps in identifying the areas which require much attention of a farmer. In this study, some nutrients are high in availability and others moderate. Some areas may need immediate attention for sustained crop production. Wherever micronutrients are deficit, they may be replenished in order to avoid the crops suffering from their deficiency and also to obtain optimum utilization of other nutrients. These maps forms the basis to control the under usage and overusage of the fertilizers and also helps in deciding the cropping pattern based on the soil fertility status.

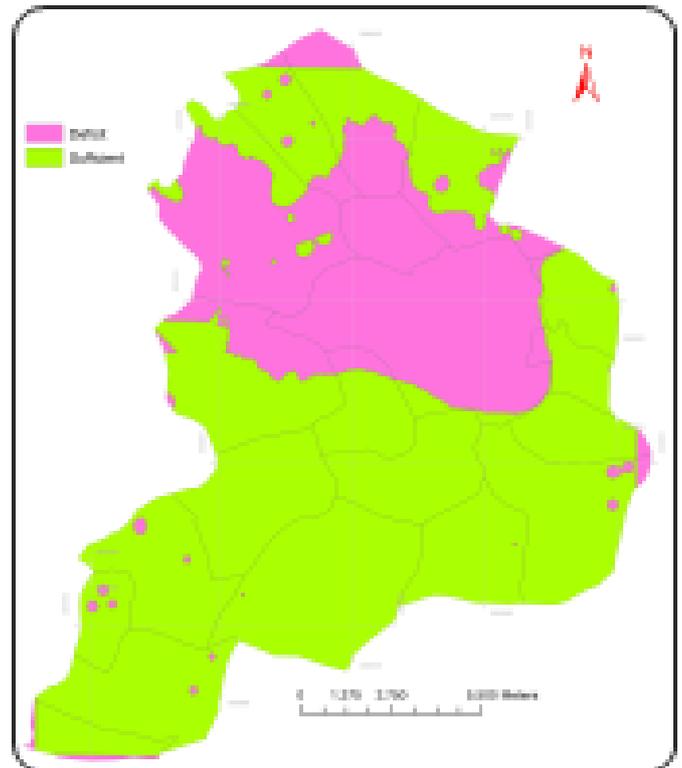


Fig.9: Spatial distribution of Zinc

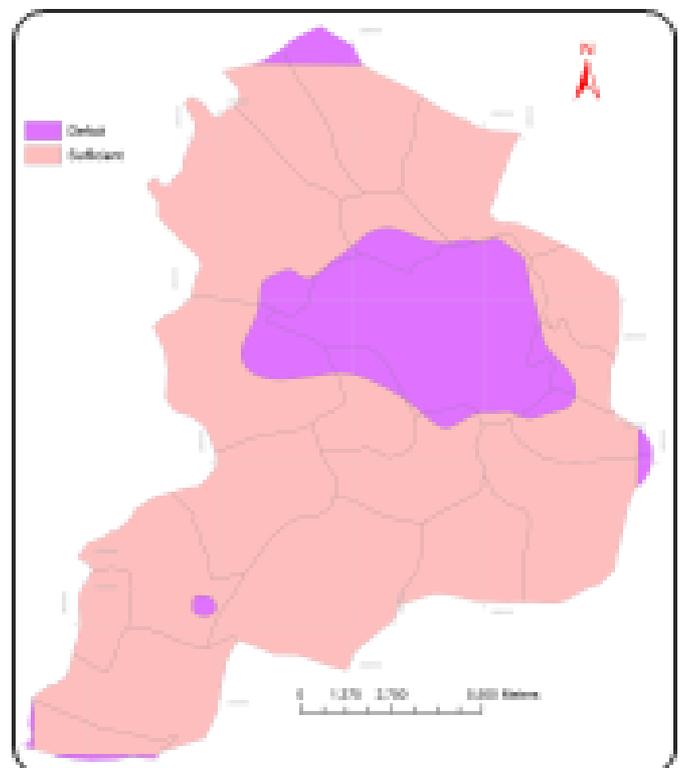


Fig. 10. Spatial distribution of Manganese

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ATTITUDE OF STAKEHOLDERS TOWARDS INFORMATION AND COMMUNICATION TECHNOLOGIES (ICTs) BASED EXTENSION SERVICES

