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LEAFHOPPER FAUNA ASSOCIATED WITH GROUNDNUT CROP ECOSYSTEM IN RAYALASEEMA REGION OF CHITTOOR DISTRICT IN ANDHRA PRADESH

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ABSTRACT

Nine leafhopper species were collected, identified and described from groundnut crop ecosystem in Rayalaseema region of Chittoor district of Andhra Pradesh. The leafhopper fauna collected from grounndut includes, *Exitianus indicus* (Distant), *Cofona spectra* (Distant), *Empoasca kerri* (Pruthi), *Empoasca motti* (Pruthi) and *Empoasca spirosa* (Dworakowska), *Empoascanara indica* (Dworakowska), *Bactracomorphus angustatus* (Osborn), *Balclutha incisa* (Matsummura) and *Balclutha saltuella* (Kirschbaum). An illustrated key along with diagnostic taxonomic characters were provided for easy identification of the leafhoppers associated with groundnut crop eco-systems.

KEYWORDS: Leafhoppers, Groundnut

INTRODUCTION

Leafhoppers, an economically important group of Auchenorrynchan Hemiptera belong to the family Cicadellidae comprising about 2,445 described genera and 22,637 species in the world and 340 genera and 1,350 species in India (Viraktamath, 2006). Leafhoppers are small wedge shaped insects of various forms, colours, sizes and can be readily distinguished from other members of Auchenorryncha by having one or more rows of small spines extending the length of hind tibia. Viraktamath (2006) carried out taxonomic studies on the economically important leafhoppers of the Indian subcontinent under the Emeritus Scientist Project financed by the Indian Council of Agricultural Research, in which he has provided the keys to subfamilies, tribes and genera and also the checklist of leafhoppers of Indian subcontinent with colour photographs for more than 198 species of leafhoppers. Leafhoppers besides causing yield loss through direct feeding activity, also act as vectors of important viral diseases that cause fatal disease and death of plants. In Andhra Pradesh, groundnut is grown in an area of 735 million hectares with a total production of 1048.41 million tonnes and productivity of 1426 kg ha^{-1} (Anonymous, 2018a). In Chittoor district, groundnut is grown in an area of 1.29 lakh hectares, with a total production 10.5 lakh tonnes and productivity of 1426 kg ha^{-1} (Anonymous, 2018b). Amongst sucking pests, leafhoppers were reported to cause a serious damage incurring losses up to 22 per cent throughout the crop growth period. The knowledge on accurate identification and biology of a pest allows formulating the management strategies effectively. This article describes the taxonomy of leafhopper fauna associated with groundnut crop in Chittoor district.

MATERIAL AND METHODS

Intensive surveys were conducted and large number of leafhopper specimens were collected from ten mandals of Chittoor district in Andhra Pradesh. About 10-15 to and fro net sweepings were taken each time and leafhoppers collected were aspirated from the net into a glass tube and killed with a cotton swab wetted with a few drops of ethyl acetate. The killed specimens were transferred to homeopathic vials, labelled, brought to the laboratory and dried in a hot air oven at 45-50 ^{0}C, for about 5 to 6 hours. For mounting and preparing slides of genitalia the procedure suggested by Knight (1965) was followed. For describing the different body parts the terminology suggested by O'Brien and Wilson (1985) was followed.

RESULTS AND DISCUSSION

During the present studies, from groundnut crop ecosystems of Rayalaseema region of Chittoor district, the following leafhopper fauna were collected, identified and described to facilitate easy identification by economic entomologists.

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S. No.	Crop	Species	Family
1.	Groundnut	*Exitianus indicus* (Distant)	Cicadellidae
2.	Groundnut	*Cofona spectra* (Distant)	Cicadellidae
3.	Groundnut	*Empoasca kerri* (Pruthi)	Cicadellidae
4.	Groundnut	*Empoasca motti* (Pruthi)	Cicadellidae
5.	Groundnut	*Empoasca spirosa* (Dworakowska)	Cicadellidae
6.	Groundnut	*Empoascanara indica* (Dworakowska)	Cicadellidae
7.	Groundnut	*Bactracomorphus angustatus* (Osborn)	Cicadellidae
8.	Groundnut	*Balclutha incisa* (Matsummura)	Cicadellidae
9.	Groundnut	*Balclutha saltuella* (Kirschbaum)	Cicadellidae

The most brief and important taxonomic and morphological characters of the above keyed species were provided here under for confirmation of identifications.

***Exitianus indicus* (Distant) (Fig. 1a-1d and Plate 1A):** Head as wide as pronotum. Vertex moderately acute with a median coronal suture. Ocelli located on anterior margin of the vertex away from the eyes by their own diameter. Clypellus slightly narrower towards vertex and extended upto the margins of genae. Pronotum wider than long. Forewings elongate, subhyaline with four apical and three anteapical cells and appendix wider. Aedeagus simple, curved having an articulation between shaft and base, apex notched. Gonopore large and subapical.

***Cofona spectra* (Distant) (Fig. 2a, 2b and Plate 1B):** Head wider than pronotum. Vertex shorter than pronotum with distinct ocelli on the basal portion of vertex. Clypeaus and clypellus are swollen. Forewings subhyaline with four apical and three ante-apical cells and appendix present. Sternal abdominal apodemes present**.** Aedeagus is 'C' shaped with the caudal end bifurcated in lateral view.

***Empoasca kerri* (Pruthi) (Fig. 3a-3d and Plate 1C):** Head as wide as pronotum. Vertex subacute and coronal suture not conspicuous; ocelli present on the anterior margin of vertex close to the eyes; clypellus parallel sided, extending beyond the margins of genae. Pronotum wider than its length. Forewings subhyaline with four apical cells, ante-apical cells and appendix absent; hindwings hyaline. Abdominal apodemes well developed, elongated and tube like. Aedeagus tubular, notched and broader apically and gradually narrowed towards the proximal end.

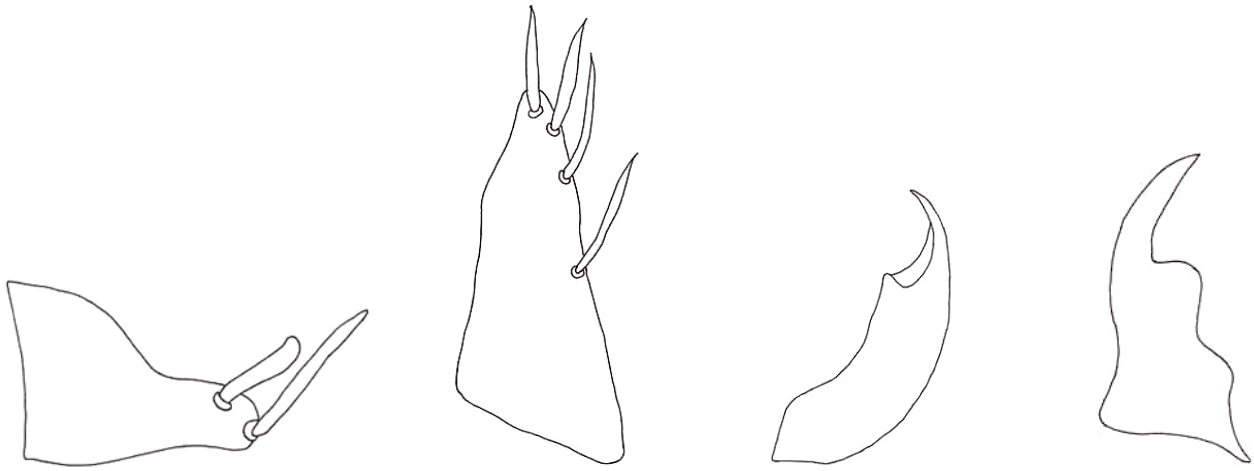
***Empoasca motti* (Pruthi) (Fig. 4a-4d and Plate 1D):** Head slightly broader than the pronotum. Vertex subacute and coronal suture indistinct. Ocelli distinct and situated on the outer margin of the vertex, which are away from the compound eyes. Forewings subhyaline with four apical cells, anteapical cells and appendix absent. Aedeagus is tubular, bulbous in middle and apex is broadened.

***Empoasca spirosa* (Dworakowska and Viraktamath) (Fig. 5a-5e and Plate 1E):** Head slightly wider than pronotum. Vertex subacute with distinct coronal suture. Ocelli conspicuous and close to the eyes. Forewings light green colour with four apical cells, anteapical cells and appendix absent; hindwings hyaline. Abdominal apodemes well developed. Aedeagus tubular, broad in the middle and apex rod like.

***Empoascanara indica* (Datta) (Fig. 6a-6f and Plate 1F):** Head as wide as or slightly broader than pronotum. Vertex subacute, smaller than its width between the eyes, median sulcus seen clearly. Ocelli present on face away from the eyes**.** Clypellus wider at base and gradually narrowed to apex, extending to margins of genae. Forewings subhyaline with four apical cells. Anteapical cells and appendix are absent. Hind wings hyaline with two apical cells. Aedeagus with its shaft simple, tubular, without any processes, broader at base, abruptly narrowed towards apex and gonopore subapical.

***Bactracomorphus angustatus* (Osborn) (Fig. 7a-7c and Plate 1G):** Head narrower than the pronotum. Vertex short, transversely rugose and anterior margin broadly rounded in dorsal aspect. Ocelli large, located on the anterior margin of face away from the eyes, twice their own diameter. Clypellus distinctly short and parallel sided. Pronotum transversely rugose and lateral margins carinate. Forewings subhyaline with four apical and three ante-apical cells. Appendix well developed. Aedeagus

Leafhopper fauna associated with groundnut crop ecosystem in Chittoor district of Rayalaseema region of Andhra Pradesh



1a **1b** **1c** **1d**

Fig. 1a - 1d. *Exitianus indicus* (Distant):
1a. Pygofer lobe, lateral view; 1b. Subgenital plate; 1c. Aedeagus, lateral view; 1d. Style.

2a **2b**

Fig. 2a, 2b. *Cofona spectra* (Distant): 2a. Aedeagus, dorsal view; 2b. Aedeagus, lateral view.

3a **3b** **3c** **3d**

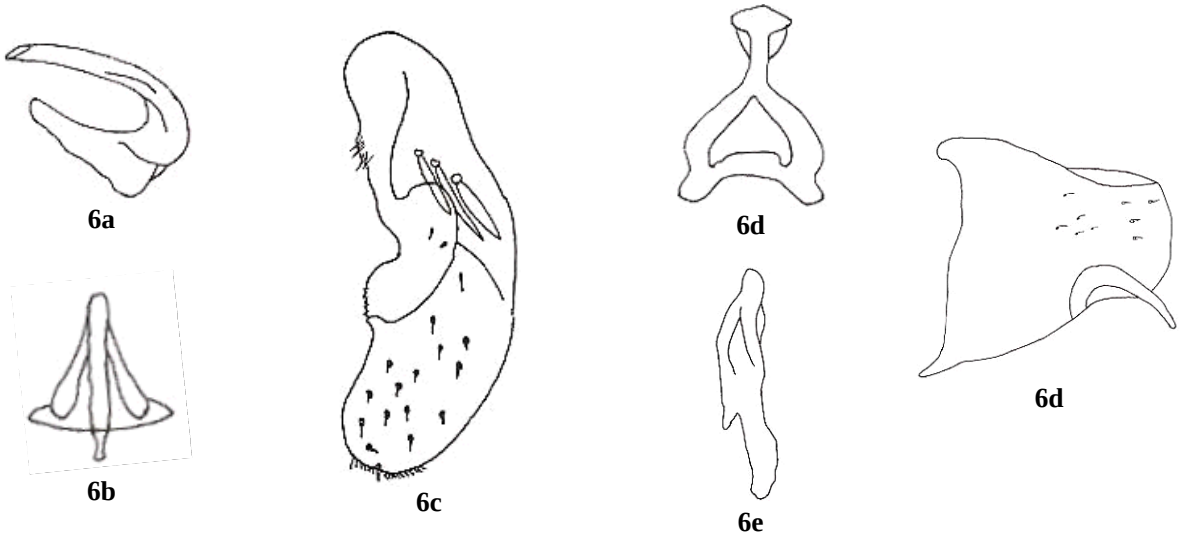
Fig. 3a - 3d: *Empoasca (Empoasca) kerri* Pruthi:
3a. Abdominal apodemes; 3b. Sub genitalplates 3c. Styles; 3d. Aedeagus (lateral view).

4a **4b** **4c** **4d**

Fig. 4a - 4f: *Empoasca (Empoasca) motti* Pruthi:
4a. Abdominal apodemes; 4b. Sub genitalplates; 4c. Styles; 4d. Aedeagus (dorsal view).

5a **5b** **5c** **5d** **5e**

Fig. 5a - 5e: *Empoasca (Empoasca) spirosa* Dworakowska and Viraktamath:
5a. Abdominal apodemes; 5b. Sub genitalplates; 5c. Pygofer process;
5d. Styles; 5e. Aedeagus (dorsal view).

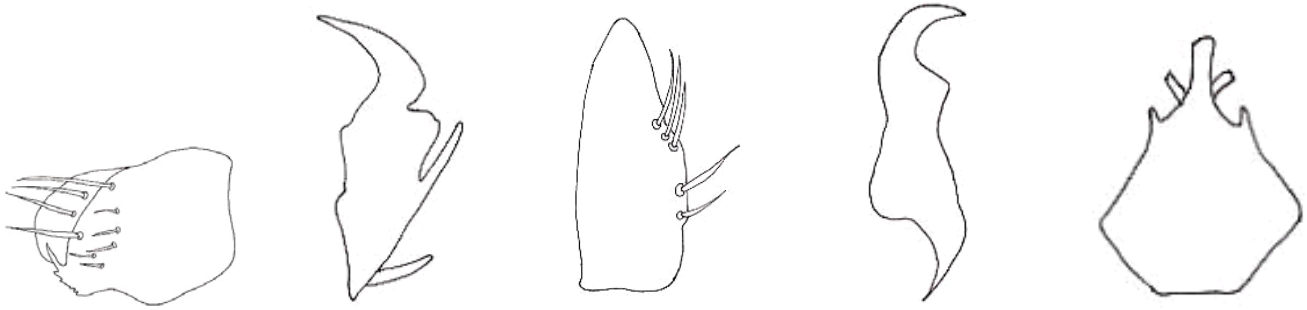


6a **6b** **6c** **6d** **6e** **6d**

Fig. 6a - 6f. *Empoascanara indica* (Datta):
6a. Aedeagus, lateral view; 6b. Aedeagus, dorsal view; 6c.Subgenital plate;
6d. Connective; 6e. Style; 6f. Pygofer.

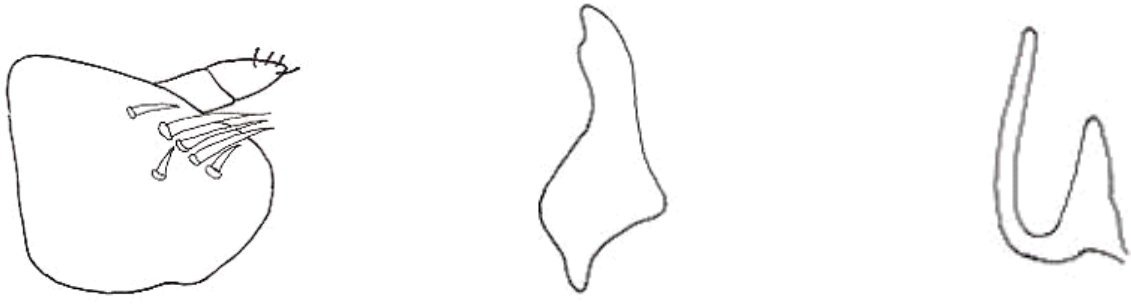
7a **7b** **7c**

Fig. 7a - 7d. *Batracomorphus agustatus* (Osborn):
7a. Aedeagus, lateral view; 7b. Style; 7c. Subgenital plate.



8a **8b** **8c** **8d** **8e**

Fig. 8a - 8e: *Balclutha incisa* (Matsumura):
8a. Pygofer, lateral view; 8b. Aedeagus, lateral view; 8c. Subgenital plate;
8d. Style; 8e. Aedeagus, dorsal view.



9a **9b** **9c**

Fig. 9a - 9c. *Balclutha saltuella* (Kirschbaum):
9a. Pygofer, lateral view; 9b. Style; 9c. Aedeagus, lateral view.

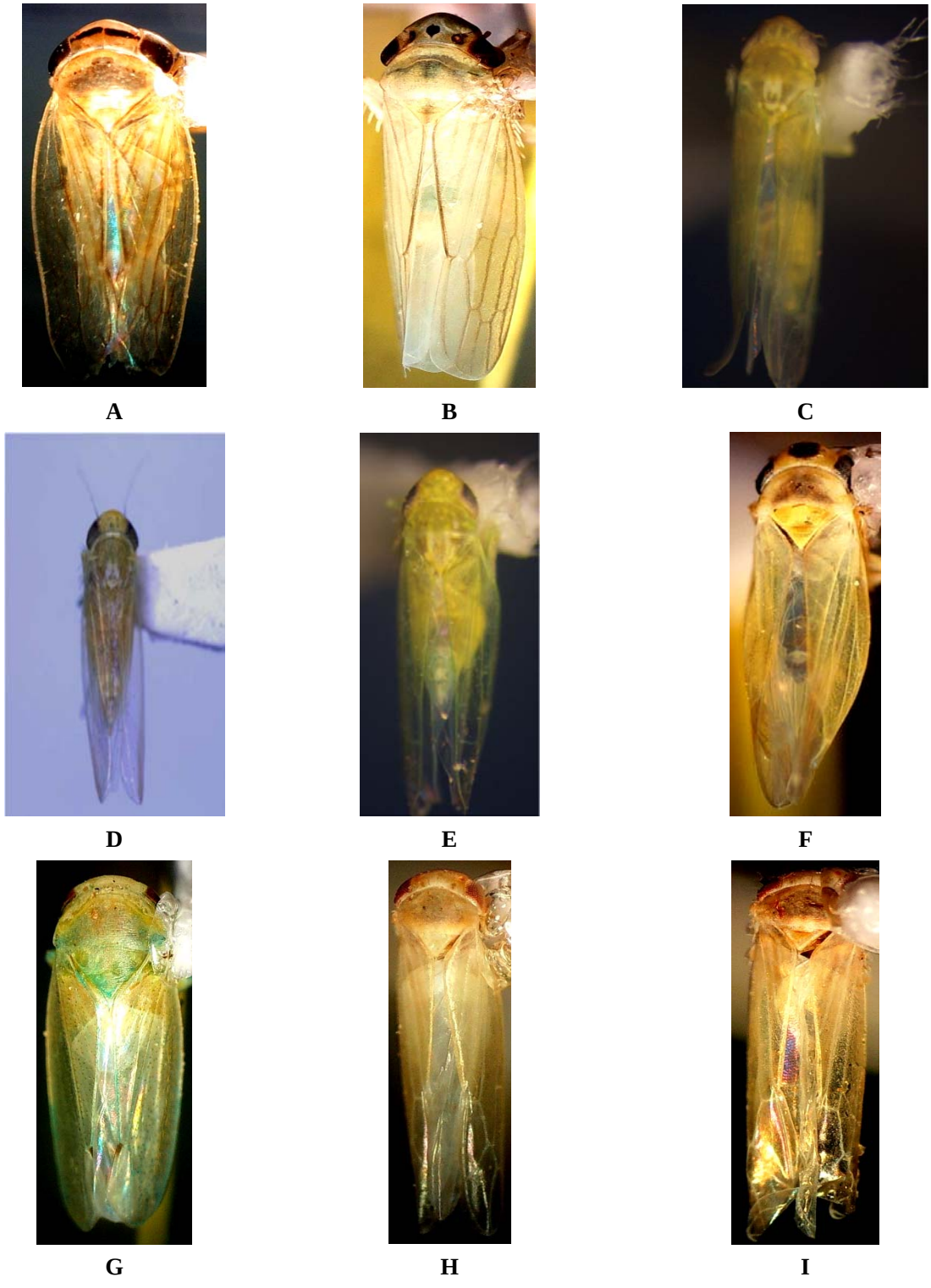


Plate 1: **A. *Extianus indicus* (Distant); B. *Cofona spectra* (Distant); C. *Empoasca (Empoasca) kerri* Pruthi; D. *Empoasca (Empoasca) motti* Pruthi; E. *Empoasca (Empoasca) spirosa* Dworakowska and Viraktamath; F. *Empoascanara indica* (Datta); G. *Bactraomorphus angustatus*; H. *Balclutha incisa* (Matsumura); I. *Balclutha saltuella* (Kirschbaum).**

loosely articulated with connective. The tip of aedeagus is clefted with two finger like projections which are widely separated.

***Balclutha incisa* (Matsummura) (Fig. 8a-8e and Plate 1H):** Head more or less as wide as pronotum. Vertex is of uniform length, much shorter than pronotum. Ocelli present on anterior margin of vertex and visible dorsally. Forewings long and slender with wider appendix and with four apical cells and only two ante-apical cells, inner one opens basally. Aedeagus broad basally with 3 pairs of processes, shaft slender directed posteriorly and curved anteriorly; gonopore apical.

***Balclutha saltuella* (Kirschbaum) (Fig. 9a-9c and Plate 1I):** Head wider than pronotum. Vertex rounded. Ocelli located on anterior margin of vertex near to the eyes. Scutellum shorter than pronotum. Pronotum shorter in length than width, plain and glabrous. Forewings long, slender, hyaline to subhyaline, appendix wider. Forewings are with three apical and two anteapical cells. Aedeagus elongate simple, shaft narrow; gonopore apical.

Young (1979) reviewed genus *Cofana* thoroughly and described seven species. Sohi and Dworakowska (1983) described 22 species in the genus *Empoasca nara*. Mathew and Ramakrishnan (1995) reported the occurrence of *E.* (*E.*) *kerri* in groundnut from Kerala. In 1995, Mathew and Ramakrishnan recorded *E.* (*E.*) *motti* on colocasia and cowpea. Jacob *et al*. (2000) reported *E. indicus* on groundnut from Andhra Pradesh. Jacob *et al*. (2002) reported the occurrence of *B. incisa* on greengram, blackgram and pigeon pea and *B. saltuella* on greengram, blackgram, pigeon pea, chickpea, soyabean and cowpea from Andhra Pradesh. Kandakoor (2011) reported the occurrence of *B. angustatus* on groundnut. Bhandhavi (2010) studied *E.* (*E.*) *kerri* and *E.* (*E.*) *spirosa* associated with vegetable crop ecosystems in Rayalaseema area. Nagesh (2018) collected, identified and described *B. angustatus* on fingermillet and maize in Rayalaseema region. In the present studies nine leafhopper species belonging to family Cicadellidae from groundnut crop eco systems were collected, identified, described and illustrated for easy and quick identification. Illustrations were also provided which will be useful aid to identify the leafhoppers by research and extension workers. The accurate identification of leafhopper fauna associated with a particular agro-ecosystem is very much needed to formulate integrated management strategies whenever they attain pest status.

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INTEGRATED NUTRIENT MANAGEMENT FOR ENHANCING GROWTH AND PRODUCTIVITY OF MAIZE (*Zea mays* L.)

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ABSTRACT

A field experiment entitled integrated nutrient management for enhancing productivity and profitability of maize (*Zea mays* L.) was conducted on sandy loam soils of dry land farm of Sri Venkateswara Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University during *kharif*, 2019. The experiment was laid out in randomized block design with nine treatments replicated thrice. The highest dry matter production, kernel yield stover yield and harvest index in maize were recorded with application of STBR + FYM @ 5 t ha^{-1} (T_8), which was statistically at par with the application of STBR + *Azospirillum*+ PSB + KSB + ZnB (T_9) and soil test based recommendation (T_7) and significantly superior over the rest of the treatments tried The lowest dry matter production, kernel yield stover yield and harvest index were observed with control (T_1).

KEYWORDS: Dry matter production, Kernel yield, INM and Maize.

INTRODUCTION

Maize (*Zea mays* L.) is the third important cereal crop next to rice and wheat in the world. It is mainly used as a food for human, feed for livestock and also a major source of industrial products like corn oil, flour, corn sugar, starch, alcohol and syrup. Worldwide maize is grown over an area of 180 million hectares with a production of 1033 million tonnes and productivity of 5.71 tonnes per hectare. In India, it is grown over an area of 9.5 million hectares with a production of 25 million tonnes with a productivity of 2.6 tonnes per hectare (Anonymous, 2017). In spite of magnificent progress in acreage as well as production for the past two decades, the productivity of maize in India is far below compared to the world average productivity.One of the reasons for lower production is imbalanced use of fertilizers by the farmers without knowing soil fertility status and nutrient requirement of crops, which causes adverse effects on soil and crop both in terms of nutrient toxicity and deficiency (Ray *et al*., 2000).

Usage of chemical fertilizers in the recent past is increasing day by day in order to achieve higher productivity which led to the deleterious effect on the environment as well as soil health.It has been found that no single source of nutrient is capable of supplying the necessary elements in adequate and balanced proportion and the use of inorganic fertilizers being a costly affair also leads to deterioration of soil health and quality of the produce. However, the use of organic sources alone, do not result in spectacular increase in crop yields, due to their low nutrient status and are also not easily available for a large scale use. Hence balanced nutrition is one of the essential and necessary components of nutrient management, which plays a major role in increasing the productivity and quality of maize. Keeping this in view the present study was conducted to study the effect of "Effect different integrated nutrient management practices on growth parameters of maize (*Zea mays* L.)"

MATERIAL AND METHODS

The field experiment was carried out in Dryland Farm at S.V. Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University during Kharif 2019 on sandy loam soils with low in available nitrogen, medium in available phosphorus, potassium and zinc. The test hybrid of maize DHM-117, was used in the experiment..The experiment was laid out in randomized block design with nine treatments replicated thrice.The treatments consists of T_1 : Control, T_2 : RDF (180-60-50 kg N, P_2O_5 and K_2O ha^{-1}), T_3 : RDF + FYM @ 5 t ha^{-1}, T_4 : RDF + *Azospirillum* + PSB + KSB + ZnB, T_5 : 75% RDF + FYM @ 5 t ha^{-1}, T_6 : 75% RDF + *Azospirillum* + PSB + KSB + ZnB, T_7 : Soil test based fertilizer recommendation (STBR), T_8 : STBR + FYM @ 5 t ha^{-1} and T_9 : STBR + *Azospirillum*+ PSB + KSB + ZnB. Five

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plants at random from the border rows leaving the extreme row were destructively sampled at 25, 50, 75 DAS and at harvest. The plant samples were shade dried and then oven dried at 60°C to a constant weight and expressed in kg ha^{-1}. Grain and stover yield of each net plot was recorded separately and finally calculated in terms of kg ha^{-1}. Harvest Index (HI) was calculated by using the following formula given by Singh and Stoskofif (1971) and expressed in percentage.

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}}$$

RESULTS AND DISCUSSION

Dry Matter Production

Dry matter production of maize was significantly influenced by various integrated nutrient management practices (Table1). Among all the treatments, application of STBR + FYM @ 5 t ha^{-1} (T_8) recorded significantly higher dry matter production, which was statistically at par with application of STBR + *Azospirillum*+ PSB + KSB + ZnB (T_9) and soil test based recommendation (T_7) at all the stages of observation. The increase in dry matter production due to the application of STBR + FYM @ 5 t ha^{-1} (T_8) might be the result of increase in the plant stature, size and number of leaves, that might have increasedthe dry matter production and this was in agreement with the findings of Priya *et al*. (2014). STBR + *Azospirillum*+ PSB + KSB + ZnB (T_9) performed better due to the mobilization of nutrients in the soil by the favourable effect of bio fertilizers, which in turn increase the photosynthetic area, as a result increase in size and number of leaves thus increase in the dry matter production. Enhanced growth of maize under elevated supply of nutrients has been undisputed fact and universally acceptable proportion as could be visualized from the research evidence (Kumar *et al.,* 2010). The next best treatment producing higher dry matter production was RDF + FYM @ 5 t ha^{-1} (T_3), which was statistically at par with RDF + *Azospirillum* + PSB + KSB + ZnB (T_4) and RDF(T_2) followed by 75% RDF + FYM @ 5 t ha^{-1} (T_5) and 75% RDF + *Azospirillum* + PSB + KSB + ZnB (T_6).The lowest dry matter production was noticed in control (T_1) due to poor nutrient status of the soil.

Seed, Stover Yield and Harvest index

Seed yield and stover yield of maize differed significantly with different integrated nutrient management practices (Table 2). Application of fertilizers based on STBR + FYM @ 5 t ha^{-1} (T_8) recorded the highest seed and stover yield in maize, which was statistically at par with application of STBR + *Azospirillum*+ PSB + KSB + ZnB and soil test based recommendation. Seed yield of maize is a function of yield attributes, which were significantly higher with these nutrient management practices. Further due to supply of elevated levels of nitrogen, which might have facilitated better growth and development of maize and which ultimately increased the yield components and yield. Similar results were also reported by Rani *et al*. (2012) and Khan *et al*. (2018). Enhanced stover yield is the outcome of the positive and synergistic interaction between the nutrient supply and growth stature of maize as reflected in enhanced growth parameters with supply of highest dose of NPK. The increase in biological yield is also attributed to increase in plant height, number of leaves and dry matter production (Fageria *et al.,* 2006).

The next best treatment was RDF + FYM @ 5 t ha^{-1} (T_3), which was statistically at par with RDF + *Azospirillum* + PSB + KSB + ZnB (T_4) and RDF (T_2), which was significantly superior over 75% RDF + FYM @ 5 t ha^{-1} (T_5) and 75% RDF + *Azospirillum* + PSB + KSB + ZnB (T_6). The increase in grain yield might be due to the mobilisation of nutrients in the soil and making it more available to the plant resulting in better growth of the plant coupled with early flowering, better translocation of photosynthates to the sink, which in turn resulted in more number of larger sized seeds and finally higher yield.

Application of STBR + *Azospirillum*+ PSB + KSB + ZnB (T_9) resulted in 26 per cent increase in the grain yield over 100% RDF (T_2). This may be due to increased nutrient availability with application of 125% RDN (225 kg ha^{-1}) in combination with FYM, which might have been utilized by crop leading to higher values of growth and yield components, which ultimately increased the grain yield of maize. The results are in corroborative with the findings of Khambalkar *et al*. (2017) and Trimurthulu and Rao (2014). Similarly application of 100 RDF + FYM @ 5 t ha^{-1} (T_3) recorded 26 percent higher grain yield in maize compared to application of 75 RDF + FYM @ 5 t ha^{-1}(T_5), and this might be due to poor performance of maize at sub-optimal dose of nitrogen in T_5.

Control (T_1) recorded the lowest seed and stover yield because of the deflated stature of growth parameters

Table 1. Dry matter production (kg ha^{-1}) at different stages of maize asinfluenced by integrated nutrient management practices

Treatments	Dry matter production (kg ha^{-1})			
	25 DAS	50 DAS	75 DAS	At harvest
T_1 : Control	162	1260	1825	2820
T_2 : RDF (180-60-50 kg N, P_2O_5 and K_2O ha^{-1})	299	2791	6100	9328
T_3 : RDF + FYM@ 5 t ha^{-1}	312	2882	6338	9780
T_4 : RDF + *Azospirillum* + PSB + KSB + ZnB	309	2808	6251	9565
T_5 : 75% RDF + FYM @ 5 t ha^{-1}	276	2518	5410	8450
T_6 : 75% RDF + *Azospirillum* + PSB + KSB + ZnB	274	2492	5400	8100
T_7 : Soil test based fertilizer recommendation (STBR)	331	3125	6752	10680
T_8 : STBR + FYM @ 5 t ha^{-1}	341	3246	6942	10890
T_9 : STBR + *Azospirillum* + PSB + KSB + ZnB	336	3194	6804	10688
SEm±	6.0	46.2	108.1	198.4
CD (P= 0.05)	18	141	328	600

Table 2. Seed yield, stover yield (kg ha^{-1}) and harvest index (%) of maize as influenced by integrated nutrient management practices

Treatments	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
T_1 : Control	629	1871	25.16
T_2 : RDF (180-60-50 kg N, P_2O_5 and K_2O ha^{-1})	4140	4875	45.90
T_3 : RDF + FYM@ 5 t ha^{-1}	4410	4990	46.80
T_4 : RDF + *Azospirillum* + PSB + KSB + ZnB	4278	4990	46.20
T_5 : 75% RDF + FYM @ 5 t ha^{-1}	3498	4444	44.00
T_6 : 75% RDF + *Azospirillum* + PSB + KSB + ZnB	3321	4379	43.12
T_7 : Soil test based fertilizer recommendation (STBR)	5020	5420	48.08
T_8 : STBR + FYM @ 5 t ha^{-1}	5400	5696	48.66
T_9 : STBR + *Azospirillum* + PSB + KSB + ZnB	5120	5468	48.35
SEm±	130	140	0.29
CD (P = 0.05)	400	424	0.91

and yield attributes and finally lower yields due to the deficiency of N, P, K and Zn as the experimental soil is poor in all the above nutrients in available form, there by poor root and shoot growth. These results are corroborated with the findings of Ramachandrappa *et al.* (2007) and Zerihun *et al*., (2013), Priya *et al*., (2014), Lone *et al*., (2013) and Shanwad *et al*., (2010).

Among the various treatments, the highest harvest index (48.66) in maize was obtained with the application of STBR + FYM @ 5 t ha^{-1}, which was statistically at par with the application of STBR + *Azospirillum*+ PSB + KSB + ZnB (48.35) and soil test based recommendation (48.08) and was significantly superior over the other treatments tried. This might due to better absorption, translocation of essential nutrients in balanced proportion, which increased the physiological activity of the plant to mobilize the photosynthates from source towards sink. Application of STBR + FYM @ 5 t ha^{-1} (T_8) might have resulted in maintaining the crop demand during its peak period, thus resulting in higher grain yield and finally the increment in the harvest index. Control (T_1) resulted in the lowest harvest index over other treatments (5) that might be due to the poor soil nutrient reserve in the soil causing poor source sink relationship during the crop peak period, which in turn resulted in poor yields and thus lower harvest index.

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EVALUATION OF DIFFERENT STORAGE CONTAINERS AGAINST PULSE BEETLE *Callosobruchus chinensis* (Linnaeus) IN BLACKGRAM

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ABSTRACT

A laboratory experiment was conducted to study the effect of different storage containers against pulse beetle *Callosobruchus chinensis* attack on blackgram seeds in storage during 2019-20. Different storage containers *viz*., earthen pot, metal bin, plastic bin, plastic bin with 3 cm sand layer above the grain, polypropylene bag, double layered poly ethylene bag, triple layered poly ethylene bag, polyethylene lined gunny bag and gunny bag as control were used for management of pulse beetle. The experiment was conducted with nine treatments and three replication in Completely Randomized Design. The results revealed that maximum oviposition was recorded on metal bin (27.33 eggs/female on 500 seeds) followed by earthen pot (27.00 eggs/female on 500 seeds) and plastic bin (24.33 eggs/female on 500 seeds) and lowest oviposition was recorded on triple layered polyethylene bag (6.33 eggs/female on 500 seeds) followed by Plastic bin with 3 cm sand layer above the grain (14.00 eggs/female on 500 seeds) for 500 seeds than gunny bag (30.33 eggs/female on 500 seeds) and significantly different with each other. Triple layered polyethylene bag and plastic bin with 3 cm sand layer above the grain were found superior and effective in reducing per cent weight loss (5.43% and 9.89%) of seeds, respectively at 90 days after infestation. Earthen pot (20.78%) and Metal bin (19.47%) were the least effective treatments in reducing the per cent weight loss of grains.

KEYWORDS: Blackgram, *Callosobruchus chinensis*, per cent weight loss, storage containers

INTRODUCTION

"Blackgram" (*Vigna mungo* L.) is commonly known as urd, uradbean, mashbean, minapapappu, mungbean, black mapte bean, which is one of the most assertive pulse crops cultivated worldwide in tropical and subtropical regions. It has wide range of adaptability and can be grown around the year in different agro-ecological regions of the country. Pulses are generally stored for a year or more than a year in different types of storage structures or containers until the next harvest where in measurable loss was seen due to infestation by number of stored grain insect pests. Pulses are being attacked by more than 25 species of stored product insects *viz., Callasobruchus chinensis* (Linnaeus), *Rhizopertha dominica* (Fabricius), *Tribolium castaneum* (Herbest), *Corcyra cephalonica* (Stainton), *Lasioderma serricorne* (Fabricius), *Stegobium paniceum* (Linnaeus) and few species of mites (Prabhakar, 1979). The seeds of all pulses are more vulnerable to bruchids infestation. Their damage can be observed both in the field as well as in storage. Primary infestation which happens in the field is practically unimportant, while secondary infestation that happens during the storage is causing substantial losses to the seeds of pulses.

The pulse beetle, *Callosobruchus chinensis* (Bruchidae : Coleoptera) is a cosmopolitan and polyphagous pest causing huge damage to blackgram seeds during storage conditions. The blackgram seed is found to be infested by two main species of *Callosobruchus i.e., Callosobruchus chinensis* (Linnaeus) and *Callosobruchus maculatus* (Fabricius) in large scale storage. Among the eight legumes, the highest damage caused by *C. chinensis* was reported in greengram (79.59%) followed by blackgram (59.30%), cowpea (51.04%), white gram (29.98%) and pea (1.70%) (Muhamad, 2007). *C. chinensis* has a very short life cycle, hence many number of generations in a year with high reproductive potential. The beetle shows a high degree of specificity for its development towards various legumes. Gujar and Yadav (1978) reported 55 to 60 per cent losses in seed weight and 45.50 to 66.30 per cent losses in protein content due to its damage and seeds are not fit for human consumption as well as for cultivation purpose. The storage containers play a pivotal role in decreasing the degree of damage done by the bruchid in storage condition and also a profound influence on the population build-up of bruchid.

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Table 1. Details of containers used

S. No.	Treatments	Name of container
1	T_1	Earthen pot
2	T_2	Metal bin
3	T_3	Plastic bin
4	T_4	Plastic bin with 3 cm sand layer above the grain
5	T_5	Polypropylene bag
6	T_6	Double layered poly ethylene bag
7	T_7	Triple layered poly ethylene bag
8	T_8	Polyethylene lined gunny bag
9	T_9	Gunny bag (control)

Table 2. Evaluation of different storage containers against *C. chinensis* on blackgram seeds in storage conditions during 2019-2020

S. No.	Treatments	No of eggs laid on 500 seeds	**Per cent weight loss (%)
T_1	Earthen pot	27.00^{b}	20.78^{b} (27.11)
T_2	Metal bin	27.33^{ab}	19.47^{b} (26.17)
T_3	Plastic bin	24.33^{bc}	15.46^{c} (23.13)
T_4	Plastic bin with 3 cm sand layer above the grain	14.00^{d}	9.89^{f} (18.32)
T_5	Polypropylene bag	23.33^{c}	12.17^{e} (20.40)
T_6	Double layered poly ethylene bag	15.67^{d}	11.59^{e} (19.89)
T_7	Triple layered poly ethylene bag	6.33^{e}	5.43^{g} (13.46)
T_8	Polyethylene lined gunny bag	16.67^{d}	13.77^{d} (21.76)
T_9	Gunny bag (control)	30.33^{a}	23.11^{a} (28.72)
	SEm±	1.094	0.356
	CD @5%	3.277	1.065
	CV%	9.221	2.785

** Values in the parentheses are angular transformed values.

* Values with the same alphabet are not significantly different as per DMRT.

MATERIAL AND METHODS

Mass culture of the pulse beetle

The mother culture of *C. chinensis* was obtained from the local market and it was multiplied on locally available greengram seeds under laboratory conditions. About 20 pairs of adult beetles were released into plastic boxes containing 500 g of disinfested greengram seeds at 55ºC for 4 hours. Fifteen of such containers were maintained for mass culturing of the test insect. The boxes were kept undisturbed under laboratory condition till the emergence of F_1 adults. The test insect was mass cultured in the laboratory for 2-3 generations and freshly emerged adults were used in the experimental study.