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ABSTRACT

Harnessing ICTs in agriculture received high priority which can be used vary widely in the promotion of agricultural technologies. With this technology revolution several ICT initiatives have been in operation in India. Study was formulated to measure the attitude of stakeholders towards ICT based extension services offered by *e-sagu*, *e-choupal* and VASAT ICT initiatives in Andhrapradesh. In this study Attitude was operationalised as the degree of positive or negative feeling of stakeholders i.e., farmers, extension services providers and ICT functionaries towards the information communication Technologies (ICTs) based extension services. Sample size of 150 farmers availing ICT extension services, 60 farmers availing non ICT extension services were selected randomly and 60 extension service providers and 15 ICT functionaries were selected purposively. Attitude of farmers and extension service providers towards ICT based extension was measured with the help of attitude scale developed for this study. The results indicated that vast majority (71.34%) of farmers had favourable attitude, where as 15.33 per cent has more favorable attitude towards ICT based extension services. More than half of (66.70%) extension service providers had favorable attitude towards ICT based extension services followed by more favourable (18.33%) and less favourable (15.00%) attitude. With regard to ICT functionaries only 40 per cent had favourable attitude and 33.33 per cent had less favourable attitude towards ICT extension service profession.

KEYWORDS: ICT, Stakeholders, Information, Extension services.

INTRODUCTION

Agriculture continues to be the occupation and way of life for more than half of Indian population even today making single largest contribution to the GDP accounting for 18 per cent of the total. Sustainable prosperity of this class of farmers and the land less agricultural laborers holds the key for improving the overall human resource development scenario in the country.

In this context, quick dissemination of technological information from agricultural research system to the farmers in the field and reporting of farmers feed back to the research system is one of the critical inputs in dissemination of agricultural technology. The information and communication support during past 50 years has mainly been through conventional methods. Agricultural extension which depends to a large extent on information exchange between and among farmers on the one hand and a broad range of other factors on the other, has been identified as one area in which ICTs can play a significant role. Harnessing ICTs in agriculture received high priority

which can be used widely in the promotion of agricultural technologies. With this technology revolution several ICT initiatives have been in operation in India. Study was formulated to measure the attitude of stakeholders towards ICT based extension services offered by *e-sagu*, *e-choupal* and VASAT ICT initiatives in Andhra Pradesh. In this study attitude was operationalised as the degree of positive or negative feeling of stakeholders i.e., farmers, extension service providers and ICT functionaries towards the information communication Technologies (ICTs) based extension services.

MATERIAL AND METHODS

Exploratory research design was adopted for conducting the study. The study was conducted in Warangal, Adilabad and Mahaboobnagar districts of Andhra Pradesh, where ICT initiatives *e-sagu*, *e-choupal* and VASAT were implemented respectively. These districts were selected purposively because the above said ICT initiatives are functioning at these districts for the past three years. Apart from these districts three districts

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from three regions of Andhra Pradesh were selected randomly for those who are not availing services of ICT initiatives are Anantapur from Rayalaseema region, Nalgonda from Telangana region and Krishna from Coastal region. From each ICT project area two villages were selected randomly. Twenty five farmers from each village, who are availing ICT services were selected randomly. Thus making a total of 150 farmers constituted the sample for the study. For non-ICT farmers, one mandal selected randomly from each selected district and two villages selected randomly from these mandals. Thus making a total of six villages for non ICT area. 10 farmers from each village were selected randomly from non ICT area thus making a total of 60 farmers.

Apart from 3 ICT projects, extension service providers from Kisan Call Centers (1551, ANGRAU 1100) and farm telecast program of government of A.P. (Rytu Nestam) were considered relevant for this study. To obtain information with regard to ICT based extension services, 10 from each above center were selected to get their attitude and problems in delivering ICT enabled extension services. All the functionaries of the three ICT projects viz., e-sagu, e-choupal and VASAT constituted the population of the study for collecting data regarding orientation towards ICT based extension services. Five functionaries from each project were selected randomly. Thus a total of 15 were selected. In this study measurement of attitude of farmers and extension service providers towards ICTs based extension services was measured with Attitude scale was developed using the Likert method of summated rating.

RESULTS AND DISCUSSION

Attitude of farmers towards ICT based extension services

Attitude of farmers towards ICT based extension was measured with the help of attitude scale. The respondents were categorized into three groups viz., less favourable attitude, favourable attitude and more favourable attitude based on mean and standard deviation. It is clear from the Table 1 that majority of the (60.00%) farmers in e-sagu area had favourable attitude towards ICT based extension followed by more favourable (28.00%) and less favourable (12.00%). In case of e-choupal vast majority (64.00%) had favourable attitude followed by more favourable (20.00 %) and less favourable (16.00%)

attitude. Whereas farmers in VASAT area majority (64.00%) had favourable attitude followed by less favourable (24.00%) and more favourable (12.00%) attitude towards ICT based extension services. The results of pooled data indicate that vast majority (71.34%) had favourable attitude followed by more favourable (15.33%) and less (13.33%) favourable attitude towards ICT based extension.