Evaluation of different storage containers against pulse beetle

Nine different containers were used to conduct the experiment as follows;

One kg of TBG-104 blackgram variety was taken in each storage container and 10 pairs of freshly emerged adults of *C. chinensis* were released in each container treatment wise. The containers were assessed to *C. chinensis* infestation based on the following parameters.

No. of eggs laid

After 15 days of infestation, 500 seeds of blackgram were sampled randomly from each container and observation on number of eggs laid on seeds were recorded and later added to the same container. The containers were kept in the laboratory without disturbing up to 90 days.

Per cent weight loss

The final weight of the seeds were recorded at 90 days after release of adults and the weight loss due to insect infestation was calculated by deducting the final weight of the infested seeds from the initial weight of the healthy seeds and expressed in terms of per cent weight loss.

Per cent weight loss =

$$\frac{\text{Initial weight of grains - Final weight of grains}}{\text{Initial weight of grains}} \times 100$$

Statistical Analysis

The collected data was subjected to statistical analysis in Completely Randomized Design (CRD) using SPSS software.

RESULTS AND DISCUSSION

Fecundity of *C. chinensis* on blackgram

The results of present investigation revealed that, the mean number of eggs laid by the pulse beetle among the tested containers varied from 6.33 to 27.33 eggs on 500 seeds as against 30.33 eggs in gunny bag (control) (Table 2).

The highest number of eggs were recorded on blackgram seeds confined in metal bin (27.33 eggs/female on 500 seeds) followed by earthen pot (27.00 eggs/female on 500 seeds) and plastic bin (24.33 eggs/female on 500 seeds) which were significantly on par with each other. The lowest number of eggs were found in triple layered polyethylene bag (6.33 eggs/female on 500 seeds) followed by Plastic bin with 3 cm sand layer above the grain (14.00 eggs/female on 500 seeds) which were significantly different from each other. The other treatments; Polyethylene lined gunny bag and Double layered poly ethylene bag were also recorded least number of eggs with 16.67 and 15.67 eggs respectively on blackgram seeds and were significantly on par with each other and also on par with (T_4) plastic bin with 3 cm sand layer above the grain. However the next more number of eggs laid by pulse beetle was recorded in Polypropylene bag which is significantly different with highest and lowest number of eggs laid by pulse beetle (Table 2).

Per cent weight loss

The results of the present studies revealed that the per cent weight loss caused by the pulse beetle after 90 days varied from 5.43 to 20.78 per cent. Whereas in control (gunny bags) 23.11 per cent of weight loss was recorded (Table 3.1).

The highest percentage of weight loss was observed in earthen pot (20.78%) followed by metal bin (19.47%) which were statistically on par with each other. While the lowest per cent weight loss was observed in triple layered polyethylene bag (5.43%) followed by Plastic bin with 3 cm sand layer above the grain (9.89%), double layered polyethylene bag (11.59%), polypropylene bag (12.17%) which were significantly different from other

treatments. While the treatments polyethylene lined gunny bag and plastic bin were recorded with 13.77 and 15.46 per cent weight loss of blackgram seeds and are significantly different with each other.

The present results are similar with the findings of Dwivedi *et al*. (1991) who reported that the maximum damage was caused by pulse beetles in urd (8.7%) and moong (8.3%) stored in bags for a period of 6 months. Tin containers proved to be the best structures for storage of urd and moong at farm level. Moong was relatively preferred than urd during storage by pulse beetles. Tammanagouda (2002) observed seed infestation of 34.10 per cent in polythene bag as compared to those in cloth bag at the end of 10 months of storage period. Meena and Bhargava (2003) revealed that significantly higher dry mass loss (5.29%) and damage kernels (29.24%) were noticed in mud pot kernels. The number of adults varied from 2.33 in gunny bag to 4.00 in cloth bag against *C. cephalonica* in stored kernels of groundnut. Sharma (2013) found maximum weight loss in mud pot (1.40%), followed by gunny bag (1.33%), urea bag (1.25%), cloth bag (1.16%), polythene bag (1.00%) and metal bin (0.90%) against *Trogoderma granarium.*

The present results are in accordance with Sudini *et al.* (2015) who evaluated different containers and reported that after four months of storage under ambient conditions, triple-layer bags supported retention of seed weight, germinability and oil content significantly better than cloth bags. Baributsa *et al.* (2017) After 6-7 months of storage period, weight loss of 8.2% for unshelled groundnuts and 28.7 per cent for shelled groundnut was recorded when stored in woven bags. In Purdue Improved Crop Storage (PICS) bags for both shelled and unshelled groundnut, the density of insect pests did not increase and there was no weight loss and germination was also not affected. Manjunath *et al*. (2019) investigated the effect of different bins and bags against *Caryedon serratus* on oviposition preference, adult emergence and per cent pod damage. The results revealed that least infestation was observed in magic cover followed by plastic bin and triple layered polythene bag. The per cent pod damage was least in plastic bin followed by magic cover and triple layered polythene bag. Whereas, per cent weight loss recorded was least in magic cover followed by triple layered polythene bag and plastic bin. Swamy *et al*. (2019) who revealed that among the storage containers tested against *Sitophilus zeamais*; maize seeds stored in polythene bags were recorded with the less per cent (16.58%) seed damage, lowest per cent weight loss (5.41%), less moisture content (10.98%) and the less pest population (40.00 adults) of *S. zeamais* while the highest per cent seed damage (50.25%), weight loss (15.88%), more moisture content (12.34%) and the highest pest population (80.33 adults) was recorded in earthen pots followed by gunny bags (48.00%, 15.13%, 12.25% and 78.67 adults) recorded by *S. zeamais* at 120 days of storage period.

CONCLUSION

It is to conclude that triple layered polyethylene bag and plastic bin with 3 cm sand layer above the grain were found superior and effective in minimizing the oviposition and per cent weight loss against pulse beetle attack in the storage of the blackgram seed.

The superiority of triple layered polyethylene bagand plastic bin with 3 cm sand above the grain may be due to unfavourable structural compositions that with the growth and development of pulse beetle. In triple layered polyethylene bags there will be less amount of oxygen available for the insects for their development. The plastic bin with sand layer was providing anaerobic conditions filling the spaces which makes the microclimate unsuitable for the development of the pulse beetle. Earthen pot, metal bin and gunny bag were very comfortable for the egg laying and development as they maintain good moisture and optimum temperature conditions to the pulse beetle. Hence, triple layered polyethylene bag and plastic bin with 3 cm sand layer above the grain may be used for storing the blackgram seeds without compromising with the quality of seeds.

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BRAND LOYALTY OF URBAN AND RURAL CONSUMERS TOWARDS BRANDED EDIBLE OILS IN CHITTOOR DISTRICT OF A.P.

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ABSTRACT

The main objective of the study is to know the consumers brand loyalty towards branded edible oils. The study was based on a sample of 60 rural and 60 urban consumers. The findings of the study revealed that majority of the urban consumers of branded edible oils were brand loyal compared to the rural consumers. The main reason for switching to other brand by the urban respondents was that the competitor's brand was very good in quality, whereas rural consumers were shifting to another brand due to the price of the current brand is very high. Majority of the respondents were not aware about the various edible oil brands available in the market.

KEYWORDS: Andhra Pradesh, Brand loyalty, Chittoor and Edible oil.

INTRODUCTION

Edible oils compose a principal component of food expenditure in the Indian households. India is the third largest consumer of edible oils after China and the EU countries. In India people in different regions uses different oils based on the taste and availability of local oils. People in northern and central part of India mostly prefer soya bean oil due to local availability of soya bean. In the east and north east part of India people mostly prefer mustard oil since of its use in the local cuisine. In southern part of India Groundnut oil, sunflower oil, coconut oils are widely consumed apart from this palm oil is also mostly used due to easy availability from south east Asia.

Increasing disposable income and rising consumer awareness about healthy lifestyle boosted the consumption of packaged edible oil in the country. Strong marketing activities of leading edible oil brands, changing buying behaviour of consumers, establishment of modern grocery retailers like hypermarkets and supermarkets, shifted the consumption pattern of edible oils towards branded oils. Brand loyalty places an important role to get more revenue by the edible oil companies. Brand loyalty can be defined as the extent of consumer faithfulness towards a specific brand and this faithfulness is expressed through repeat purchases and other positive behavior's such as word of mouth advocacy, irrespective of the marketing pressures generated by the other competing brands (Kotler & Keller, 2006). Singh and Singh (1981) found that consumers had single or multi brand loyalty based on the nature of the Product, like necessaries or luxuries. Padmanaban and Sankaranarayanan (1999) revealed that the price of the preferred brand, efficiency of the preferred brand and influence of advertisement significantly influenced the brand loyalty. Usha (2007) analysed the buying behaviour of consumers for instant food products in Kolar district of Karnataka state and found that high price and poor taste were the reasons for not purchasing a particular brand while best quality, retailers influence, and availability were considered for preferring a particular brand of product by consumers. Kulkarni and Srivastava (2018) disclosed that sales promotion, purchase intention, quality and price have a positive correlation with brand loyalty at varying degrees; nevertheless, there is a fairly good amount of impact of purchase intention on brand loyalty (29.50%), as compared to other variables viz., price (27.8%), sales promotion (18.2%) and quality (11.5%). With this background the present study was carried out with an objective of analyzing the brand loyalty of urban and rural consumers towards branded edible oils in Chittoor district of Andhra Pradesh.

MATERIAL AND METHODS

Chittoor district was purposively selected for the study as it is one of the urbanized districts of the state of Andhra Pradesh. From Chittoor district, based on highest urban population areas viz., Tirupati, Chittoor and

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Madanapalli were selected. Based on the same criteria i.e., two highest rural population areas corresponding to each urban area were selected thus the rural areas selected for the study were Chellur and Ramireddypalle from Tirupati, Gundlapalle and Aragonda from Chittoor and Bairupalle and Gollapalle from Madanapalli. A sample of 20 consumers from each urban area was selected randomly and from each rural area 10 consumers were selected randomly. Thus, a total of 60 urban consumers and 60 rural consumers constituted the sample of the survey. Simple percentage analysis was employed to examine the brand loyalty of urban and rural consumers towards the branded edible oils.

RESULTS AND DISCUSSION

Socio-economic characteristics of sample respondents:

The findings of the study revealed that majority of the respondents in both urban areas and rural areas were male, aged between 36-55 years and were married. About 31.66 per cent and 33.33 per cent respondents from urban and rural areas were illiterates, 35.00 per cent and 30.00 per cent respondents from urban and rural areas were working as private employees and 41.66 per cent and 46.66 per cent respondents from urban and rural areas were earning a monthly income of ₹ 10,000 to 25,000 (Table 1).

Consumers preference towards different brands of edible oils:

a) Consumer preference towards different brands of sunflower oil:

Regarding to sunflower oil different brands were available in both urban and rural markets. The preference of consumers for different brands of sunflower oil were analysed and presented in Table 2.

From the table it was clear that nine brands of sunflower oil were preferred by urban respondents, about 23.33 per cent of the respondents consume Freedom brand, followed by Fortune (16.66%), Gold Winner (16.66%), Gold drop (13.33%), Priya (10.00%), sunsolite (6.66%), Saffola (6.66%), Sun drop (3.33%) and sun rich (3.33%). With respect to rural areas, 42.85 per cent of the respondents favoured fortune brand followed by Freedom (21.42%), Gold Winner (21.42%), Gold drop (7.14%) and Sun rich (7.14%).

b) Respondents preference towards different brands of peanut oil:

Consumer preference towards different brands of peanut oil consumed in urban and rural areas were analysed and the results were presented in Table 3. In urban areas about 28.57 per cent of the respondents were consuming Freedom brand, Fortune (19.04%), Gold winner (19.04%), Dhara (14.28%), Vijaya (9.52%), Saffola Gold (4.76%) and Sun drop (4.76%). Where as in rural areas 27.77 per cent preferred Vijaya brand, Gold winner (22.22%), Freedom (16.66%), Dhara (16.66%), Sun drop (11.11%) and the remaining 5.55 per cent were consuming Fortune brand.

c) Respondents preference towards different brands of palmolein oil:

With respect to brands of palmolein, Ruchi gold is the brand which is mostly used by both urban and rural respondents. In urban areas 50.00 per cent of the respondents were consuming Ruchi gold, Priya palm rich (25.00%), Best choice (18.75%), and Patanjali (6.25%). Whereas in rural areas 37.50 per cent were consuming Ruchi gold, Best choice (25.00%), Priya palm rich (18.75%) and the rest 18.75 per cent of the respondents were consuming Gopi Krishna oil brand (Table 4).

d) Respondents preference towards different brands of sesamum oil:

In case of sesamum oil, 52.94 per cent of the urban respondents were consuming Idhayam, A.S brand (29.41%) and 17.64 per cent were consuming Patanjali. In rural areas 62.50 per cent were using Idhayam, and the rest 37.50 per cent of the respondents were consuming A.S Brand (Table 5).

Consumers brand loyalty towards branded edible oils:

a) Brand loyalty of respondents towards branded edible oils:

Brand loyalty is the tendency of consumers to continuously buy the same brand products over another. The results revealed that 61.66 per cent (Table 2) of the urban respondents were brand loyal and remaining 38.33 per cent were brand disloyal. Whereas in rural areas 65.00 per cent of the respondents were brand disloyal and remaining 35.00 per cent of the respondents were brand loyal. The results indicated that urban respondents were more brand loyal when compared to the rural respondents.

Table 1. Socio-economic characteristics of urban and rural consumers

S. No.	Particulars	Urban (n = 60)		Rural (n = 60)	
		Number of respondents	Percentage to the total	Number of respondents	Percentage to the total
1.	**Gender**				
	Male	35	58.33	42	70.00
	Female	25	41.66	18	30.00
	Total	**60**	**100**	**60**	**100**
2.	**Age group (in years)**				
	Young age (20-35)	19	31.66	17	28.33
	Middle age (36-55)	32	53.33	31	51.66
	Old age (>55)	9	15.00	12	20.00
	Total	**60**	**100**	**60**	**100**
3.	**Marital status**				
	Single	3	5.00	2	3.33
	Married	57	95.00	58	96.66
	Total	**60**	**100**	**60**	**100**
4.	**Education**				
	Illiterate	19	31.66	20	33.33
	Primary	11	18.33	18	30.00
	Secondary	13	21.66	12	20.00
	Intermediate	7	11.66	5	8.33
	Graduation	6	10.00	4	6.66
	Post-Graduation	4	6.66	1	1.66
	Total	**60**	**100**	**60**	**100**
5.	**Occupation**				
	Agriculture	2	3.33	14	23.33
	Farm labour	0	0.00	8	13.33
	Non-farm labour	9	15.00	5	8.33
	Animal husbandry	3	5.00	4	6.66
	Business	15	25.00	7	11.66
	Private employee	21	35.00	18	30.00
	Government Employee	10	16.66	4	6.66
	Total	**60**	**100**	**60**	**100**
6.	**Monthly Income**				
	Less than Rs. 10,000	10	16.66	19	31.66
	Rs. 10,000 – 25,000	25	41.66	28	46.66
	Rs. 25,000-50,000	18	30.00	12	20.00
	Rs. 50,000 – 1Lakh	6	10.00	1	1.66
	More than one lakh	1	1.66	0	0.00
	Total	**60**	**100**	**60**	**100**

Table 2. Consumers preference towards different brands of sunflower oil

(n = 44)

S. No.	Area	Sunflower oil		
		Name of the brand	No. of respondents	Percentage
1.	Urban (n = 30)	Freedom	7	23.33
		Fortune	5	16.66
		Gold Winner	5	16.66
		Gold Drop	4	13.33
		Priya	3	10.00
		Sunsolite	2	6.66
		Saffola	2	6.66
		Sun drop	1	3.33
		Sun rich	1	3.33
		Total	**30**	**100.00**
2.	Rural (n = 14)	Fortune	6	42.85
		Freedom	3	21.42
		Gold winner	3	21.42
		Gold Drop	1	7.14
		Sun rich	1	7.14
		Total	**14**	**100.00**

Table 3. Consumers preference towards different brands of peanut oil

(n = 39)

S. No.	Area	Peanut oil		
		Name of the brand	No. of respondents	Percentage
1.	Urban (n = 21)	Freedom	6	28.57
		Gold winner	4	19.04
		Fortune	4	19.04
		Dhara	3	14.28
		Vijaya	2	9.52
		Saffola Gold	1	4.76
		Sun drop	1	4.76
		Total	**21**	**100.00**
2.	Rural (n = 18)	Vijaya	5	27.77
		Gold Winner	4	22.22
		Freedom	3	16.66
		Dhara	3	16.66
		Sun drop	2	11.11
		Fortune	1	5.55
		Total	**18**	**100.00**

b) Consumer Behaviour Towards Brand loyalty

In urban area 46.66 per cent of the respondents were suggesting the brand to others followed by 41.66 per cent were confirm to use new product launched by current brand company, 8.33 per cent were willing to purchase same brand even price increases and 3.33 per cent were willing to wait for the brand in case of non-availability of preferred brand in the market. Whereas in rural areas 51.66 per cent of the respondents were confirm to use new product launched by current brand company followed by 43.33 per cent were suggesting the brand to others, 3.33 per cent were willing to purchase same brand even price increases and 1.66 percent of the respondents were willing to wait for the brand in case of non-availability of preferred brand in the market (Table 3).

c) Frequency of switching to other brands of edible oil

Table 4 indicated that in urban area 43.33 per cent of the respondents occasionally switched over for other brands followed by 38.33 per cent switched over frequently and only 18.33 per cent switched over very frequently. While in rural areas 41.66 per cent of the respondents switched over frequently followed by 36.66 per cent of the respondents switched over very frequently and only 21.66 per cent occasionally.

d) Reasons for switching to other brands of edible oil

Information related to reason for switch over to other brands of edible oils were analyzed and presented in Table 5. In urban areas 30.00 per cent of the respondents switched over due to new brand is very good followed by 28.33 per cent due to price of the present brand is very high, influenced by advertisement (20.00%), doctor's advice (15.00%) and only 6.66 per cent is due to required brand is not available. While in rural areas 36.66 per cent is due to price of the present brand is very high followed by new brand is very good (26.66%), influenced by advertisement (23.33%), doctor's advice (10.00%) and only 3.33 per cent of the respondents switched over to another brand due to required brand is not available.

The results indicated that Product quality, price and promotional strategies plays an important role in maintain the brand loyalty.

e) Consumer importance about the labelling on the edible oil packet

Consumers importance about the labelling on the various brands of edible oil packets were analyzed and the results were presented in the Table 6. In urban areas 81.66 per cent of the respondents were giving importance to MRP of the product followed by 68.33 per cent to net weight, 50.00 per cent to expiry date, 35.00 per cent to nutritional information and only 3.33 per cent to date of manufacturing of the product. While in rural areas 80.00 per cent of the respondents to MRP of the product followed by 78.33 to net weight, 60.00 per cent to expiry date, 5 per cent to the nutritional information and none of the respondents were giving importance to the date of manufacture of the product in rural areas. The results indicated that majority of the respondents both in urban

Table 4. Consumer preference towards different brands of palmolein oil

(n = 48)

S. No.	Area	Palmolein oil		
		Name of the brand	No. of respondents	Percentage
1.	Urban (n = 16)	Ruchigold	8	50.00
		Priya palm rich	4	25.00
		Best choice	3	18.75
		Patanjali	1	6.25
		Total	**16**	**100.00**
2.	Rural (n = 32)	Ruchi gold	12	37.50
		Best choice	8	25.00
		Priya palm rich	6	18.75
		Gopi Krishna	6	18.75
		Total	**32**	**100.00**

Table 5. Consumer preference towards different brands of sesamum oil

(n = 25)

S. No.	Area	Sesamum oil		
		Name of the brand	No. of respondents	Percentage
1.	Urban (n=17)	Idhayam	9	52.94
		A.S Brand	5	29.41
		Patanjali	3	17.64
		Total	**17**	**100.00**
2.	Rural (n=32)	Idhayam	5	62.50
		A.S Brand	3	37.50
		Total	**8**	**100.00**

Table 6. Brand loyalty of respondents towards branded edible oils

(n = 120)

S. No.	Particulars	Urban (n = 60)		Rural (n = 60)	
		No. of respondents	Percentage	No. of respondents	Percentage
1.	Brand loyal	37	61.66	21	35.00
2.	Brand disloyal	23	38.33	39	65.00
	Total	**60**	**100.00**	**60**	**100.00**

Table 7. Consumer behavior towards brand loyalty

(n = 120)

S. No.	Brand loyalty	Urban (n = 60)		Rural (n = 60)	
		No. of respondents	Percentage	No. of respondents	Percentage
1.	Confirm to use new product launched by current brand company	25	41.66	31	51.66
2.	Suggest the brand to others	28	46.66	26	43.33
3.	Purchase brand even price increases	5	8.33	2	3.33
4.	Non availability in market wait for that brand	2	3.33	1	1.66
	Total	**60**	**100.00**	**60**	**100.00**

Table 8. Frequency of switching to other brands of edible oil

(n = 120)

S. No.	Frequency of switching	Urban (n = 60)		Rural (n = 60)	
		No. of respondents	Percentage	No. of respondents	Percentage
1.	Very Frequently	11	18.33	22	36.66
2.	Frequently	23	38.33	25	41.66
3.	Occasionally	26	43.33	13	21.66
	Total	**60**	**100.00**	**60**	**100.00**

Table 9. Reasons for switching to other brands of edible oil

(n = 120)

S. No.	Reasons to change the brand	Urban (n = 60)		Rural (n = 60)	
		No. of respondents	Percentage	No. of respondents	Percentage
1.	Required brand is not available	4	6.66	2	3.33
2.	New brand is very good	18	30.00	16	26.66
3.	Price of the current brand is very high	17	28.33	22	36.66
4.	Influenced by advertisements	12	20.00	14	23.33
5.	Doctors advise	9	15.00	6	10.00
	Total	**60**	**100.00**	**60**	**100.00**

and rural areas were look about the labelling on the edible oil packets and they were giving more importance to the labelling aspects before buying oil.

f) Brand awareness on edible oil

Information related to brand awareness on edible oils available in the market were collected from the sample respondents and it was analyzed that in urban area 56.66 per cent of the respondents were aware about the brands and 43.33 per cent were not aware about the brand. Whereas in rural areas majority (71.66 %) was not aware about the brand and only 28.33 percent were aware about the brands available in the market. It seems that most of the rural respondents doesn't have awareness about brands of edible oils. Edible oil companies have to concentrate more on the advertising strategies in order to raise awareness among the consumers (Table 7).

CONCLUSION

1. The study revealed that 61.66 per cent were brand loyal in urban areas whereas in rural areas only 35.00 per cent were brand loyal.
2. About 46.66 per cent of the respondents in urban areas were suggesting the brands to others, whereas in rural areas 51.66 per cent were confirm to use new product launched by current brand company.
3. About 43.33 per cent of the respondents in urban areas shifted to another brand occasionally, whereas in rural areas 41.66 per cent shifted to another brand frequently.
4. About 30.00 per cent of the respondents in urban areas were shifted to other brand due to the fact that new brand is very good, while 36.66 per cent in rural areas were shifted to other brand due to the fact that price of the present brand is very high.

Table 10. Consumer importance about the labelling on the edible oil packet

(n = 120)

S. No.	Particulars	Urban (n = 60)		Rural (n = 60)	
		No. of respondents	Percentage	No. of respondents	Percentage
1.	Date of manufacture	2	3.33	0	0
2.	Expiry date	30	50.00	36	60.00
3.	Nutritional Information	21	35.00	3	5.00
4.	Net weight	41	68.33	47	78.33
5.	MRP	49	81.66	48	80.00

Multiple responses were given by individual respondents

Table 11. Brand awareness on edible oil

(n = 120)

S. No.	Brand awareness	Urban (n = 60)		Rural (n = 60)	
		No. of respondents	Percentage	No. of respondents	Percentage
1.	Aware	34	56.66	17	28.33
2.	Not aware	26	43.33	43	71.66

5. Majority 81.66 per cent of the urban respondents a look for MRP, whereas 80.00 per cent of the rural respondents look for MRP.

6. About 56.66 per cent of the respondents in urban areas and 28.33 per cent in rural areas were aware of all brands.

SUGGESTIONS

1. The brand loyalty among the respondents were less. So, the edible oil business companies have to follow good promotional strategies like giving discounts or special offers and also, should provide consistent quality. If consumers feel value and are getting a fair deal from their loyalty, then they have no chance to shift to other brand.

2. The rural respondents were preferring the brands which are mostly available in the retail outlets. So, those companies which are involved in the edible oil business should concentrate on the availability of their product in each and every store.

3. Most of the respondents were not aware about the various edible oil brands available in the market. So, the edible oil manufacturers are advised to create awareness through many promotional and advertising techniques.

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LEAF MORPHOLOGY AND POLLEN VIABILITY OF BLACKGRAM [*Vigna mungo* (L.) Hepper] GENOTYPES UNDER HEAT STRESS CONDITION

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ABSTRACT

Laboratory experiment was conducted to screen fifty blackgram genotypes for high temperature tolerance using Temperature Induction Response (TIR) technique with nine tolerant blackgram genotypes *viz.*, LBG 977, PU 1504, LBG 982, LBG 977, ABF 04, LBG 973, NRISRI, TBG 129, LBG 888 and one susceptible genotype TBG 125 were selected based on TIR for further screening them for high temperature stress tolerance under field condition. Sowings were carried in such a way that flowering of the genotypes coincided with the high temperatures. A wide variation was observed among the genotypes in their leaf characters such as leaf thickness, leaf pubescence, cuticle thickness and pollen viability percentage. The genotypes LBG 888 and TBG 129 were found to have higher leaf thickness, pubescence and pollen viability percentage, which denote their heat tolerance and ability to withstand higher temperature. Whereas, the susceptible genotype TBG 125 recorded lower values for leaf thickness pubescence and pollen viability percentage.

KEYWORDS: Blackgram, Leaf thickness, Leaf pubescence, Pollen viability.

INTRODUCTION

Blackgram is a tropical leguminous plant belongs to the Asiatic *Vigna* species. Among grain legumes blackgram thrives better in all the seasons and can be grown as a sole crop, intercrop or as a fallow crop. It is an important pulse with high nutritive value and consists of high proteins, vitamins, amino acids and minerals thus; it is an important part in the dietary practices for large population in the world.

Constraints in blackgram production includes abiotic stresses, abrupt climatic changes, emergence of new insect-pests, diseases and deficiency of secondary & micronutrients in soils. (Ali and Gupta, 2012). Among pulses, blackgram accounts for 28 percent of world total grain legume production. It can be grown both summer and winter seasons (Sritharan *et al*., 2015).

Economic yield of blackgram mainly depends on physiological traits, such as ability to produce high biomass and partitioning of the photosynthates to reproductive organs. Biomass production depends on the extent of solar energy intercepted and its utilisation efficiency. In blackgram high temperature and drought are the most important constraint causing about 50 per cent of the yield loss (Anitha *et al*., 2015).

Reproductive tissues are highly sensitive to heat stress, and a few degrees raise in temperature during flowering can lead to loss in the economic produce. Inside a flower ovules are more resistant to high temperature than pollen and anthers. (Sharma *et al*., 2016). Under high temperature (30°C), floret sterility has been correlated with diminished anther dehiscence, poor shedding of pollens, low pollen germination percentage , decreased pollen tube elongation and reduced in vivo pollen germination (Fahad *et al.,* 2015). Plants use different mechanisms to control leaf temperature, like changing the leaf traits like hairiness, colour and thickness. (Monteiro *et al*., 2016). Keeping these in view, a field experiment was conducted to evaluate leaf morphological traits and pollen viability of blackgram genotypes under high temperature condition.

MATERIAL AND METHODS

The experiment was laid out in a randomized block design with 3 replications and 10 blackgram genotypes *viz.,* LBG 977, PU 1504, LBG 982, LBG 977, ABF 04, LBG 973, NRISRI, TBG 129, LBG 888 and TBG 125 (susceptible genotype) were sown in the wet land farm of S.V. Agricultural College, Tirupati, ANGRAU, during the 1st fortnight of February 2020.

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Leaf thickness (mm)

Leaf thickness was measured with the Verniercalliper at random locations on leaf, excluding the mid rib and represented in millimeters (mm)

Leaf pubescence (No. of trichomes per sq.cm)

Leaf pubescence was measured by using stereomicroscope (40X). The leaflet was cut into bits of 1 cm^2 and number of trichomes present on the upper and lower surface was counted under stereo zoom trinocular microscope and expressed as number of trichomes per square centimeter of leaf area.

Pollen viability test

The pollen grains from anthers of randomly selected flowers were collected and taken on cavity slides and stained with iodine-potassium iodide solution (0.44 g Iodine + 20.8 g potassium iodide in 500 ml of 70% alcohol). The viable pollen turns immediately to dark blue and non-viable ones remained as light yellow. The number of viable and non-viable ones were counted using OLUMPUS SZ61 microscope. The viability percentage was calculated from the mean of three microscopic field counts for each genotype (Jensen, 1962)

Viability percentage =

$$\frac{\text{Number of viable pollengrains}}{\text{Total number of pollengrains}} \times 100$$

Cuticle thickness (µm)

Fresh leaf samples were collected and fixed in cold FAA (Formalin - acetic acid- alcohol) and dehydrated in a *tetra*- butyl alcohol series (Berlyn and Miksche, 1976) and embedded in paraffin. Thin sections were made and mounted on slides and stained for 1hr with Sudan III in ethylene glycol (Jensen, 1962). Thickness of cuticle was measured with the help of calibrated ocular and stage micrometer at 400X under oil immersion. (Delucia and Berlyn, 1983). For calibration of stage micrometer, the number of ocular division coinciding with the stage division was found out. After calibration, stage micrometer is removed and the sample is placed on the stage slide and focused. The number of ocular division occupied by leaf sample was counted. Multiplying the number of division with calibration factor gives thickness of cuticle. Three such readings were taken and average is determined.

RESULTS AND DISCUSSION

Leaf thickness (mm)

Leaf thickness was measured at various stages of crop growth *i e*. at 20, 40, 60 days after sowing (DAS) and at harvest presented in Table 1. All genotypes showed reduction in leaf thickness from 40 DAS onwards. Among the genotypes TBG 129 showed highest value for thickness during entire crop growth stages. At harvesting stage TBG 129, LBG 888 and PU 1504 showed highest value of leaf thickness as 0.587 mm, 0.557 mm and 0.533 mm respectively. Thermo sensitive genotype TBG 125 showed lower leaf thickness during all growth stages. The possible reason for decrease in the leaf thickness at later stages of crop might be due to accelerated leaf senescence at high temperature condition. The results from this study implies that genotypes such as TBG 129, LBG 888 and PU 1504 showed high leaf thickness compared to susceptible genotype TBG 125. These findings are in conformity with Salem-fnayou *et al*. (2011), Groom *et al*. (2004) and Givnish (1978).

Leaf pubescence (No. of trichomes sq cm^{-1})

All genotypes showed increase in the number of trichomes sq cm^{-1} during the entire crop growth period. The rate of increase was less during later stages of crop growth. *i.e* at 60 DAS. Among the tolerant and susceptible genotypes, mean number of trichomes per sq. cm of tolerant genotypes was higher at all growth stages *i.e*. at 20 DAS (11.41), at 40 DAS (19.44) and at 60 DAS (20.52) compared to susceptible genotype TBG 125. During the flowering time LBG 888 showed highest number of trichomes per sq. cm (25), followed by TBG 129 (23), and PU 1504 (21.67) and was lowest for ABF 04 (14.67). TBG 129 showed highest value (24.67) followed by TBG 129 and PU 1504. ABF 04 and TBG 125 showed lowest value *i.e.* 15 and 15.67 respectively. The results from the current study displays that trichomes present on the leaf surface minimize the rate of transpiration by means of high boundary layer resistance thus increase the water use efficiency of the crop further pubescence reduces leaf absorbance ensuring in reduced heat load and as a consequence lower leaf temperature, much lower than air temperature. As a result, leaf temperatures are near the temperature optimum for photosynthesis. This is why tolerant genotypes showed more number of trichomes than susceptible one. These present findings are in conformity with Roy and Basu (2009) and Monteiro *et al.* (2016).

Table 1. Leaf thickness (mm) of blackgram genotypes at different growth stages under high temperature condition

Genotypes	Leaf thickness (mm)			
	20 DAS	40 DAS	60 DAS	Harvest
Tolerant genotypes				
LBG 977	0.383	0.577	0.520	0.413
PU 1504	0.410	0.617	0.560	0.533
LBG 982	0.403	0.597	0.550	0.507
LBG 971	0.377	0.590	0.530	0.420
ABF 04	0.360	0.503	0.443	0.340
LBG 973	0.380	0.553	0.540	0.470
NRISRI	0.367	0.510	0.493	0.437
TBG 129	0.427	0.707	0.647	0.587
LBG 888	0.457	0.647	0.607	0.557
Mean	**0.396**	**0.589**	**0.543**	**0.473**
Susceptible genotype				
TBG 125	0.340	0.503	0.480	0.357
CD (P= 0.05)	0.056	0.048	0.042	0.044
SEm±	0.019	0.016	0.014	0.015

Cuticle thickness (µm)

Cuticle thickness (µm) measured at various phases of crop growth was presented in Table 2. Significant difference was there between genotypes for thickness of cuticle throughout the crop growth period. Results showed that cuticle thickness gradually increased upto 60 DAS in all genotypes and later decreased. Genotype PU 1504 showed highest value of cuticle thickness during all phases of crop growth and lowest value was showed by thermo sensitive genotype TBG 125. Reduction in cuticle thickness at harvest stage might be because the cuticle deposition is persistent until the leaf reaches morphological maturity after which no further deposition occurs. High cuticular thickness of thermo tolerant genotypes linked to water loss prevention under dry summer conditions. These findings are in accordance with England and Attiwill, (2011), Shepherd *et al.* (2006).

Pollen viability percentage (%)

Heat tolerant and sensitive genotypes varied in pollen viability when exposed to high temperature. Result showed that viability percentage varied from 60.77 to 86.77. Lowest pollen viability was showed by susceptible genotype (60.77) and highest value was showed by LBG 888 (86.77) followed by TBG 129 (81.64) (Fig. 1.)

Poor pollen viability might be the product of under nourished pollen due to stress during growth. Tapetal layers in anthers, which contribute nutrients to pollen production, are the subject of thermal stress as recorded in cowpea (Ahmed *et al*. 1992), chickpea (Kumar *et al*. 2010) and mungbean (Porch and Jahn, 2011). Result revealed that viability percentage was lowest for thermo sensitive genotype TBG 125. This is because the function of pollen, stigma, and ovule in heat tolerant genotypes was held significantly higher than sensitive one. Those findings are consistent with previous studies in chickpea Kumar *et al.* (2013).

From the investigation the following conclusions were drawn, among the genotypes screened TBG 129 showed highest leaf thickness and susceptible genotype TBG 125 with lowest leaf thickness. Reduction in pollen viability was more in sensitive genotype TBG 125 and LBG 888 recorded highest pollen viability percentage. High summer temperature during flowering time leads to reduction in pollen viability percentage in susceptible genotype TBG 125. Among the morphological characters studied such as leaf thickness, leaf pubescence and cuticle thickness genotype LBG 888 and TBG 129 showed highest value compared to all other genotypes which made them more tolerant to temperature stress.

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Table 2. Leaf Pubescence (No. of trichomes per sq. cm) and Cuticle thickness (µm) of blackgram genotypes

	Leaf Pubescence (sq cm^{-1})			Cuticle thickness (µm)			
Genotypes	**20 DAS**	**40 DAS**	**60 DAS**	**20 DAS**	**40 DAS**	**60 DAS**	**Harvest**
Tolerant genotypes							
LBG 977	9.33	16.67	17.67	0.074	1.15	1.36	1.293
PU 1504	15.00	21.67	23.67	0.091	1.33	1.527	1.467
LBG 982	12.33	21.00	21.67	0.079	1.133	1.327	1.29
LBG 971	11.33	17.33	18.33	0.081	1.227	1.39	1.337
ABF 04	7.00	14.67	15.00	0.075	1.143	1.32	1.277
LBG 973	11.33	19.33	20.33	0.078	1.203	1.417	1.37
NRISRI	9.00	16.33	17.00	0.078	1.133	1.333	1.293
TBG 129	13.00	23.00	24.67	0.089	1.27	1.477	1.43
LBG 888	14.33	25.00	26.33	0.082	1.237	1.447	1.387
Mean	**11.41**	**19.44**	**20.52**	**0.081**	**1.203**	**1.400**	**1.349**
Susceptible genotype							
TBG 125	5.33	15.00	15.67	0.052	0.943	1.057	0.993
CD (P= 0.05)	3.511	4.175	1.942	0.008	0.03	0.031	0.02
SEm±	1.182	1.405	0.654	0.003	0.01	0.011	0.007

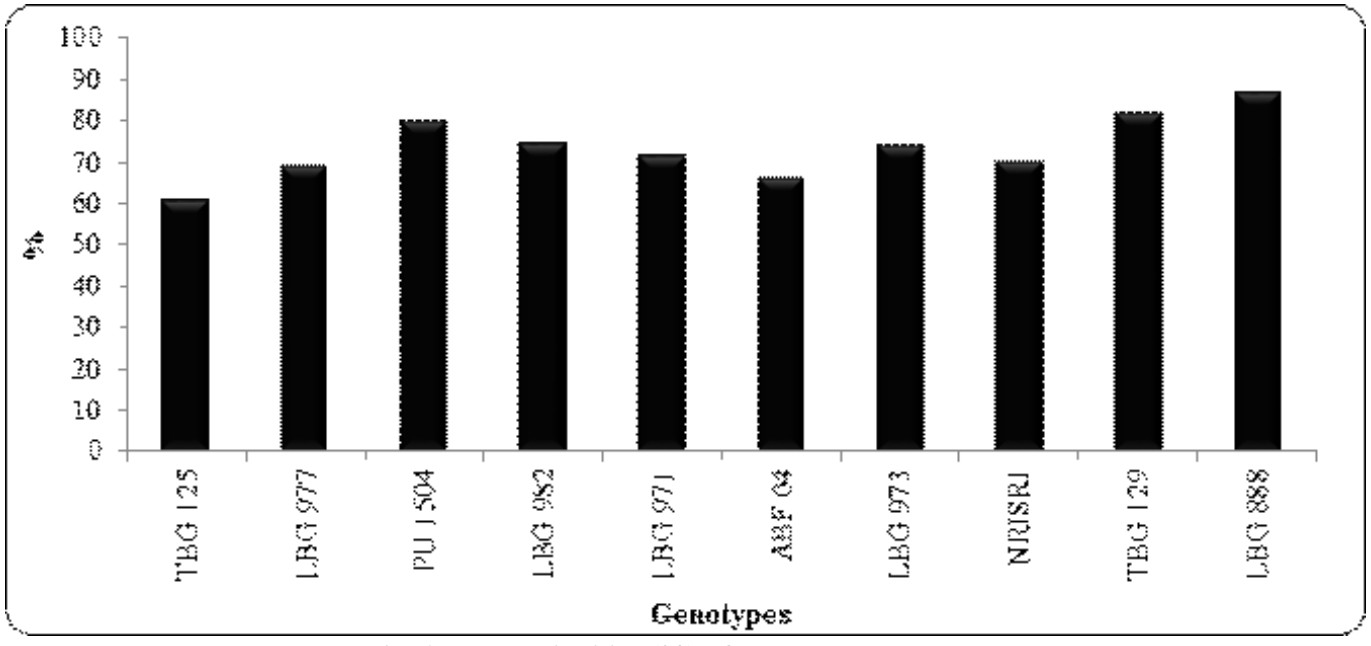

Fig. 1. Pollen viability (%) of blackgram genotypes

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PERCEPTION OF STUDENTS TOWARDS LEARNING ENVIRONMENT IN ACHARYA N.G. RANGA AGRICULTURAL UNIVERSITY

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ABSTRACT

The study was conducted in two colleges of Acharya N.G. Ranga Agricultural University *i.e*. S.V. Agricultural College, Tirupati, Chittoor district and Agricultural College, Mahanandi, Kurnool district. To study the perception of students towards learning environment a total 120 respondents were randomly selected and data was collected using a structured interview schedule. The findings of the study revealed that majority (56.70) of the respondents belonged to the age of 21 years, 50.80 per cent were of female students, 77.50 per cent showed an excellent academic performance, 47.50 per cent participated in only one extracurricular activity, 41.70 per cent belonged to Open category, parents of 50.80 per cent had no possession of immovable assets, owned 3 or 4 movable assets (58.30%), 79.20 per cent had medium total annual income, 45.00 per cent of students with medium level of academic interest, resided in college hostel (96.70%), got their financial assistance from parents (45.83%), practiced both poor and good learning style(35.00%) and had neutral attitude towards the university (45.00%). Under perception towards learning environment factors majority of students strongly agreed to the statements *viz.,* Students Cohesiveness: "I make friendship among students in college", Teacher Support: "Professors talk with me", Involvement: "I am asked to explain how I solve problems", Task Orientation: "I try to understand the work in this class" and Cooperation: "I cooperate with other students when doing assignment work".