Attitude of non-ICT farmers towards ICT based extension services

Table 2 revealed that majority of the farmers (66.70%) in non-ICT project area had favourable attitude towards ICT based extension services followed by less favourable (20.00%) and more favourable (13.30%) attitude. But their mean scores (61.41) are on par with the score of ICT farmers (62.87). This might be because of still majority of the farmers depending on informal sources such as input dealers, peer farmers, friends and relatives to get information related agricultural problems. And they are not getting appropriate information in a timely manner from existing extension system. They thought that extension services delivered on using ICT tools may break the barriers in obtaining the relevant information at opportune time. So the above result was noticed.

Attitude of extension service providers towards ICT based extension services

Attitude of extension service providers towards ICT based extension was measured with the help of attitude scale developed by Likert method of summated rating. The respondents were categorized into three groups viz., less favourable attitude, favourable attitude and more favourable attitude based on mean and standard deviation.

From the table 3 it is clear that majority (66.60%) of the respondents had favourable attitude towards ICT based extension followed by more favourable (18.33%) and less favourable (15.00 %) attitude. This is due to the fact Indian agriculture witnessed change of subsistence agriculture into a commercial activity. With this farmers' information needs are diversified. Traditional extension system and its approach failed to meet the needs of all the farmers in a timely manner. By using ICTs to reach the needy farmers this gulf can be bridged, where it can improve the accessibility to the information sources but also its relevance to local development. Hence this result was noticed. These findings were in partial conformity with Nagalakshmi (2008).

Attitude of stakeholders towards ICTs

Table 1. Distribution of farmers according to their attitude towards ICT based extension services

N=150

S. No.	Attitude	<i>e-sagu</i> (n=50)	<i>e-choupal</i> (n=50)	VASAT (n=50)	Total N = 150
1	Less favourable	6 (12)	8 (16)	12 (24)	20 (13.33)
2	Favourable	30 (60)	32 (64)	32 (64)	107 (71.34)
3	More favourable	14 (28)	10 (20)	6 (12)	23 (15.33)
	Mean	67.84	60.36	60.42	62.57
	SD	8.97	13.14	7.456	10.67

Table 2. Distribution of non-ICT farmers according to their attitude towards ICT based extension services

N=60

S. No.	Category	Frequency	Percentage
1	Less favourable	12	20
2	Favourable	40	66.7
3	More favourable	8	13.3
	Mean		61.41
	SD		8.87

Table 3. Distribution of extension service providers based on attitude towards ICT based extension services

N=60

S. No.	Category	Frequency	Percentage
1.	Less favourable	9	15.00
2.	Favourable	40	66.67
3.	More favourable	11	18.33
	Mean		97.68
	SD		8.05

Table 4. Distribution of project functionaries' orientation towards ICT extension services profession

N = 15

S. No.	Category	Frequency	Percentage
1	Less favourable	5	33.33
2	Favourable	6	40.00
3	Highly favourable	4	26.67
	Mean		22.00
	SD		3.84

Orientation of project functionaries towards ICT extension service profession

Orientation of an individual is directing the interests of himself towards something. In the present context the orientation of functionaries towards ICT extension i.e. using information and communication technologies in agricultural extension services was studied. For this orientation scale was developed. The scale comprised of eight statements, each statement was measured on five point continuum ranging from score 1 to 5. Thus total score ranging from 8 to 40. The frequency distribution of respondents on their orientation towards ICT extension service profession is reported in table 4.

As it can be seen from the data in table majority (40.00%) functionaries had favourable orientation (Meera 2002) followed by less favourable (33.33%) and highly favourable (26.67%) orientation towards ICT extension service profession. This may be due to their lower educational and professional qualifications and less number of trainings received and lower remuneration being paid to them. Through proper trainings, motivation and attractive incentives may inculcate favourable orientation towards ICT extension service profession among the project functionaries.

CONCLUSION

The study showed that majority of farmers had favourable attitude towards ICT based extension services. It implies that immediate effort should be made to overcome the present constraints by establishing village level kiosk in all the regions of country and also making it affordable and easy access among the farmers. Attitude of extension service providers was favourable. Hence all state agricultural universities should incorporate ICT related curricula in agricultural education as early as possible to develop strong human capital to act as interfaces between ICTs and farmers. The apex bodies in agricultural education need to develop full fledged strategies in promoting information access to farmers through ICTs.