KEYWORDS: Perception, Students, Learning environment

INTRODUCTION

Learning environment refers to the diverse physical locations, contexts, and cultures in which students learn. There is no single optimum learning environment, rather there is an infinite number of possible learning environments and that makes teaching and learning so interesting.Some of the components of a learning environment include: Student Cohesiveness, Teacher support, Involvement, Task orientation and Cooperation. Student cohesiveness means alliance among students in college. When there is good cohesion among students, they can alleviate each other as students understand and cope differently. Besides students being there for each other they can also use teachers support in learning.

Involvement means an act of participating or taking part in something. It has been proven that students tend to accumulate more knowledge when they are involved. In conjunction with involvement, task orientation can also be a form of motivation for learning. Task orientation means having focus on and devoted to completing certain tasks, especially those that contribute to the success of a main task. Cooperation is the action or process of working together to the same end. All the aspects of a learning environment correspond with each other to make a complete learning environment.

MATERIAL AND METHODS

In the study, *Exploratory* research design was followed is conducted about a research problem when there are few or no earlier studies to refer to. The focus was on gaining insights and familiarity for later investigation or undertaken when problems are in a preliminary stage of investigation.

The state of Andhra Pradesh was selected purposively for the study. Rayalaseema region comprising of four districts *viz*., Kurnool, Chittoor, Anantapur and YSR Kadapa districts was purposively selected for the study. Two Agricultural colleges of Rayalaseema region i.e., S.V. Agricultural College, Tirupati, Chittoor district and Agricultural College, Mahanandi, Kurnool district were selected purposively for the study. After obtaining the total number of undergraduate students studying third year B.Sc. (Hons) Agriculture from both the selected

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agricultural colleges of a total of 120 students were selected following proportionate simple random sampling procedure. The data was collected by personal interview method through a structured interview schedule and analyzed by employing suitable statistical methods. Eleven independent variables were identified for the study.

RESULTS AND DISCUSSION

Profile characteristics

1. Age

Table1 indicates that the majority i.e. 56.70 per cent respondents belonged to age group 21 years, followed by 29.20 per cent respondents who belonged to age group 22 years and the remaining 14.20 percent respondents were belonging to age group 20 years. These findings are in line with the work of Mlambo (2011), Wafaa and Safaa (2017).

It can be concluded that majority of the third year B.Sc. (Hons) Agriculture students had an age of 21 years. The possible reason is that after completion of intermediate, students joined, under graduation as per the chronology.

2. Gender

Table 1 clearly indicates that out of 120 respondents, 50.80 per cent of respondents were female students and the rest of respondents *i.e.* 49.20 per cent were male students. These findings are similar with the finding of Ebenuwa-Okoh (2010), Mlambo (2011) and David-Kacso *et al*. (2014).

This shows that the population of female students is slightly higher than male students. The possible reason may be in the recent times parents were giving importance to the education to all of their children irrespective of the sex. The possible reason for the finding is that girl students are more enthusiastic and focused in schoolwork, leading to better grades and marks in the entrance examinations and at all levels of study, as a result more of them are able to enroll in universities.

3. Academic Performance

Table 1 indicates that from 10th class through intermediate and to B.Sc. (Hons) Agriculture, majority (77.50%) of the respondents had an excellent academic performance followed by 17.50 per cent had good academic performance and 5.00 per cent of respondents had average performance. The findings are in line with the works of Patel (2005), Christian (2010) and Bhosale (2011).

The possible reason for the above finding is that students tend to put more effort into their schoolwork as they grow older, practical classes help them in remembering what they have been taught. Only the students who are meritorious will join the professional course like B.Sc. (Hons) Agriculture which is based on obtaining the rank at the state level entrance examination.

4. Participation in extracurricular activities

Table 1 indicates that majority (47.50%) of students participated in only one extracurricular activity followed by 30.00 per cent of students who did not take part in any extracurricular activity and 22.50 per cent students who participated in two extracurricular activities. The results are in line with the works of Sathyan (2008) and Aher (2010).

Some of the students felt that, as the number of extracurricular activities increase, students partaking decreases towards academics and education. This may be because in the semester system of the undergraduate programme there is limited amount of time to the students to participate more in the extracurricular activities, also that time is used for attending to assignments, record writing and other works as the number of credits registered in the undergraduate programmes went on increasing time to time. Improper time management could be another reason for the results above.

5. Social background

It is evident in Table 1 that majority (41.70%) of students belong to Open Category followed by Backward Category which is slightly lower by 40.80 per cent of students, then the third position is Scheduled Caste with 12.50 per cent and lastly Scheduled Tribe by 5.00 per cent. The findings find support from the works of Bhosale (2011) and Verma (2014).

From the results it is clear that the majority of students belong to Open Category. The possible reason is that social background of the students is in accordance with admission procedures at the time of counselling at the university and as the rules governing reservations of seats which is being followed by Acharya N.G. Ranga Agricultural University.

6. Economic status of parents

i. Immovable assets

Immovable assets are those assets that cannot be moved from one place to another, they are also called as fixed assets. Mostly owning immovable assets is costly. These immovable assets include land, house, etc. According to Table 1 majority (50.80%) of student parents had no immovable assets, followed by 35.00 per cent low possession, 12.50 per cent moderate possession and 1.70 per cent high possession.

It can be concluded that, immovable assets possession ranges between nil to low. This is probably because most students come from families of medium income and farmer quota. The students from the rich families might have taken seats in still higher professional courses like medicine on payment basis.

ii. Movable assets

A movable asset is any property that can be moved from one location to another. The movable assets which were included in the study are Car, Television, Refrigerator, Air conditioner, Music system, Two-wheeler and others. The was analysed based on number of movable assets students' parents possess. The results in Table 1 indicates that majority (58.30%) of students' parents owned 3 or 4 movable assets followed by 20.00 per cent who owned 1 or 2 movable assets, 13.30 per cent owned more than 4 movable assets and 8.30 per cent owned no movable asset.

It was observed that a movable asset which was owned by most families was television followed by two-wheeler, refrigerator, air conditioner then music system. This might be due to the probable reason that families prioritize when it comes to movable asset ownership i.e., they buy the most convenient assets. Other movable assets which were mentioned are tractors, sewing machines and tractor drawn water tank. The possible reason is that the families buy movable assets based on whether they are essential.

iii. Total Annual income

Parents' annual income was categorized into three categories i.e. Low income, Medium income and High income. According to Table 1 majority (79.20%) of parents had medium income followed by high income (15.00%) and low income (5.80%) levels. The findings are evident with the findings of Shingwan (2002) and Gadhvi (2012).

Therefore, it can be concluded that majority of parents of students had medium to high annual income. The possible reason for this is that some families have more than one source of income.

7. Academic interest

From Table 1 it is shown that majority (45.00%) of third year B.Sc. (Hons) Agriculture undergraduate students had medium level of academic interest followed by high level (30.00%) and low level (25.00%) of academic interest. It can be concluded that students had medium to high level of academic interest.

8. Type of residence

The distribution of respondents according to where they resided while at college is presented in Table 1. It is evident from the data that majority (96.70%) of students resided in college hostel while they were at college followed by 3.30 per cent of students who stayed at their own house. None of the students stayed at a rented house or at relatives' house.

It can be concluded that students resided in hostel because their native places are far from colleges, hence it is difficult to commute also other students want to get help easily from their classmates in hostel. The other reason is that staying at hostel is cheaper as compared to other accommodations.

9. Financial assistance

Financial assistance was divided into 5 categories viz. Central Government Assistance, State Government Assistance, Parent Assistance, Central Government Assistance & Parent Assistance and State Government Assistance & Parent Assistance. It is apparent from Table 1 that majority (45.83%) of the respondents got their financial assistance from Parents followed by 35 per cent of students who got their financial assistance from State Government, 7.50 per cent of students who got their financial assistance from both State Government and Parents, 5.83 per cent of Central Government and 5.83 per cent from both Central Government and parents.

It can be concluded that majority of students got financial assistance from their parents. The possible reason for the findings is that Central and State Government gives few scholarships to undergraduate students.

Table 1. Distribution of ANGRAU growers according to their profile characteristics (n = 120)

S. No.	Category	Frequency (f)	Percentage (%)
I	**Age**		
1.	20 years	17	14.20
2.	21 years	68	56.70
3.	22 years	35	29.20
II	**Gender**		
1.	Male	59	49.20
2.	Female	61	50.80
III	**Academic performance of the students**		
1.	Average	6	5.00
2.	Good	21	17.50
3.	Excellent	93	77.50
IV	Participation in extracurricular activities		
1.	Nil	36	30.00
2.	1	57	47.50
3.	2 and more	27	22.50
V	Social background		
1.	Open category	50	41.70
2.	Backward category	49	40.80
3.	Scheduled caste	15	12.50
4.	Scheduled tribe	6	5.00
VI	**Economic status of parents**		
a.	**Immovable assets**		
1.	NO immovable assets	61	50.80
2.	Low (<Rs.30lakh)	42	35.00
3.	Moderate (Rs.30lakh-60lakh)	15	12.50
4.	High (Rs.60lakh-90lakh)	2	1.70
b.	**Movable assets**		
1.	Nil	10	8.30
2.	1 or 2	24	20.00
3.	3 or 4	70	58.30
	More than 4	16	13.30
c.	**Total annual income**		
1.	Low income	7	5.80
2.	Medium income	95	79.20
3.	High income	18	15.00

Cont...

S. No.	Category	Frequency (f)	Percentage (%)
VII	**Academic interest**		
1.	Low	30	25.00
2.	Moderate	54	45.00
3.	High	36	30.00
VIII	**Type of residence**		
1.	College Hostel	116	96.70
2.	Own House	4	3.30
3.	Rented house	0	0.0
4.	Relatives house	0	0.0
IX	**Financial assistance**		
1.	Central Government Assistance	7	5.83
2.	State Government Assistance	42	35.00
3.	Parent Assistance	55	45.83
4.	Central Government Assistance and Parent Assistance	7	5.83
5.	State Government Assistance and Parent Assistance	9	7.50
X	**Learning style**		
1.	Poor	42	35.00
2.	Average	36	30.00
3.	Good	42	35.00
XI	**Attitude towards university**		
1.	Unfavourable	36	30.00
2.	Neutral	54	45.00
3.	Favourable	30	25.00

10. Learning style

Results presented in Table 1 clearly shows that both poor and good learning style was practiced by 35.00% of the students followed by average learning style at 30.0 per cent.

The results show that the learning style practiced by students is spread out through the three categories. The results are due to the fact that students have different methods they use to study.

11. Attitude towards university

It is clear in Table 1 that when it comes to attitude towards university, majority of students i.e. 45 per cent of the students had neutral attitude towards the university, followed by unfavourable at 30 per cent and favourable attitude at 25.0 per cent. The results show that students have neutral to unfavourable attitude towards the university.

Perception towards learning environment

1. Student Cohesiveness

The results on student cohesiveness highlighted that the students strongly agreed and agreed with the given statement in this order: “I make friendship among students in college”, “I am friendly to other students”, “I know other students in my college”, “I get help from other students”, “I work well with other class members” and “Students in this college like me”.

Student cohesiveness has to do with the idea of creating a bond amongst students, so it can be concluded

Table 2. Distribution of respondents according to perception towards learning environment

(n = 120)

S. No.	Learning Environment	Frequency (N)	Percentage (%)
1	Unfavourable	31	25.80
2	Neutral	53	44.20
3	Favourable	36	30.00
	Total	**120**	**100.0**

that there is a strong bond amongst students and this might be due to the provision of accommodation facility in the form of a hostel to students by the university. When students spend so much time with each other the strength of the bond increases, also students are given group assignments all the time hence working together strengthens the bond, extracurricular activities contribute to student cohesiveness.

2. Teacher Support

The distribution of respondents according to their perception on Teacher Support indicated that majority of students agreed and strongly agreed that professors help students when they have trouble with the work followed "Professors talk with me", "Professors' questions help me to understand", "Professors go out of their way to help students", "Professors consider students' feelings", "Professors take a personal interest in all students" and "Professors are interested in my problems".

It can be concluded that all the statements had a score between average and above average. The professors support is thus due to the fact that ratio of professor to students is a bit high so this makes it hard for professors to create time to for one on one sessions with students.

3. Involvement

The results of students perception on their involvement indicated that majority of the students agreed and strongly agreed on the statement: "I am asked to explain how I solve problems" followed by "Students discuss with me how to go about solving problems", "The professors ask me questions", "I explain my ideas to other students", "I discuss ideas in classes", "I give my opinions during class discussions", "My ideas and suggestions are used during classroom discussions" and "I ask the professors questions".

The results above might be due to the fact that students lack confidence so that is stopping them from contributing during classes, also students do not pay attention in class.

4. Task Orientation

The results of students' perception on their task orientation revealed that majority of students agreed and strongly agreed to "I try to understand the work in this class" followed by "I know how much work I have to do", "Getting a certain amount of work done is important to me" and "I know what I am trying to accomplish". All the given statements had a majority score of between average and above average.

The probable reason is that students help each other in tackling assignments given in class, library has a variety of learning materials for reference and professors are always willing to assist students.

5. Cooperation

The results of students' perception on their cooperation revealed that majority of the students agreed and strongly agree in "I cooperate with other students when doing assignment work", "I share my books and resources with other students when doing assignments", "There is teamwork whenever we are given group work", "I work with other students on projects", "I learn from other students in college", "I work with other students in class" and "Students work with me to achieve class goals".

It can be noticed that the all the given statements yielded majority of agreed and strongly agreed. The possible reason for the findings is that there is strong bond amongst students and they like helping each other in getting their goals to be achieved.

Perception towards learning environment

The results in Table 2 shows that 44.20 per cent of students had a neutral perception towards learning environment followed by 30.00 per cent of students who had a favourable perception towards learning environment and 25.80 per cent of students had an unfavourable perception towards learning environment. The findings of the study are in line with the work of Pai *et al*. (2014).

CONCLUSION

Study revealed that majority of the respondents belonged to the age of 21 years, showed an excellent academic performance, with medium level of academic interest, resided in college hostel, got their financial assistance from parents, practiced both poor and good learning style and had neutral attitude towards the university

Under perception towards learning environment factors majority of students strongly agreed to the statements viz., Students Cohesiveness: "I make friendship among students in college", Teacher Support: "Professors talk with me", Involvement: "I am asked to explain how I solve problems", Task Orientation: "I try to understand the work in this class" and Cooperation: "I cooperate with other students when doing assignment work".

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RESPONSE OF CHICKPEA (*Cicer arietinum* L.) TO CROP RESIDUE INCORPORATION, TIME OF SOWING AND IRRIGATION IN VERTISOLS OF A.P.

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ABSTRACT

A field experiment was undertaken Regional Agricultural Research Station, Nandyal during 2018-18 and 2019-20 to study the effect of crop residue incorporation, sowing time and irrigation on chickpea *(Cicer arietinum.* L.) under double cropping system in vertisols of Andhra Pradesh. The data pooled over for two successive years revealed that significantly higher dry matter production (4642 kg ha^{-1}), seed yield (1546 kg ha^{-1}) was recorded with incorporation of foxtail millet crop residue. Chickpea sown during November 1st FN recorded significantly higher number of pods per plant (33.1), seed weight plant^{-1} (10.1 g), dry matter production (4719 kg ha^{-1}), seed yield (1660 kg ha^{-1}) and stover yield (3524 kg ha^{-1}). Application of irrigation during pre-flowering and pod development stage recorded significantly higher plant height (45.3 cm), number of branches plant^{-1} (8.4), number of pods plant^{-1} (34.1), seed weight plant^{-1} (10.1 g), dry matter production (4861 kg ha^{-1}), seed yield (1819 kg ha^{-1}), stover yield (3926 kg ha^{-1})and harvest index (46.3). Interaction effect between foxtail millet crop residue incorporation and November 1st FN sowing recorded significantly higher dry matter production (5146 kg ha^{-1}) and seed yield (1839 kg ha^{-1}) of chickpea, which proved to be best option for rabi chickpea production.

KEYWORDS: Chickpea, Crop residue incorporation, Time of sowing, Irrigation, Seed yield.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the third most important pulse crop in the world, whereas in India chickpea is first most important pulse crop cultivated over an area of 9.55 million hectares producing 9.94 million tonnes with an average productivity of 1041 kg ha^{-1} (Anonymous, 2020). Chickpea cultivation in Andhra Pradesh under vertisols was also increased in recent years and occupied 5th position in area and production during the year 2018, due to increased area under double cropping system under rainfed and irrigated condition. Because farmers are adopting foxtail millet/ greengram-chickpea cropping system under rainfed situation and maize-chickpea cropping system in irrigated conditions, rather than cereal-cereal sequence cropping system. Once preceding crop was harvested, farmers have to decide what to do with the remaining crop residue *i.e*. the above ground biomass that is cut but not harvested. As such, it is thought to help maintain, or even to some extent restore, soil fertility Among pulses, chickpea is more sensitive to temperature (Kiran and Chimmad, 2018). Hence, time of sowing is an important agronomic factor affecting the productivity of chickpea, owing to changes in environmental conditions to which phenological stages of crops are exposed. Under late sown conditions, the growth of chickpea is affected resulting in lower yield. Grain yield is significantly sensitive to water stress during the pod setting to grain development periods irrespective of soil texture. Since most cultivators are not in a condition to irrigate chickpea crop, they could not irrigate properly as a result the seed yield is drastically reduced.

MATERIAL AND METHODS

A field experiment was undertaken on vertisols of Regional Agricultural Research Station, Nandyal during 2018-19 and 2019-20 to study the effect of crop residue incorporation, sowing time and irrigation on Chickpea *(Cicer arietinum* L.) under double cropping system. The experiment was laid out in a split-split plot design with foxtail millet, greeengram and fallow during *kharif* as main plots, time of sowing (October 2nd FN, November 1st FN, November 2nd FN and December 1st FN) as sub plots and irrigation time (irrigation at pre-flowering stage, irrigation at pod development stage and irrigation twice at pre-flowering and pod development stage) as sub sub plots. The varieties used for experimentation are

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"suryanandi" for foxtail millet, "WGG 42" for greengram and "Nandyala sanaga" (NBeG-3) for chickpea. *Kharif* crops were raised, economic parts *viz*. panicles/pods were harvested and residue was incorporated into soil, followed by chickpea sowing as per treatments. Soil of the site was medium in fertility and saline in reaction having pH 8.42, EC-0.24 dSm^{-1}, organic carbon (0.32%) with available N of 143 kg ha^{-1}, available P_2O_5 of 53 kg ha^{-1} and available K_2O of 451 kg ha^{-1}. An amount of 20 kg N+50 kg P_2O_5 were applied through urea and single SSP and given as basal just below the seed. Sowing was done in four intervals as D_1 on October 2nd FN, D_2 on November 1st FN, D_3 on November 2nd FN, D_4 on December 1st FN, in respective schedule. Healthy and matured seeds possessing high germination percentage was used for sowing. Seed @ 50 kg ha^{-1} was sown in the open furrows made with the help of hand hoe. The seeds were dropped to a depth of 5 cm and covered thoroughly. The spacing adopted for sowing was 30 cm x 10 cm. The data recorded on various parameters of crop during the course of investigation was statistically analyzed by following the analysis of variance procedure as suggested by Panse and Sukhatme (1985). Statistical significance was tested with 'F' test at 5 per cent level of probability and compared the treatment means with critical difference.

RESULTS AND DISCUSSION

Effect of crop residue incorporation

Results on chickpea growth and yield attributes were presented in Table 1. Indicating that crop residues incorporation did not significantly influence plant height at harvest and 100 seed weight during both years of study and pooled, but drymatter production, number of branches per plant, and number of pods per at harvest was significantly influenced. Highest drymatter, more number of branches $plant^{-1}$ and number of pods $plant^{-1}$ at harvest was recorded in the plots which incorporated foxtail millet crop residue followed by greengram crop residue plots. Lower values were observed with fallow treatment during both the years of study. Organic matter added through organic resides might had prominent beneficial effect on soil properties which is more important for crop growth.

Incorporation of crop residues, shown significant effect on seed weight plant-1, seed yield, stover yield but failed to differ significantly with harvest index during both years of study and pooled (Table 2). Yearly variations were observed and all three yield components were significantly higher with foxtail millet crop residue incorporation followed by greengram crop residue incorporation.

The pooled values of seed weight per plant (8.7 g), seed yield (1546 kg ha^{-1}) and stover yield (3192 kg ha^{-1}) were also significantly higher with foxtail millet crop residue incorporation and at par with greengram crop residue incorporation field (7.8 g, 1474 kg ha^{-1}, and 3192 kg ha-1 respectively). Incorporation of crop residues before chickpea sowing might be undergone decomposition and releases mineral nitrogen in root zone throughout crop growth stages which is readily available to chickpea crop and shown positive effect on production of more number of branches compared to fallow treatment. These findings were in agreement with Rehan *et al*. (2018).

Effect of time of sowing

The time of sowing did not significantly influenced plant height at harvest and 100 seed weight in both years and pooled, but drymatter production, number of branches per plant, and number of pods per at harvest was significantly influenced. Highest drymatter, more number of branches $plant^{-1}$ and number of pods $plant^{-1}$ at harvest was recorded in November 1st FN sowing followed by november 2nd Fnsowing sowing. lower values were recorded when sowings delayed, during both the years of study.

Chickpea sown during November 1st FN recorded significantly higher seed weight per plant (10.1 g), seed yield (1660 kg ha^{-1}) and stover yield (3524 kg ha^{-1}). Significantly lower seed weight per plant (5.9 g), seed yield (1167 kg ha^{-1}) and stover yield (2624 kg ha^{-1}) was recorded with sowing of chickpea during December 1st FN sowing.. Similar trend was observed during both the years of study. The improvement in seed yield in November 1st FN sowing over other dates of sowing was due to better availability of moisture, nutrients and congenial temperature prevailing at the time of germination and seedling establishment which might had contributed better growth, development of yield attributes and thus higher seed yields. The next best sowing times were November 2nd F.N, October 2nd FN and December 1st FN, in order of descent. These findings were in agreement with Sekhar *et al*. (2015)

Table 1. Growth and yield attributes of chickpea as influenced by crop residue incorporation, time of sowing and irrigation

Treatments	Plant height at harvest (cm)			Dry matter production (kg ha^{-1}) at harvest			No. of branches plant^{-1} at harvest			No. of pods plant^{-1} at harvest			100 grain weight (g)		
	2018	2018	2018	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
Crop residue incorporation															
C_1 : Foxtail millet	36.3	45.2	41.1	3254	5144	4652	7.2	10.4	8.7	23.2	35.5	29.4	31.5	32.0	31.8
C_2 : Greengram	36.0	44.7	40.7	3127	5057	4359	7.1	9.9	8.5	23.9	35.1	29.5	32.4	33.1	32.8
C_3 : Fallow	35.0	47.0	41.0	2663	3966	3243	5.8	7.3	6.8	20.6	31.1	25.5	31.8	32.1	31.9
SEm ±	0.27	1.63	1.53	21.8	75.7	108.9	0.08	0.25	0.07	0.2	0.48	0.29	0.4	0.6	0.4
CD (P=0.05)	NS	NS	NS	85	295	330	0.3	0.9	0.3	0.8	1.87	1.1	NS	NS	NS
Time of sowing															
D_1 : October 2nd FN	33.4	45.8	38.8	2956	4458	3709	6.1	8.2	7.0	20.6	31.2	25.9	31.7	32.4	32.1
D_2 : November 1st FN	35.6	46.1	40.7	3585	5540	4742	8.1	13.3	10.4	27.6	38.7	33.1	31.5	32.0	31.8
D_3 : November 2nd FN	34.0	46.6	40.3	3143	4999	3972	7.1	9.6	8.4	22.6	34.2	28.4	30.9	31.9	31.5
D_4 : December 1st FN	30.1	45.2	37.6	2339	3892	3195	5.4	6.3	5.9	19.9	30.6	25.2	30.6	31.8	31.3
SEm ±	1.21	1.47	1.32	51.3	41.8	43.7	0.13	0.14	0.13	0.37	0.83	0.43	0.6	0.2	0.3
CD (P=0.05)	NS	NS	NS	152	124	130	0.39	0.3	0.4	1.1	2.49	1.3	NS	NS	NS
Time of irrigation															
I_1 : Irrigation at pre-flowering stage	33.7	46.7	40.2	3366	4155	3880	6.2	7.4	5.9	19.5	27.1	23.2	31.5	32.1	31.9
I_2 : Irrigation at pod development stage	36.2	43.9	40.1	3692	4819	4409	6.2	8.9	7.3	21.1	34.1	27.5	30.8	32.2	31.6
I_3 : Irrigation at pre-flowering and pod development stage	40.5	50.1	45.3	4096	5260	4861	8.6	10.6	8.4	27.4	40.7	34.1	32.4	31.9	31.2
SEm ±	0.27	1.18	0.92	33.2	44.2	42.5	0.12	0.22	0.13	0.28	0.73	0.39	0.6	0.2	0.3
CD (P=0.05)	0.8	3.4	2.8	104	132	121	0.3	0.6	0.4	0.8	2.08	1.1	NS	NS	NS
Interaction															
C × D															
SEm ±	1.35	1.56	1.23	33.2	35.2	35	0.23	0.23	0.23	0.26	0.43	0.32	0.4	0.4	0.5
CD (P=0.05)	NS	NS	NS	98	125	105	0.68	0.70	0.68	0.65	1.3	1.0	NS	NS	NS
C × I															
SEm ±	0.48	1.46	1.42	136.6	127.3	73.7	0.28	0.23	0.22	0.6	1.26	0.68	0.6	0.3	0.3
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
D × I															
SEm ±	0.96	1.70	0.99	139.4	240.1	150	0.24	0.27	0.25	0.8	1.46	0.79	0.4	0.4	0.9
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C × D × I															
SEm ±	0.96	1.57	1.46	132.8	141.5	147	0.41	0.47	0.43	1.25	2.5	1.36	0.5	0.7	0.6
CD (P=0.05)	NS	NS	NS	NS	NS	4642	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2. Seed weight per plant, seed yield, stover yield and harvest index of chickpea as influenced by crop residue incorporation, time of sowing and irrigation

Treatments	Seed weight plant^{-1} (g)			Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})			Harvest index (%)		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
Crop residue incorporation												
C_1 : Foxtail millet	6.9	10.3	8.7	1229	1867	1546	2629	4098	3146	46.7	44.3	45.5
C_2 : Greengram	6.2	9.2	7.8	1142	1828	1474	2376	4008	3192	48.1	45.5	46.8
C_3 : Fallow	5.3	7.7	6.5	974	1447	1216	2082	3167	2624	47.0	45.7	46.4
SEm ±	0.1	0.1	0.2	40.4	34.4	39	75.9	89	47	0.62	0.53	0.61
CD (P=0.05)	0.3	0.3	0.5	158	135	115	297	346	183	NS	NS	NS
Time of sowing												
D_1 : October 2nd FN	6.1	8.5	7.4	1044	1700	1380	2197	3603	2969	47.8	45.37	46.57
D_2 : November 1st FN	8.7	11.3	10.1	1702	1957	1660	2705	4303	3524	447	43.50	44.21
D_3 : November 2nd FN	6.6	9.8	8.3	1180	1770	1472	2509	3877	3193	46.6	45.73	46.26
D_4 : December 1st FN	4.5	7.3	5.9	935	1429	1167	1999	3247	2624	47.0	44.84	45.92
SEm ±	0.2	0.3	0.3	22.3	31.8	31	44.4	63.2	38.3	0.33	0.21	0.24
CD (P=0.05)	0.5	1.0	0.9	66	95	92	132	188	44	1.1	0.6	0.6
Time of irrigation												
I_1 : Irrigation at pre-flowering stage	5.8	8.3	7.1	801	1445	1117	1696	3100	2451	47.5	45.0	46.3
I_2 : Irrigation at pod development stage	6.5	9.5	8.1	985	1633	1300	2091	3623	2857	47.1	45.1	46.1
I_3 : Irrigation at pre-flowering and pod development stage	7.9	12.2	10.1	1557	2064	1819	3301	4550	3926	47.1	45.4	46.3
SEm ±	0.1	0.1	0.2	27.4	31.7	34	56.2	86	45.2	0.25	0.33	0.37
CD (P=0.05)	0.3	0.3	0.6	78	90	101	160	245	128	NS	NS	NS
Interaction												
C × D												
SEm ±	0.8	0.9	0.9	38.5	55.2	22.5	76.9	109	66.3	0.62	0.66	0.92
CD (P=0.05)	NS	NS	NS	115	164	96	228	325	197	NS	NS	NS
C × I												
SEm ±	1.3	1.2	1.4	47.4	55.0	38.2	97.4	149	78.4	0.93	0.54	0.62
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
D × I												
SEm ±	0.2	0.2	0.5	54.8	63.5	52.5	112.5	172	90.5	0.32	1.02	0.94
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C × D × I												
SEm ±	1.2	1.3	1.5	94.9	110.0	75.4	194.9	298	156.8	0.95	0.64	0.52
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3. Dry matter production (kg ha^{-1}) of chickpea at harvest as influenced by interaction between crop residue incorporation and time of sowing (Pooled)

Interaction	C_1	C_2	C_3	Mean of D
D_1	4067	3999	3062	**3709**
D_2	5109	5095	4023	**4742**
D_3	4239	4242	3436	**3972**
D_4	3762	3803	2022	**3195**
Mean of C	**4352**	**4359**	**3243**	
SEm ±		35.2		
CD (P = 0.05)		105		

Table 3A. Number of branches plant^{-1} of chickpea at harvest as influenced by interaction between crop residue incorporation and time of sowing (Pooled)

Interaction	C_1	C_2	C_3	Mean of D
D_1	7.9	7.1	6.0	**7.0**
D_2	11.5	10.5	9.3	**10.4**
D_3	9.2	8.7	7.3	**8.4**
D_4	6.6	6.6	4.5	**5.9**
Mean of C	**8.7**	**8.5**	**6.8**	
SEm ±		0.23		
CD (P = 0.05)		0.7		

Table 3B. Number of pods plant^{-1} of chickpea as influenced by interaction between crop residue incorporation and time of sowing (Pooled)

Interaction	C_1	C_2	C_3	Mean of D
D_1	26.1	27.6	24.1	**25.9**
D_2	35.6	35.5	29.2	**33.1**
D_3	29.6	29.9	25.7	**28.4**
D_4	26.4	29.1	23.0	**25.2**
Mean of C	**29.4**	**29.5**	**25.53**	
SEm ±		0.32		
CD (P = 0.05)		0.9		

Table 3C. Seed yield (kg ha^{-1}) of chickpea as influenced by interaction between crop residue incorporation and time of sowing (Pooled)

Interaction	C_1	C_2	C_3	Mean of D
D_1	1548	1449	1143	**1380**
D_2	1839	1683	1375	**1630**
D_3	1601	1561	1256	**1472**
D_4	1205	1206	1691	**1167**
Mean of C	**1546**	**1474**	**1216**	
SEm ±		22.5		
CD (P = 0.05)		96		

Effect of time of irrigation

The data indicated that time of irrigation influence growth and yield parameters during both years of study and also on pooled basis. Application of irrigation twice at pre-flowering and pod development stage recorded significantly higher plant height (45.3 cm), dry matter production (4861 kg ha^{-1}), number of branches plant^{-1} (8.4), number of pods plant^{-1} (34.1), seed weight plant^{-1} (10.1 g), seed yield (1819 kg ha^{-1}), stover yield (3926 kg ha^{-1}) and harvest index (46.29). Application of irrigation during pre-flowering stage recorded significantly lower number of branches per plant (6.0), number of pods per plant (23.2), seed weight per plant (7.1 g), dry matter production (3880 kg ha^{-1}), seed yield (1117 kg ha^{-1}) and stover yield (2451 kg ha^{-1}). Similar trend was recorded during 2018 and 2019. Irrigation enhanced number of branches plant^{-1} due to indeterminate growth habit of chickpea. Application of irrigation twice at pre-flowering and pod development stage enhanced dry matter production. This might be due to net gain of dry matter in vegetative structures after flowering is much higher with irrigation at pod filling stage. These results are in agreement with Razzak *et al*. (2017) and Kumar and Luther (2018).

Interaction effect

All the interaction effect of different treatments was non-significant except interaction between crop residue incorporation and irrigation stages. Interaction between crop residue incorporation and time of sowing significantly influences number of branches plant^{-1}, number of pods plant^{-1}, dry matter production, seed yield and stover yield. Interaction effect between foxtail millet

crop residue incorporation and November 1st FN sowing recorded significantly higher dry matter production (5109 kg ha^{-1}) number of branches $plant^{-1}$(11.5) number of pods $plant^{-1}$(35.6) and seed yield (1839 kg ha^{-1}) (Table 3, 3A, 3B and 3C). More number of branches $plant^{-1}$ plant was recorded with November 1st FN sowing (D_2) may be due favourable soil moisture and nutrients availability at root zone at growth period of crop.

CONCLUSION

The study revealed that in vertisols of scarce rainfall zone of AP in double cropping system, raising of foxtail millet during *kharif* was best option for crop residue incorporation, followed by raising of chickpea during November 1st FN with two irrigations one at pre-flowering and one at pod development stage for higher yield and to sustain soil fertility.

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STUDY ON THE PROGRESS AND PERFORMANCE OF MGNREGA IN CHITTOOR DISTRICT OF ANDHRA PRADESH

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ABSTRACT

The study was conducted during the year 2018-19 in Chittoor District of Andhra Pradesh in which 4 mandals were selected on the basis of highest average man days per household per year. Using the same criteria from each mandal, 2 villages were selected from each village, 10 households covered under MGNREGA were selected randomly. Thus the total sample size of the study constitutes to 80. Compound annual growth rates of person days generated through MGNREGA in Chittoor district from the year 2006-07 to 2018-19 for total beneficiaries was 0.72, for women also it was 0.79, but for SC and ST people it was -1.22 and -1.48. The work completion rate was decreasing. Growth rates of total available funds at national level was 4.37, the funds released from the centre was 5.53, for the expenditure of funds it was 6.31 and the per cent utilization of funds was varying. Growth rates of total available funds for Andhra Pradesh was 1.13, the funds released from the centre was -1.47, for the expenditure of funds it was 3.41 and the per cent utilization of funds was varying. The growth rates of the households issued with job cards was 2.92. The households demanding and provided with employment were same with a growth rate of -0.23 and the percentage of total job card holding household which got employment -3.06. The number of households completed 100 days of work was showing a growth rate of 5.38.

KEYWORDS: Compound annual growth rate, employment, MGNREGA, utilization of funds

INTRODUCTION

Poverty and unemployment are the two major stumping blocks of developing countries. Nearly 72.22 percent of population live in rural areas and majority of them are suffering from seasonal unemployment, under-employment and disguised unemployment, even though the labour force in India is increasing numerously. Government of India passed National Rural Employment Guarantee Act (NREGA) on August 25th, 2005 to empower the rural labourers to get 100 days of employment per household per year during off-season. The act has been launched on February 2nd, 2006 in Ananthapur district of Andhra Pradesh and it came to effect from April 1st, 2006. Further the Government of India renamed its premium rural job guarantee programme- National Rural Employment Guarantee Act (NREGA) as Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) on 2nd October, 2009.

Since the implementation of the programme in India, 14.61 crore job cards were issued, 3102.7 crore person days were generated till 2019-20 with the total expenditure of Rs. 619716.29 crore. The total number of active workers were 14.01 crore. Total person days generated were 268.24 crore, average days of employment provided per household were 41 with the average wage rate given per day per person was Rs. 200 for the year 2019-20. (www.nrega.nic.in) The current scenario of AP-MGNREGA is that the total number of job cards issued were 6397284 till 2019-20. Over all 6514235 individuals were provided with employment in the year 2019-20 with the generation of 200792978 person days of employment. The average wage rate per day per person was Rs. 203 which is more than the national average of 200 and the average number of days employment provided per household was 50. (www.nrega.ap.gov.in, 2020). Since the performance of the AP-MGNREGA is much better in terms of wage rate earned, (Srinivas and Pandyaraj, 2017) this study was initiated to assess the progress and performance of MGNREGA in the study area.

METHODOLOGY

The list of all 66 mandals of Chittoor district, was prepared and four mandals *viz*., Pulicherla, Rompicherla, Chinnagottigollu and Vadamalapeta were selected for the

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present study based on the highest average number of mandays. All the villages in selected mandals were listed out and two villages from each selected mandals were selected based on the criterion of highest number man days thus the total sample villages to eight. The selected villages were Pathapeta, Devalampet, Bandakindapalle, Ganugachintha, Kotabylu, Thippiredddygaripalle, Appalayagunta, Lakshmammakandriga. All the farmers in selected villages were listed out. From each village, 10 wage seekers of MGNREGA were selected at random. Thus, the total sample constitutes 80 respondents.

TOOLS OF ANALYSIS

Estimation of compound growth rate

Growth of any variable indicates it past performance. The analysis of growth is usually used in economic studies to find out the trend of a particular variable over a period of time. It clearly indicates the performance of the variable under consideration and hence it can be very well used for making policy decisions.

The growth rate was estimated using the exponential growth function of the form

$$Y = a*b^t u^t$$

where,

Y = Dependent variable for which growth rate was estimated

a = intercept

b = regression coefficient

t = time variable

u = disturbance term

The compound growth rate

$$r = (b-1) *100$$

RESULTS AND DISCUSSION

PROGRESS AND PERFORMANCE OF MGNREGA

To assess the progress and performance of MGNREGA, the employment generated to different categories of people, work completion rate and financial performance of the programme in the study area is undertaken.

Employment of MGNREGA workers

To assess the progress and performance of MGNREGA, person days generated for SC, ST and for women were taken and presented in the Table 1 and Fig. 1. For that, the data of total person days generated was taken from the year 2006-07 to 2018-19 in the study area.

From the table, it is observed that the number of person days generated were increased from the year 2006-07 to 2018-19. The same is also observed with all the sectors. When the compound annual growth rate was calculated it is observed that there is a positive growth rate with total person days generated (0.72), others (1.80) and women (0.79). The share of SC people is 31.54 and for ST people is 4.16 per cent as the programme is also aimed to achieve strong social net for the vulnerable groups. The employment share for women is 58.35 per cent, equal and non-discriminatory wages to both men and women, no need of special knowledge, work timings and work within 5 kms helped women to participate in the work more actively than men. More participation of women was also confirmed by Gulzar *et al.* (2016). There was a negative growth rate with SC (-1.22) and ST (-1.48). Similar results were observed in the study of Ranjithumar (2018).

Works undertaken and their completion rate under MGNREGA

From the Table 2 and Fig. 2, it is observed that the number of works undertaken is showing a positive growth of 12.23 as the works undertaken by MGNREGA for each year were increasing for creation of assets. And the number of works in progress were increased and the number of works completed also showing a positive growth of 9.8 whereas the work completion rate is showing a negative growth of -2.15 and it is only 76.14 and 67.50 per cent work completion rate for the years 2017-18 and 2018-19 which is showing under capability of MGNREGA programme to develop into an asset creation programme. Due to the slack attitude of both workers and officials towards the programme, there was less work completion rate in the study area. The results were in conformity with the study of Ranjan (2016).