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VARIABILITY AND CORRELATION STUDIES IN OKRA (*Abelmoschus esculentus* L. Moench)

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ABSTRACT

A study was conducted to evaluate fourteen genotypes of okra for yield and various yield attributing traits at Vegetable Breeding Station, Agricultural Research Institute, Rajendranagar, Hyderabad. The data were utilized to estimate the genetic variability in terms of mean, genotypic and phenotypic coefficients of variation, heritability and expected genetic advance as per cent mean. The present investigation showed that phenotypic coefficient of variation was higher than genotypic coefficient of variation for all traits suggesting the influence of environment in their expression. The estimates of GCV, heritability and heritability coupled with genetic advance as per cent of mean were higher for number of fruits plant⁻¹, internode length and plant height. The correlation study indicated that the yield plant⁻¹ had high positive association with number of fruits plant⁻¹, plant height, internode length and fruit girth at both genotypic and phenotypic levels. Among the traits studied, number of fruits plant⁻¹ had direct contribution on yield, where as plant height, internode length and fruit girth showed contribution.

KEYWORDS: Okra, Correlation, Genetic Variability, Heritability, Path analysis

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) is an important vegetable crop grown for its tender fruits throughout India. It is an important protective food because of its high nutritional value which plays a pivotal role in human nutrition. Nowadays, the productivity of okra shows a declining trend. In India, it occupied in an area of 530.27 ha with an annual production of 6350.27 kg (National Horticulture Base data base 2012-13). Hence, developing high yielding varieties bestowed with fruits of high quantity as well as quality is of utmost importance in this crop. To improve the yield and other characters, information on genetic variability and interrelationship among different traits is necessary. The improvement in any crop is proportional to the magnitude of its genetic variability, present in the population. Hence, an attempt was made to generate information on genetic variability, association of different characters and path analysis to select promising genotypes for utilization in okra breeding.

MATERIALS AND METHODS

A field experiment was conducted at Vegetable Breeding Station, Agricultural Research Institute, Rajendranagar, Hyderabad during *kharif* 2006 and 2007 in a randomized block design with three replications. The experimental plot size was 4 × 4 m and experimental

material consisted of fourteen okra genotypes sourced from All India Coordinated Research Centers of Indian Council of Agricultural Research. Seeds were sown with a spacing of 45 × 30 cm². All the agronomic recommended package of practices including plant protection measures were taken and maintained healthy crop. Data were recorded on randomly selected five plants from each genotype for plant height (cm), number of branches, node number at first fruit appeared, number of nodes plant⁻¹, number of fruits plant⁻¹, average fruit weight (g), fruit length (cm), fruit girth (cm) and yield plant⁻¹ (g). The generated data were subjected to analysis of variance as per Panse and Sukhatme, (1984) and genotypic and phenotypic coefficients of variation by Burton and De Vane, (1953). Heritability and genetic advance were calculated according to Johanson *et al.*, (1955) and Robinson *et al.*, (1949) respectively. Correlation coefficients were computed at phenotypic and genotypic levels between pairs of characters adopting the formula given by Al-Jibori *et al.*, (1958) and Path coefficient analysis of Dewey and Lu, (1959) was used to estimate the actual contribution of an attributes and its influence through other characters considering yield as a dependent variable.

RESULTS AND DISCUSSION

The extent of variability measured in terms of range, genotypic variance (V_g), phenotypic variance (V_p), genotypic coefficient of variation (GCV), phenotypic

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coefficient of variation (PCV), heritability, expected genetic advance (GA) and expected genetic advance as per cent of mean are presented in Table 1. Maximum range of mean values was observed for yield plant⁻¹ (101g to 296 g) while minimum range was found for fruit girth (5.77 to 6.87 cm). Among the characters, yield plant⁻¹ and plant height showed wide range of variation, indicating the presence of variability for these characters and offers ample scope for selecting better genotypes. Bendale *et al.* (2003) and Hazra and Basu (2006) also reported wide range of variation for yield and plant height for other genotypes in okra. Phenotypic coefficient of variation was found to be more than genotypic coefficient of variation for all characters indicating the influence of environment on expression of the characters. These results were in agreement with that of Pathk and Singh, (1999). The fruit yield plant⁻¹ exhibited high phenotypic coefficient of variation estimate (31.19) followed by number of fruits plant⁻¹ (26.34), internode length (25.60) and plant height (22.43) indicated these characters were highly influenced by environmental factors. Fruit length and girth recorded minimum value of phenotypic coefficient of variation compared to other characters. The genotypic coefficient of variation (GCV) would be more useful for assessing the variability since high estimates of phenotypic coefficient of variation (PCV) alone will not be enough to determine exact nature of variability. The relative magnitude of difference between PCV and GCV was low for plant height, fruit girth and yield plant⁻¹ indicating the low influence of environmental factors on these characters.

The genotypic coefficient of variation along with heritability estimate would give the best scope for selection (Burton and De Vane, 1953). In the present study, the estimates of heritability varied from 0.35 to 0.89. Highest heritability values were found for plant height (0.89) followed by yield plant⁻¹ (0.88) internode length (0.88) and number of fruits plant⁻¹ (0.84). High heritability for these characters might be useful for plant breeder for making effective selection. Low heritability value was observed for fruit length (0.35) followed by number of nodes plant⁻¹ (0.47) suggested that environmental factors constituted a major portion of total phenotypic variation and hence direct selection for these characters would not be appropriate.

Though heritability gives a useful indication of relative value of selection based on phenotypic expression, it cannot be reliable on heritable alone unless genetic advance under selection is not taken into consideration

along with heritability (Johanson *et al.*, 1955). Genetic advance as per cent mean was found to be highest for internode length (46.11) followed by number of fruits plant⁻¹ (45.89) and plant height (40.97). These results suggesting the important role of genetic factors in the expression of these characters as genetic advance was estimated on the basis of heritability in broad sense (since, heritability in narrow sense give the information on additive type of gene action where the character expression was not influenced by environment). Hence, these characters would be selected on the basis of phenotypic values. According to Johanson *et al.* (1955) heritability estimate along with genetic advance is more useful than the heritability alone in predicting the resultant effect for selection. In the present investigation, high estimates of heritability accompanied with high genetic advance as per cent mean were recorded for internode length, number of fruits plant⁻¹ and plant height indicating the suitability of characters for phenotypic selection. Low heritability associated with low expected genetic advance as per cent mean observed for fruit length, and girth.

The correlation study (Table 2) revealed that the genotypic correlation coefficients were higher in magnitude than the corresponding phenotypic correlation coefficients. The results from table 3 revealed that all the characters were positively and significantly correlated with yield plant⁻¹ except node number at first fruit appeared which showed negative association with yield. Among the characters, number of fruits plant⁻¹ exhibited highest positive correlation (1.035, 0.902) with yield followed by plant height (0.789, 0.748) both at genotypic and phenotypic levels and fruit girth (0.797) at genotypic level only. These results indicated that these characters can be considered for selection. These results are in confirmation with that of Bendale *et al.*, (2003).

Plant height had high positive and significant correlation coefficients with internode length (0.894, 0.841), fruit girth (0.849, 0.621), number of fruits plant⁻¹ (0.811, 0.711) and number of nodes plant⁻¹ (0.750, 0.578). Number of fruits plant⁻¹ expressed positive correlation with plant height (0.811, 0.711) and fruit girth (0.763, 0.578) at both the levels. Fruit length had positive association with fruit girth (0.609, 0.329). These findings suggested that these traits should be considered during direct selection for genetic improvement for yield in okra. Dhall *et al.* (2000) also reported similar association among for these characters.

Table 1. Estimates of mean, range, variance components and genetic parameters for different characters

Characters	Mean \pm SE	Range	CV	GCV	PCV	Heritability (broad sense)	Genetic Advance	Genetic Advance as % of mean
Plant height (cm)	87.86 \pm 3.82	56.13 – 117.6	7.53	21.13	22.43	0.89	36.00	40.97
Internode length (cm)	5.66 \pm 0.29	3.87 – 9.27	9.02	23.96	25.60	0.88	2.61	46.11
Node No. at 1 st fruit appeared	4.63 \pm 0.28	3.67 – 5.73	10.33	12.96	16.59	0.61	0.96	20.73
Number of nodes/plant	18.51 \pm 0.83	15.20 – 21.53	7.74	7.27	10.61	0.47	1.88	9.72
Number of fruits/plant	17.74 \pm 1.06	9.00 – 25.3	10.38	24.21	26.34	0.84	8.14	45.89
Average fruit weight (g)	20.04 \pm 0.86	17.50 – 23.33	7.47	7.94	10.91	0.53	2.38	11.88
Fruit length (cm)	15.42 \pm 0.59	14.03 – 18.20	6.67	4.90	8.28	0.35	0.92	5.97
Fruit girth (cm)	6.33 \pm 0.15	5.77 – 6.87	4.13	5.00	6.32	0.58	0.52	8.21
Yield/plant (g)	197.83 \pm 12.32	101.00 – 296.67	10.79	29.26	31.19	0.88	11.91	6.02