The same trend was observed at A.P state and all India level.

Table 1. Extent of employment of MGNREGA workers

Financial year	Total person days generated				
	Total	**SC**	**ST**	**Others**	**Women**
2006-07	9626275.5	3258863	500665	5866747.5	5446482.5
2007-08	15401125	4964406.5	771984.5	9664734	9345717.5
2008-09	14583228	4641020	696071	9246137	8455870.5
2009-10	19997726.5	6704984	813567.5	12479175	11621664
2010-11	11964821.5	4239583.5	504255.5	7220982.5	6930631.5
2011-12	7304052	2857041	300058.5	4146952.5	4249512.5
2012-13	11697691	3882206	422426	7393059	6688238
2013-14	11400856	3706875.5	409242.5	7284738	6607987.5
2014-15	10096334.5	3151348.5	368402	6576584	5854750.5
2015-16	12814656	3922781	471279	8420596	7521187
2016-17	13299400	3742398	552276	9004726	7712442
2017-18	13386893	3770663	529716	9086514	7966450
2018-19	17565817	4500581	703557	12361679	10288702
Grand total	169138876 (100)	53342751 (31.54)	7043500.5 (4.16)	108752624.5 (64.30)	98689635.5 (58.35)
CGR	**0.72^{NS}**	**-1.22^{NS}**	**-1.48^{NS}**	**1.80^{NS}**	**0.79^{NS}**

NS : Non- Significant

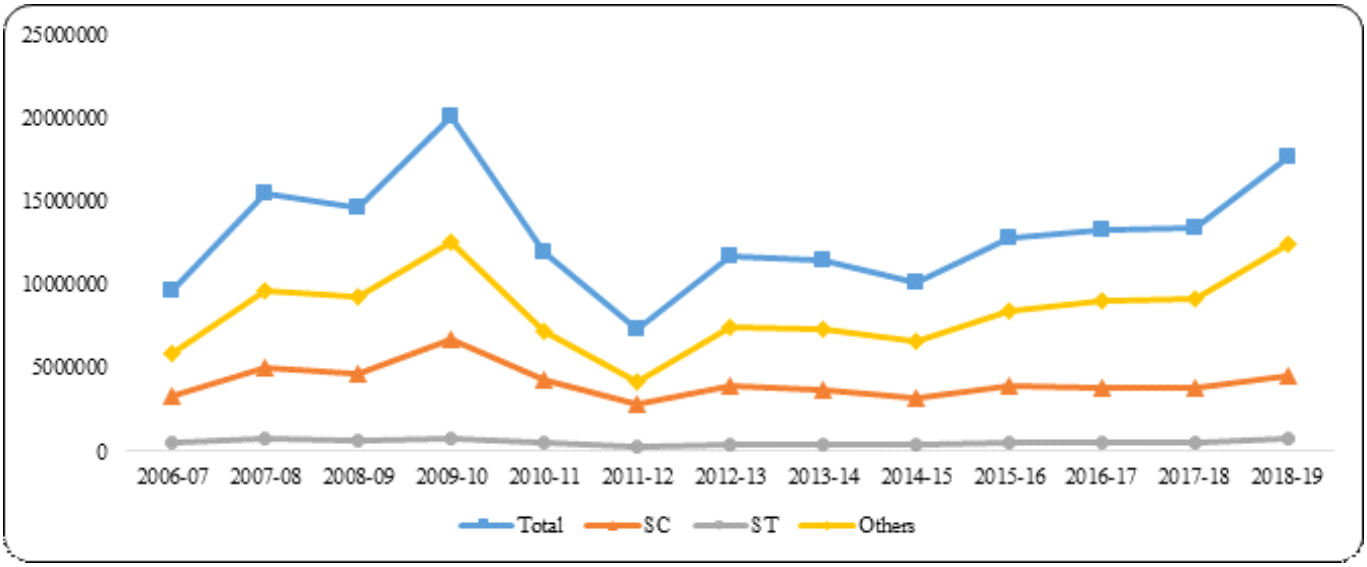

Fig. 1. Extent of employment of MGNREGA workers.

Table 2. Works undertaken and their completion rate under MGNREGA

Year	Total no. of works undertaken	No. of works in progress	No. of works completed	Work completion rate in terms of no. of works undertaken
2006-07	30811	4	30,807	99.98
2007-08	16678	9	16,669	99.94
2008-09	18296	9	18,287	99.95
2009-10	57584	9	57,575	99.98
2010-11	29921	9	29,912	99.96
2011-12	25927	36	25,891	99.86
2012-13	66411	49	66,362	99.92
2013-14	39857	115	39,742	99.71
2014-15	25370	258	25,112	98.98
2015-16	32117	969	31,148	96.98
2016-17	119406	4,207	1,15,199	96.47
2017-18	79895	19,063	60,832	76.14
2018-19	104289	33,799	70,490	67.59
CGR	**12.23****	**114.67****	**9.81***	**-2.15***

* : Significance at 5 per cent level
** : Significance at 1 per cent level
NS : Non- Significant

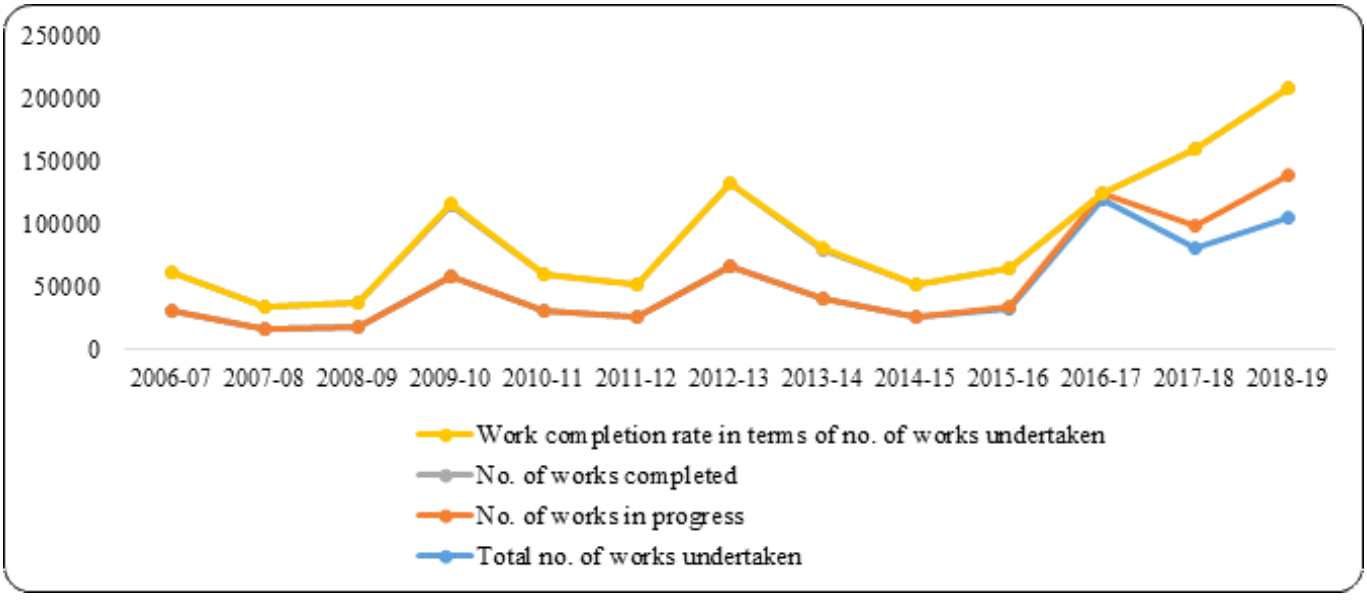

Fig. 2. Works undertaken and their completion rate under MGNREGA

CONCLUSION

Growth rates of person days generated through MGNREGA in the study area for total beneficiaries and women were positive. But for SC and ST people it was negative. Growth rates of total number of works undertaken, number of works in progress and number of works completed were highly positive. But the work completion rate was in decreasing order. It can be concluded that, the programme is showing an over all good performance in the study area except for the focus on work completion through the programme. In addition to creating medium term assets, long term asset creation and completion might be the need of the hour.

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PHOTOTHERMAL REQUIREMENTS AND RESPONSE OF CHICKPEA (*Cicer arietinum* L.) GENOTYPES UNDER DIFFERENT DATES OF SOWING

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ABSTRACT

A field experiment was conducted at Regional Agricultural Research Station, Nandyal during rabi season of 2018-19 and 2019-20 to find out optimum time of sowing and suitable genotypes of chickpea in scarce rainfall zone of Andhra Pradesh. The experiment consisted of three sowing dates 1st FN of October, 1st FN of November and 1st FN of December and fifteen genotypes was laid out in factorial randomized block design with three replications. Among the genotypes, desi genotypes are NBeG 47, NBeG 49, JG 11, Jaki, NBeG 452, NBeG 738, NBeG 776, NBeG 779, NBeG 857, and kabuli types are NBeG 119, NBeG 399, NBeG 440, NBeG 458, Vihar and KAK2. Results revealed that desi genotypes, NBeG-779 recorded higher total drymatter and in kabuli genotypes, NBeG-440 recorded higher total drymatter. Among the dates of sowing, 1st fortnight of November (D2) recorded higher total drymatter. Higher total dry matter in November sowing can be due to higher accumulation of GDD during flowering and pod development stage and higher GDD and PTU during the grain filling stage compared to other two sowings. The genotypes which recorded higher yields i.e NBeG-779 (1811 kg ha^{-1}) desi genotype and NBeG-440 (1662 kg ha^{-1}) kabuli genotype also recorded highest HUE values of 0.93 kg ha^{-1} ^oC day^{-1} and 0.77 kg ha^{-1} ^oC day^{-1} respectively. Similarly the genotypes sown during 1st FN of November recorded higher HUE followed by December and October sowings.

KEYWORDS: Chickpea, Growing degree days, Heat use efficiency

INTRODUCTION

The world faces the growing challenge of feeding over 9.5 billion people by 2050 under the looming threat of climate change. To address this challenge while reducing the carbon footprint and conserving water, our reliance on protein from plants will need to increase significantly. Chickpea is the third most important protein rich grain legume which is directly consumed as human food in the poorer countries where the projected population increases are most likely to occur. The crop is also important for sustainability of farming systems due to its nitrogen fixing ability. Chickpea yields are constrained by the crop's high sensitivity to a number of abiotic stresses including frost, drought and heat stress. The major chickpea-growing states in India are Madhya Pradesh, Uttar Pradesh, Rajasthan, Andhra Pradesh, Haryana and Maharashtra, which constitute 85 per cent area with 89 per cent production. Andhra Pradesh is one of the major chickpea producing states in India. In terms of area and production chickpea occupies 5th position, with an area of 4.78 lakh hectares producing 2.42 lakh tones with an average productivity of 508 kg ha^{-1} (Anonymous, 2020).

The exposure of crop to low temperatures during germination and seedling establishment and to high temperature during flowering and seed formation phases under delay-sown chickpea results in drastic reduction in yield. Yield loss in chickpea can vary between 30 and 60% depending on genotype, sowing time, location, and climatic conditions during sowing season. Some chickpea genotypes have capacity to tolerate drought and in that case sowing time can be delayed. Agro-climatic factors that influence crop phenology may also have a major effect on crop growth rate and the partitioning of dry matter. It is therefore useful to integrate phenological and growth responses. Optimum date of sowing provides favourable environmental conditions for growth, development and yield of crops through optimum utilization of available natural resources. The present study was an attempt to understand phenology and agro-meterological indices influence on various growth attributes, dry matter partitioning and yield in chickpea genotypes.

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MATERIAL AND METHODS

A field experiment was conducted at Regional Agricultural Research Station, Nandyal during rabi season of 2018-19 and 2019-20 to find out optimum time of sowing and suitable genotypes of chickpea in scarce rainfall zone of Andhra Pradesh. The experiment was laid out in factorial randomized block design with three replications and consisted of three sowing dates i.e., 1st fortnight of October, November and December and fifteen genotypes. Among them, desi genotypes are NBeG 47, NBeG 49, JG 11, JAKI, NBeG 452, NBeG 738, NBeG 776, NBeG 779, NBeG 857, and kabuli genotypes are NBeG 119, NBeG 399, NBeG 440, NBeG 458, Vihar and KAK2.Genotypes considered as factor one and three sowing dates as factor two. The soil of the experimental field is black cotton soil, with P^H 8.3 and EC 0.26 dS^{-m}. The data collected from the experiment was subjected to statistical analysis as described by Gomez and Gomez (1984).

Growing degree days (GDD)

Growing degree days (GDD) is an arithmetic accumulation of daily mean temperature above certain threshold temperature (base temperature) and is calculated using the formula.

$$GDD = \frac{(Tmax + Tmin)}{2} - \text{Base temperature}$$

Heliothermal units (HTU)

Heliothermal units (HTU) is the product of GDD and corresponding actual sunshine hours for that day were computed on daily basis as:

HTU (°C day hr) = GDD × Actual sunshine hours

Heat use efficiency (HUE)

Heat use efficiency (HUE) for seed was obtained as under:

Thermal use efficiency (HUE) =

$$\frac{\text{Seed yield (kg ha}^{-1})}{\text{Growing degree days (°C day)}}$$

RESULTS AND DISCUSSION

The data on stem dry weight were collected at 20 days interval from fifteen chickpea varieties sown at three dates of sowing are presented in Table 1.

Phenotypic variability for stem dry weight ranges from 9.71 g to 14.22 g at 80 DAS. Among the kabuli genotypes, significantly higher stem dry weight was recorded by NBeG-440 (13.19 g) followed by Vihar (12.86 g), whereas lowest stem dry weight was recorded by NBeG-458 (12.00 g) at 80 DAS. Among the desi genotypes, NBeG-779 recorded (14.22 g) higher stem dry weight followed by NBeG-776 (13.07 g) and lowest stem dry weight was recorded by NBeG-49 (9.71 g).The stem dry weight of chickpea for all the three dates of sowing showed exponential increase from 20 DAS to 80 DAS. Highest stem dry weight was recorded in D_2 (November 1st FN) sowing (12.48 g) followed by D_3 (December 1st FN) sowing (11.48 g) whereas lowest stem dry weight was recorded in D_1 (October 1st FN) sowing (10.98 g) at 80 DAS.

Chickpea GDD, and other heat units were numerically higher with first sown crop (D_1) compared to rest of times of sowing crop. But drymatter was less than D_2 and D_3 sown chickpea crop, because of higher GDD from sowing to emergence and comparable GDD for emergence to 50 per cent flowering than D_2. More over during second year an amount of 74.8 mm of rainfall received in eight rainy days at 44 to 46 standard weeks coincided with germination to vegetative stage of October 1st FN (D_1) sown crop, which might had suppressed the photosynthesis. Whereas November 1st FN sown (D_2) crop utilized the favourable weather condition for plant growth and recorded higher drymatter. Chickpea being a long day plant, delayed flowering increased dry matter production and accumulation, whereas condition favouring early flowering adversely affected dry matter accumulation (Pradeep and Hemantaranjan, 2012).

Phenotypic variability for leaf dry weight ranges from 4.80 g to 6.08 g at 80 DAS. Among the desi genotypes, highest leaf dry weight was recorded by NBeG-779 (6.08 g) followed by NBeG-776 (6.00 g) and NBeG-857 (5.94 g) and lowest were recorded in JG-11 (4.86 g). Among kabuli genotypes NBeG-440 (5.64 g) recorded higher dry weight followed by KAK-2 (5.60 g) whereas lowest leaf dry weight was recorded by Vihar (5.05 g) at 80 DAS. The ability of a genotype in utilizing

Table 1. Effect of temperature and photoperiod on drymatter partitioning in chickpea genotypes at different dates of sowing (*Rabi* season 2018-19 and 2019-20)

Treatments	Stem dry weight (g)		Leaf dry weight (g)		Pod dry weight (g)		Total dry matter (g)	
	60 DAS	80 DAS	60 DAS	80 DAS	60 DAS	At Harvest	60 DAS	80 DAS
Genotypes (G)								
G1 : NBeG 47	8.07	11.06	3.68	5.18	3.90	12.64	15.97	22.42
G2 : NBeG 49	6.70	9.71	3.99	5.49	2.93	10.67	15.93	22.38
G3 : JG 11	8.35	11.35	3.36	4.86	3.46	12.20	15.17	21.61
G4 : JAKI	7.24	10.24	3.75	5.25	4.46	13.20	15.45	21.90
G5 : NBeG 452	8.24	11.25	3.47	4.97	3.10	11.84	14.81	21.26
G6 : NBeG 738	8.39	11.39	4.08	5.58	4.44	13.18	17.37	23.82
G7 : NBeG 776	9.01	12.01	4.50	6.00	4.00	14.74	17.78	24.71
G8 : NBeG 779	9.26	14.22	4.58	6.08	4.04	15.78	18.49	25.42
G9 : NBeG 857	8.71	13.07	4.44	5.94	3.87	14.11	17.65	23.95
G10 : NBeG 119	8.79	12.28	3.30	4.80	3.75	11.95	15.86	22.31
G11 : NBeG 399	9.04	12.04	3.57	5.07	3.25	11.99	15.75	21.70
G12 : NBeG 440	9.70	13.19	4.10	5.64	3.21	13.32	16.10	22.55
G13 : NBeG 458	9.01	12.00	3.67	5.17	3.19	11.93	15.87	21.80
G14 : VIHAR	9.87	12.86	3.55	5.05	3.26	12.99	15.57	21.01
G15 : KAK2	9.34	12.34	4.14	5.60	3.08	12.49	16.10	21.05
SE(m)	0.54	0.80	0.06	0.07	0.035	0.095	0.28	0.38
CD (P=0.05)	1.54	2.38	0.19	0.23	0.105	0.285	0.83	1.18
Dates of Sowing (D)								
D_1 : 1st FN of October	7.99	10.98	3.72	5.22	3.28	12.02	14.99	20.42
D_2 : 1st FN of November	9.47	12.48	4.77	6.27	4.03	13.26	18.27	24.72
D_3 : 1st FN of December	8.48	11.48	4.10	5.60	3.89	12.63	16.47	22.91
SE(m)	0.24	0.57	0.08	0.13	0.045	0.075	0.25	0.31
CD (P=0.05)	0.69	1.68	0.24	0.40	0.135	0.215	0.76	0.93
Interactions (G × D)								
SE(m)	0.95	0.62	0.07	0.12	0.06	0.09	0.28	0.38
CD (P=0.05)	NS	1.77	0.22	0.35	0.20	0.29	0.86	1.16

Table 2. Effect of temperature and photoperiod on photothermal indices, heat use efficiency (kg ha $^{-1}$ ^{o}C day^{-1}) and yield (kg ha^{-1}) in chickpea genotypes at different dates of sowing (*Rabi* season 2018-19 and 2019-20)

Treatments	Growing degree days (GDD) ^{o}C	Heliothermal units (^{o}C day hrs)	Heat use efficiency (kg ha^{-1} ^{o}C day^{-1})	Yield (kg ha^{-1})
Genotypes (G)				
G1: NBeG 47	1910	14432	0.74	1498
G2: NBeG 49	1911	14452	0.76	1548
G3: JG 11	1894	14311	0.83	1659
G4: JAKI	1981	15076	0.74	1572
G5: NBeG 452	1852	13950	0.84	1635
G6: NBeG 738	1913	14468	0.80	1634
G7: NBeG 776	1896	14345	0.85	1722
G8: NBeG 779	1845	13884	0.93	1811
G9: NBeG 857	1930	14604	0.83	1704
G10 : NBeG 119	1818	13657	0.76	1465
G11 : NBeG 399	2022	15506	0.68	1463
G12 : NBeG 440	2059	15801	0.77	1662
G13 : NBeG 458	2114	16299	0.65	1465
G14 : VIHAR	2180	16961	0.61	1411
G15 : KAK2	2154	16725	0.60	1380
SE(m)	5.6	48.6	0.02	39.9
CD (P=0.05)	15.8	136.9	0.05	112.4
Dates of Sowing (D)				
D1: 1st FN of October	2112	15080	0.63	1400
D2: 1st FN of November	1954	14551	0.88	1831
D3: 1st FN of December	1830	14262	0.78	1494
SE(m)	2.51	21.75	0.009	17.86
CD (P=0.05)	7.08	61.24	0.025	50.29
Interactions (G × D)				
SE(m)	9.7	84.2	0.03	69.1
CD (P=0.05)	27.4	237.1	0.09	194.7

heat energy greatly influences its photosynthetic ability and physiological efficiency. The leaf dry weight of chickpea for all the three dates of sowing showed exponential increase from 20 DAS to 80 DAS. Highest leaf dry weight was recorded in November1st FN (D_2) sowing (6.27 g) followed by December 1st FN (D_3) sowing (5.60 g) whereas lowest leaf dry weight was recorded in October 1st FN (D_1) sowing (5.22 g) at 80 DAS.