CV: Coefficient of variation;

GCV: Genotypic coefficient of variation;

PCV: Phenotypic coefficient of variation

Table 2. Estimates of genotypic and phenotypic correlation coefficients for different characters in okra

Character	Level	Plant height	Internode length	Node number at 1 st fruit	Number of nodes/plant	Number of fruits/plant	Ave. fruit weight	Fruit length	Fruit girth	Yield/plant
Plant height	G	1.000	0.894**	0.311*	0.750**	0.811**	0.290*	0.136	0.849**	0.798**
	P	1.000	0.841**	0.255*	0.578**	0.711**	0.148	0.111	0.621**	0.748**
Internode length	G		1.000	0.227	0.547*	0.807**	0.429*	0.189	0.850**	0.789**
	P		1.000	0.209	0.469*	0.693**	0.303*	0.096	0.661**	0.747**
Node number at 1 st fruit	G			1.000	0.555*	0.007	-0.184	-0.413*	-0.023	-0.015
	P			1.000	0.392*	0.017	-0.098	-0.038	-0.020	-0.014
Number of nodes / plant	G				1.000	0.392*	0.139	-0.304*	0.420*	0.407*
	P				1.000	0.275*	0.079	-0.024	0.213	0.297*
Number of fruits/plant	G					1.000	0.212	0.260*	0.763**	1.035**
	P					1.000	0.164	0.237	0.578**	0.902**
Average fruit weight	G						1.000	0.595**	0.453*	0.306*
	P						1.000	0.457*	0.416*	0.284*
Fruit length	G							1.000	0.609**	0.390*
	P							1.000	0.329*	0.193
Fruit girth	G								1.000	0.797**
	P								1.000	0.662**
Yield/plant	G									1.000
	P									1.000

*, ** Significant at 0.05% and 0.01% probability respectively; G, P: Genotypic and Phenotypic Coefficient of correlation

Table 3. Estimates of direct and indirect effects of yield and yield related characters in okra

Character	Level	Plant height	Internode length	Node number at 1 st fruit	Number of nodes/plant	Number of fruits/plant	Ave. fruit weight	Fruit length	Fruit girth	Correlation with yield
Plant height	G	-0.245	-0.403	-0.003	0.073	1.148	-0.004	0.022	-0.028	0.876
	P	0.172	-0.013	-0.004	-0.015	0.405	0.014	-0.005	0.024	0.766
Internode length	G	-0.216	-0.458	-0.003	0.085	1.009	-0.018	0.047	-0.029	0.789
	P	0.127	-0.018	-0.006	-0.020	0.401	0.042	-0.006	0.026	0.747
Node number at 1 st fruit	G	-0.056	-0.104	-0.013	0.087	0.008	0.008	-0.104	-0.000	-0.015
	P	0.026	-0.004	-0.028	-0.017	0.010	-0.014	0.003	-0.001	0.014
Number of nodes / plant	G	-0.115	-0.251	-0.007	0.156	0.490	-0.006	-0.076	-0.014	0.407
	P	0.060	-0.008	-0.011	-0.043	0.159	0.011	-0.002	0.008	0.297
Number of fruits/plant	G	-0.225	-0.370	-0.000	0.061	1.251	-0.001	0.065	-0.026	0.662
	P	0.120	-0.12	-0.001	-0.012	0.578	0.023	-0.016	0.023	1.035
Average fruit weight	G	-0.022	-0.197	0.002	0.022	0.266	-0.043	0.149	-0.015	0.306
	P	0.017	-0.005	0.003	-0.003	0.095	0.140	-0.030	0.017	0.284
Fruit length	G	-0.021	-0.087	0.005	-0.048	0.325	-0.025	0.251	-0.021	0.390
	P	0.014	-0.002	0.001	-0.001	0.137	0.064	-0.066	0.013	0.193
Fruit girth	G	-0.200	-0.390	-0.000	0.066	0.954	-0.019	0.153	-0.034	0.193
	P	0.106	-0.012	0.001	-0.009	0.334	0.058	-0.022	0.040	0.797

Path coefficient analysis studies revealed that number of fruits plant⁻¹ showed the highest positive effect (1.251) on yield plant⁻¹ (Table 3). Among the characters studied, all the traits showed positive direct effect on yield except internode length which showed negative direct effect on yield plant⁻¹. The highest indirect effect of number of fruits plant⁻¹ was observed with plant height (1.148), internode length (1.009) followed by fruit girth (0.954). These characters also showed significant positive correlation with yield. These findings indicating that direct selection for these traits might be effective and there is possibility of improving yield plant⁻¹. Similar results have been reported by Nasit *et al.* (2010) and Mehta *et al.* (2006).

The above finding suggested that for getting higher yield, selection should be practiced for yield related traits giving equal importance to number of fruits, number of nodes, plant height and the selected genotypes may be tested under potential areas for identification of best cultivar either for general cultivation or for using in future breeding programme.

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INFLUENCE OF SOWING DATE ON YIELD AND YIELD COMPONENTS OF BAJRA IN RAINFED ALFISOLS OF ANDHRA PRADESH

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ABSTRACT

A field experiment was conducted in split plot design during *khariif* 2013 and 2014 on sandy loam soils in bajra to find out the suitable sowing time for hybrid bajra. The results revealed that second fortnight of June recorded significantly higher yield attributes viz. ear head length, girth, weight, 1000 grain weight and grain yield of bajra hybrid PHB-3 compared to rest of the dates of sowing. The heat use efficiency (HUE) and heliothermal use efficiency (HTUE) was the highest with June second fortnight sown crop.

KEYWORDS: Bajra, Thermal Unit, HUE

INTRODUCTION

In India bajra is cultivated in an area of 8.9 million hectares with grain production of 6.51 million tones and productivity of 731 kg ha⁻¹. In Andhra Pradesh, it is cultivated in an area of 0.05 million hectares with grain production of 0.05 million tones and productivity of 1178 kg ha⁻¹. Bajra is a coarse grain crop and drought tolerant suitable to cultivate in drylands of Andhra Pradesh. Sowing during appropriate time enables any crop to take full advantage of favourable weather conditions. Sowing time for rainy season crops can be determined through information on onset and withdrawal of monsoon, probability of rainfall and rainfall distribution. However, determination of sowing time depends upon the soil moisture availability, optimum temperature, heat unit requirement and thermal use efficiency of crops. (Sahu *et al.*, 2007)

MATERIALS AND METHODS

Two hybrids of bajra viz. PHB-3 and PHB-306 were sown on three different dates viz. 30th May, 15th June and 30th June 2013 at an interval of 15 days during *khariif* season of 2013 and 2014 in the dryland farm of Regional Agricultural Research Station, Tirupati in a split plot design with dates of sowing as main plot and bajra hybrids as sub plot treatments. Recommended agronomic practices were adopted for the region on red sandy loam soils was adopted for growing bajra crop. The soil of the experimental site was sandy loam with a pH of 6.8, E.C

of 0.11, organic carbon of 0.18 available N of 129 kg ha⁻¹ available P of 10.2 kg ha⁻¹ and available K of 139.7 kg ha⁻¹.

Periodical observations on phenological development, yield and yield attribute characters (Table 1) were recorded. Growing degree days (GDD) were calculated using base temperature of 10°C from daily mean temperature. The thermal use efficiency for the seed yield of bajra was computed as heat use efficiency and heliothermal use efficiency.

Heat use Efficiency (HUE) = Seed yield (kg ha⁻¹) / GDD °C day.

Heliothermal use Efficiency (HTUE) = Seed yield (kg ha⁻¹) / HTU °C hr.

RESULTS AND DISCUSSION

Yield and Yield attributes

The yield attributing characters like ear head girth (10.3 cm) and 1000 grain weight (9.98 g) were superior in June 2nd fortnight sowing where the crop received good distribution of rainfall with optimum temperature and maximum bright sunshine hours during 2013 (Table 1a). Among the hybrids, PHB-3 recorded the highest ear head length (23.97 cm), girth (10.2 cm) weight (41.72 g) and 1000 grain weight (9.08g) which are significantly superior than PHB-306. Similarly during 2014 (Table 1b) all the yield attributing characters like ear head length (23.11 cm), girth (10.11 cm), ear head weight (29.02 g) and 1000

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Table 1a: Effect of sowing dates on yield attributes and yield of Bajra hybrids during *Kharif*, 2013

Treatment	Plant height (cm)	Ear head length (cm)	Ear head girth (cm)	Ear head weight plant ⁻¹ (g)	1000 grain weight (g)	Grain yield (Kg ha ⁻¹)	Straw yield (Kg ha ⁻¹)
Date of Sowing (D)							
D1-31.5.2013	136.4	22.93	9.6	38.60	7.19	3341	14596
D2-15.6.2013	144.0	23.00	10.0	38.45	9.13	3892	9342
D3-28.6.2013	133.1	22.59	10.3	39.22	9.98	4326	4828
CD 5%	NS	NS	0.42	NS	0.98	742	1512
Hybrids (H)							
H1 (PHB-3)	142.6	23.97	10.2	41.72	9.08	4004	11077
H2 (PHB-306)	132.9	21.71	9.8	35.78	8.45	3701	8101
CD 5%	NS	0.93	0.45	2.81	0.61	301	1937
D × H	Sig	NS	NS	NS	NS	NS	Sig

Table 1b: Effect of sowing dates on yield attributes and yield of Bajra hybrids during *kharif*, 2014

Treatment	Plant height (cm)	Ear head length (cm)	Ear head girth (cm)	Ear head weight/plant (g)	1000 grain weight (g)	Grain yield (Kg ha ⁻¹)	Straw yield (Kg ha ⁻¹)
Date of Sowing (D)							
D1-30.5.2014	137.95	18.92	9.3	26.80	7.75	4833	12072
D2-15.6.2014	138.76	19.54	9.52	27.95	6.18	5572	13691
D3-30.6.2014	143.87	23.11	10.11	29.02	12.7	6937	14083
CD 5%	NS	2.13	0.38	1.60	1.16	208	861
Hybrids (H)							
H1(PHB-3)	143.06	10.04	28.71	9.21	21.72	6335	21.72
H2(PHB-306)	137.32	9.25	27.13	8.54	19.33	5226	19.33
CD 5%	5.11	0.46	NS	0.61	1.88	264	1.88
D × H	NS	NS	NS	NS	NS	NS	NS

Table 2a: Duration and accumulated heat units, thermal use efficiency for different dates of bajra sowing (2013)

Treatment	Duration	GDD	DV	HTU	HUE	HTUE
D1	95	2891	9.44	10,089	1.15	0.33
D2	95	2873	9.32	10,227	1.36	0.38
D3	91	2677	9.01	9,637	1.62	0.45

Table 2b: Duration and accumulated heat units, thermal use efficiency for different dates of bajra sowing (2014)

Treatment	Duration (days)	GDD	DV	HTU	HUE	HTUE
D1	91	2877	10.6	12243	1.68	0.39
D2	88	2705	10.3	10395	2.06	0.53
D3	95	2782	10.3	10866	2.49	0.63

grain weight (12.7 g) are superior in June 2nd fortnight sowing and PHB-3 recorded superior performance in yield and yield attributing characters. During both the years, the interaction effect was not significant among the dates of sowing and hybrids.

In the present study significantly higher grain yield (4326 and 6937 kg ha⁻¹) of bajra was recorded when the sowing was done at 2nd fortnight of June (D3) followed by June 1st fortnight (D2) (3892 and 5572 kg ha⁻¹) respectively during 2013 and 2014 (Table 1a and 1b). Significantly lower yield was observed with 1st date of sowing (D1) (3341 and 4833 kg ha⁻¹) in both the years of study. The variation in grain yield of bajra during the both the years was due to difference in amount of rainfall received, but both the years showed similar trend (Deshmukh *et al.*, 2009).

During both the years D1 (May 2nd fortnight) sown crop received less amount of rainfall with less rainy days during its growth period whereas June 1st and June 2nd fortnight sown crops received good amount of rainfall with well distribution and bright sunshine hours which might have contributed in getting good yields. The earliest sown crop experienced extreme moisture stress during the earhead emergence period which drastically reduced the partitioning of drymatter to earhead and its development could not be received even with sufficient moisture conditions later on. On the other hand, favourable moisture conditions during entire period enhanced the contribution to earhead considerably, as in case of June

2nd fortnight sowing (Annual reports of AICRP on Agrometeorology 2000-01). The heat use efficiency and heliothermal efficiency was highest in June 2nd fortnight sown crop compared to May 2nd fortnight and June 1st fortnight crop in both the years (Table 2a and 2b). The efficiency of thermal energy conversion for yield and dry matter production depend upon the genetic factors of crop and sowing time. The thermal use efficiencies were the highest for 3rd sowing (June 2nd fortnight) followed by 2nd and 1st sowings. The poorest thermal use efficiency was observed under the 1st sowing, which might have resulted low yields of bajra.

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