In the present study similar to stem dry weight, leaf dry weight was also higher during November 1st FN (D_2) sowing because of higher heat utilizing ability and it further support that adequate rainfall, accumulated GDD during vegetative growth favours crop growth in terms of plant height, leaf area and stem dry weight compared to other two sowings.

It is clear from the experimental results that higher temperature during crop growth period lowered the drymatter accumulation under late and early planted chickpea crop. The results are in synchronous with Tripati *et al*. (2008) and Singh and Shono (2012) and they reported that high temperature during the reproductive stage induces increase in rate of respiration, resulting in loss of stored food material, which in turn reduces fresh weight and there was decline in shoot length and dry weight with corresponding decrease in dry weight of leaf, stem and pod.

The pod dry weight of chickpea at all the three dates of sowing increased from 60 DAS to harvest. Highest pod dry weight was recorded in November 1st FN (D_2) sowing (13.26 g) followed by December 1st FN (D_3) sowing (12.63 g) whereas lowest leaf dry weight was recorded in October 1st FN (D_1) sowing (12.02 g) at harvest due to high temperatures and low soil moisture availability. The higher pod dry weight in November sown crop may be attributed due to sufficient soil moisture available in root zone at reproductive stage and increased the partitioning efficiency from source to sink i.e., from stem and leaves to pods.

Phenotypic variability for total dry matter ranges from 21.01 g to 25.42 g at 80 DAS. Among desi genotypes highest total dry matter was recorded by NBeG-779 (25.42 g) followed by NBeG-776 (24.71 g) and NBeG-857(23.95 g) and lowest dry matter were recorded in NBeG-452 (21.26 g). Among kabuli genotypes highest total dry matter was recorded by NBeG-440 (22.55 g) followed by NBeG-458 (21.80 g) and was at par with NBeG119 (21.70 g) respectively whereas lowest total dry matter was recorded in Vihar (21.01 g). Different genotypes had significant effect on dry matter accumulation at all stages of chickpea. The results are in accordance with Mrudula *et al*. (2012).

The total dry weight of chickpea at all the three dates of sowing showed exponential increase from 20 DAS to 80 DAS. Highest total dry matter was recorded in November 1st FN sowing (24.72 g) followed by in December 1st FN sowing (22.91 g) whereas lowest total dry matter was recorded in October 1st FN sowing (20.42 g) at 60 DAS.

GDD significantly varied among the genotypes, from sowing to physiological maturity, and the accumulated Growing degree days (GDD) ranged from 1818° day to 2180° day across all the three dates of sowing, whereas among the dates of sowing, GDD ranges from 1830° day to 2112° day (Table 2). Under late sown conditions, lower GDD was required by the crop to attain maturity. However, when dates of sowing were advanced, higher GDD was needed by the chickpea crop to attain maturity. Similar results were reported by Rathod and Chimmad (2016) and Kiran and Chimmad (2018). Heat use efficiency (HUE) ranges from 0.60 kg ha^{-1} °C day^{-1} to 0.93 kg ha^{-1} °C day^{-1} at physiological maturity, across the three dates of sowing, HUE ranges from 0.63 kg ha^{-1} °C day^{-1} (D_1) to 0.88 kg ha^{-1} °C day^{-1} (D_2). Mhaske *et al*. (2019) reported that HUE was significantly superior in desi genotype compared to kabuli genotype and also envisaged that increase in dry matter resulted in proportionate increment in HUE.

Variability for grain yield ranges from 1380 kg ha^{-1} to 1811 kg ha^{-1}. Among the desi genotypes, NBeG 779 (1811 kg ha^{-1}) recorded significantly higher yield followed by NBeG 776 (1722 kg ha^{-1}) and was at par with NBeG 857 (1704 kg ha^{-1}) and lowest was recorded in NBeG 47 (1498 kg ha^{-1}). Among kabuli genotypes NBeG 440 (1662 kg ha^{-1}) recorded higher yield followed by NBeG 458 and NBeG 119 (1465 kg ha^{-1}) whereas lowest grain yield were recorded by KAK-2 (1380 kg ha^{-1}). Under delayed sowings chickpea reproductive phase suffers considerably due to high temperatures (35/18 °C, day/night), and under such thermal conditions, grain yield is reduced to 33% compared to that of normal conditions such as 30/10°C day/night (Summerfield *et al*., 1984).

CONCLUSION

The genotype NBeG 779 recorded higher total drymatter production and yield and its components compared to other desi genotypes like NBeG 47, NBeG 49, JG 11, JAKI, NBeG 452, NBeG 738, NBeG 776, NBeG 857 and in kabuli genotypes, NBeG 440 recorded higher total drymatter production and yield compared to NBeG 119, NBeG 399, NBeG 458, Vihar and KAK2. Among the three dates of sowing, D2 November 1st FN sowing found favourable interms of higher accumulation of GDD especially at critical phenophase and recorded higher HUE and yield compared to December and October sowing.

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COLLECTION AND ISOLATION OF *Bacillus thuringiensis* BERLINER FROM SOIL SAMPLES OF TIRUPATI REGION

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ABSTRACT

The parasporal crystal toxins produced by *Bacillus thuringiensis* are the most widely used natural insecticides in pest control in agriculture and vector control of public health. *B. thuringiensis* was isolated from soil samples of Tirupati region using sodium acetate selection method. The soil samples were buffered with 0.5M sodium acetate followed by heat shock at 80^{o}C and serial diluted up to 10^{-5} for eliminating non-spore forming bacteria and other microbes in the culture and then grown on LBA medium. After 24 hr of incubation, the colonies which were round, creamish with fried-egg appearance were produced. A total of 71 colonies from 100 soil samples were tested for Gram staining and observed 56 Gram positive bacteria with rod shaped structure. These 56 Gram positive cultures resulted in 42 endospore producing cultures and finally 32 crystal producing *B. thuringiensis* cultures were identified out of which 16 were bipyramidal, 9 were rhomboidal and 7 were spherical.

KEYWORDS: *B. thuringiensis*, Collection, Isolation, Soil samples

INTRODUCTION

Biological control is an important component of integrated pest management (IPM) in which microbial biocontrol plays a key role in the control of insect pests. Over 100 bacteria identified as insect pathogens, *Bacillus thuringiensis* Berliner (*Bt*) has got maximum importance as a microbial biocontrol agent (Muhammad *et al*., 2016).

B. thuringiensis is a Gram positive, rod shaped, facultative aerobic, spore-forming saprophytic soil bacteria which constitutes 95 per cent of all commercial bio-insecticides, due to its high specificity, safety and effectiveness in the control of wide spectrum of human disease vectors and agriculture-pests. Spore-formation enables *B. thuringiensis* to survive in harsh environments resulting in a ubiquitous distribution (Schünemann *et al*., 2014). Besides spore formation, insecticidal properties of *B. thuringiensis* are mainly attributed to the synthesis of insecticidal crystal proteins (ICPs) and vegetative insecticidal proteins (VIP), which are synthesized during sporulation and vegetative growth, respectively. Bravo *et al.*,1998 reported that, the crystal proteins toxic to lepidopteran insects belongs to the *cry*1, *cry*9, and *cry*2 groups, toxins active against coleopteran insects are *cry*3, *cry*7, and *cry*8 proteins, *cry*1B and *cry*1I proteins have dual activity. Among the Vip proteins, Vip1 and Vip2 are effective against Coleoptera and Hemiptera. The third group Vip3 is suitable for Lepidoptera which is having mode of action similar to Cry proteins in terms of proteolytic activation. The mode of action of Vip 4 is still unknown and the target group is also unidentified. *B. thuringiensis* strains have been isolated worldwide from many habitats, including soil, aquatic environments, dead insects and their breeding sites, herbivore faeces, stored-products, dust and deciduous and coniferous leaves (Cavado *et al*., 2001). A typical method of isolation involves heat treatment to select for spores, sometimes with an acetate enrichment step (Travers *et al*., 1987), antibiotic selection (Yoo *et al*., 1996) or non selective agar media (Chilcott and Wigley, 1993).

The objective of the present study was to collect and isolate *B. thuringiensis* from soil samples from diverse regions in and around Tirupati, Chittoor, Andhra Pradesh, India.

MATERIAL AND METHODS

The present study was carried out in the Department of Entomology, S.V. Agricultural College, Tirupati.

Collection of soil sample

A total of 100 soil samples were collected from different areas of Tirupati covering cultivated soils [field

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crops (Paddy, Maize, Jowar, Sugarcane, Ground nut, Red gram, Ragi, Variga, Kodo millet, Sesamum), horticultural crops (Tomato, Brinjal, Bhendi, Mango, Banana, Citrus, Guava, pomegranate, Papaya, Sapota), fodder crops (Fodder Jowar) and forest crops (Teak, Sesbania, Red sandels, Nerium, Tamarind, Borasses)] virgin soils and wastelands. According to soil category, 23 samples were collected from virgin soils, 55 samples from cultivated soils of which 27 samples from field crops, 23 samples from horticultural crops and 5 samples from fodder crops, 11 samples from agro-forest crops and 11 samples from wastelands. These samples were used for the isolation of *B. thuringiensis*.

Sampling method

Surface soil was scraped off to avoid surface contamination and about 10 g of soil sample was taken from a depth of 5–10 cm with sterile spatula and subsequently transferred into sterile plastic bags and brought to the laboratory for further processing. These samples were stored at 4°C until processed for isolation of *B. thuringiensis*.

Isolation of *B. thuringiensis* from Soil Samples

Modified Sodium acetate selection method given by Travers *et al*., 1987 was followed for isolating *B. thuringiensis* from soil samples. Half a gram of soil sample was added to 10 ml of Luria Bertani broth (LB) in a 50 ml of conical flask. The Luria Bertani broth was buffered with 0.5 M sodium acetate. The mixture was kept on a shaker at 250 rpm for 4 h at 28°C. The sample was taken and subjected to heat shock at 80°C for 15 min. Each sample was then subjected to five ten-fold dilutions (from 10^{-1} to 10^{-5} dilutions). One ml of heat shocked culture broth was taken and mixed with 9 ml of sterile distilled water to get 10^{-1} dilution. From 10^{-1} dilution, one ml was taken and mixed with 9 ml of sterile distilled water to get 10^{-2} dilution. This is repeated up to 10^{-5} dilutions. One hundred micro litre of 10^{-5} dilution was spread on Luria Bertani (LB) agar media petriplates with 'L' rod for bacterial growth. Then the plates were incubated at 37°C for overnight.

Staining and Microscopic observations of strains for identification of *B. thuringiensis*

After incubation, bacterial colonies were selected based on the typical morphological characteristics of *B. thuringiensis*, creamish coloured colonies having appearance of fried egg. These selected colonies were then sub-cultured onto new Nutrient Agar plates by repeated four way streaking (Merdan *et al*., 2010) and incubated at 37°C.

Smears of bacterial cultures were prepared and subjected to Gram staining, endospore staining and crystal staining for identification of *B. thuringiensis*. Gram staining of bacteria was done by following Hucker's method as described by Cappuccino and Sherman (1992). Gram positive cells appear violet colour under microscope. Gram positive cultures were streaked on T_3 medium for sporulation. After 48 hr of incubation, crystal protein staining was performed according to the protocol given by Sharif and Alaeddinoglu (1988) and they appear as dark blue coloured crystals under microscope. Endospore staining was done by using Schaeffer-Fulton method. Under the microscope, the endospores appear as green and the vegetative cells will appear red or pink (Lalitha, 2012).

RESULTS AND DISCUSSION

Out of 100 soil samples, 71 samples have shown creamy white, flat bacterial colonies with fried egg appearance, of which 17 were from virgin soils, 18 from field crops, 15 from horticultural crops, 4 from fodder crops, 8 from agro-forest crops and 9 from wastelands. These results are comparable with the findings of Frederiksen *et al.*, 2006 and Lalitha, 2012 who reported the frequent occurrence of *B. thuringiensis* in the natural environment and the possibility of isolating novel strains. Most of these studies proved the ubiquitous nature of *B. thuringiensis*, which can be found in any type of soil.

Out of 56 samples produced rod shaped Gram positive bacteria, 13 (56.52%), 13(48.14%), 14 (60.86%), 3 (60%), 6 (54.54%), 7 (63.63%) were positive in Gram staining with rod shaped bacterial cells from the soil samples of type: virgin soils, field crops, horticultural crops, fodder crops, wastelands and agro-forest crops respectively (Table 1). Zhenxiang *et al*., 2018 reported that those bacterial colonies having colony morphology of gray-white, round, opaque, flat, drying, medium-sized are positive in Gram staining.

Of the 56 Gram positive cultures tested for endospore production, a total of 42 cultures were able to produce endospores out of which 10, 9, 11, 3, 4, 5 from virgin soils, field crops, horticultural crops, fodder crops, wastelands and agro-forest crops, respectively. The Gram

Table 1. Gist of gram positive bacterial cultures representing different soil categories in Tirupati region of Andhra Pradesh

S. No.	Soils	Total soil samples collected	Sample Code	Gram positive cultures	Total	Per cent gram positive cultures
1.	Virgin soils	23	V1, V2, V3, V4, V5, V6, V7, V8, V9, V10, V11, V12, V13, V14, V15, V16, V17, V18, V19, V20, V21, V22, V23	V1,V2, V3, V5, V6, V7, V13, V15, V17, V18, V19, V21, V22	13	56.52
2.	Cultivated soils		C			
	a) Field crops	27	CF24, CF25, CF26, CF27, CF28, CF29, CF30, CF31, CF32, CF33, CF34, CF35, CF36, CF37, CF38, CF39, CF40, CF41, CF42, CF43, CF44, CF45, CF46, CF47, CF48, CF49, CF50	CF24, CF26, CF27, CF28, CF30, CF31, CF34, CF42, CF43, CF47, CF48, CF49, CF50	13	48.14
	b) Horticultural crops	23	CH51, CH52, CH53, CH54, CH55, CH56, CH57, CH58, CH59, CH60, CH61, CH62, CH63, CH64, CH65, CH66, CH67, CH68, CH69, CH70, CH71, CH72, CH73	CH52, CH53, CH54, CH55, CH57, CH58, CH59, CH60, CH62, CH64, CH66, CH69, CH70, CH71	14	60.86
	c) Fodder crops	5	CFo74, CFo75, CFo76, CFo77, CFo78	CFo74, CF$_O$75, CFo76	3	60.00
3.	Wastelands	11	W79, W80, W81, W82, W83, W84, W85, W86, W87, W88, W89	W81, W80, W82, W83, W85, W86	6	54.54
4.	Agro-Forest crops	11	AF90, AF91, AF92, AF93, AF94, AF95, AF96, AF97, AF98, AF99, AF100	AF92, AF93, AF95, AF96, AF98, AF99, AF100	7	63.63
	Total	**100**			**56**	

Table 2. List of Endospore positive Bacterial cultures representing different soil categories in Tirupati region of Andhra Pradesh

S. No.	Soils	Endospore positive cultures	Gram positive cultures	Endospore producing Strains	Per cent endospore positive strains
1	Virgin soils	V1,V2, V5, V6, V13, V17, V18, V19, V21, V22	13	10	43.47
2	Cultivated soils				
	a) Field crops	CF24, CF26, CF30, CF31, CF42, CF43, CF47, CF49, CF50	13	9	33.33
	b) Horticultural crops	CH52, CH53, CH54, CH58, CH59, CH60, CH64, CH66, CH69, CH70, CH71	14	11	47.82
	c) Fodder crops	CFo74, CF$_O$75, CFo76	3	3	60.00
3	Wastelands	W80, W83, W85, W86	6	4	36.36
4	Agro-Forest crops	AF92, AF95, AF96, AF98, AF100	7	5	45.45
	Total		**56**	**42**	

Table 3. List of Crystal positive *Bacillus* cultures representing different soil categories in Tirupati region of Andhra Pradesh

S. No.	Soils	Crystal positive strains	Total	Per cent crystal positive strains
1.	Virgin soils	V12, V13, V17, V19, V20	5	21.73
2.	Cultivated soils			
	a) Field crops	CF24, CF31, CF43, CF48, CF49, CF50	6	22.22
	b) Horticultural crops	CH52, CH53, CH54, CH57, CH58, CH60, CH64, CH66, CH70, CH71	10	43.47
	c) Fodder crops	CFo74, CF$_O$75, CFo76	3	60.00
3.	Wastelands	W81, W80, W83, W85, W86, W87	6	54.54
4.	Agro-Forest crops	AF96, AF98	2	18.18
	Total		**32**	

Fig. 1. Colony morphology of *Bacillus thuringiensis*

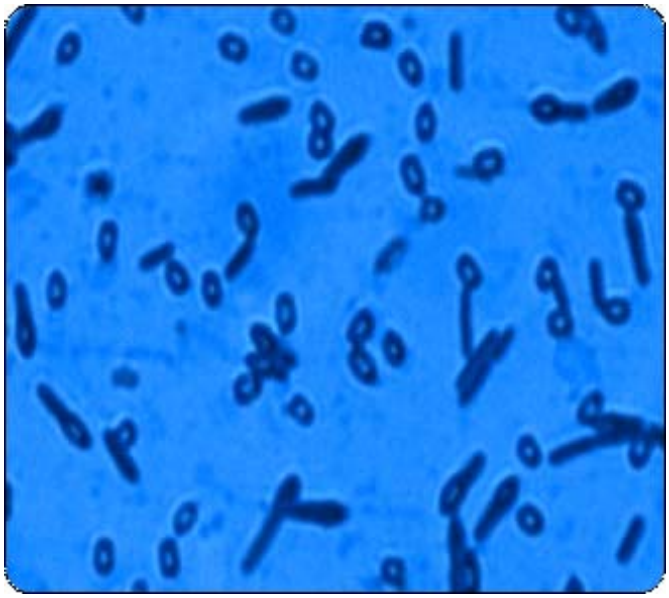

Fig. 3. Microscopic observations of Gram stained cultures (Magnification X 1000)

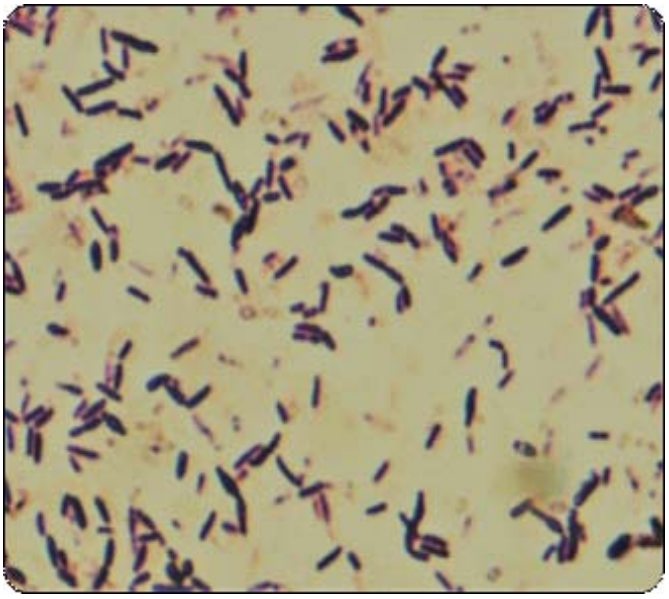

Fig. 2. Microscopic observations of Gram stained cultures (Magnification X 1000)

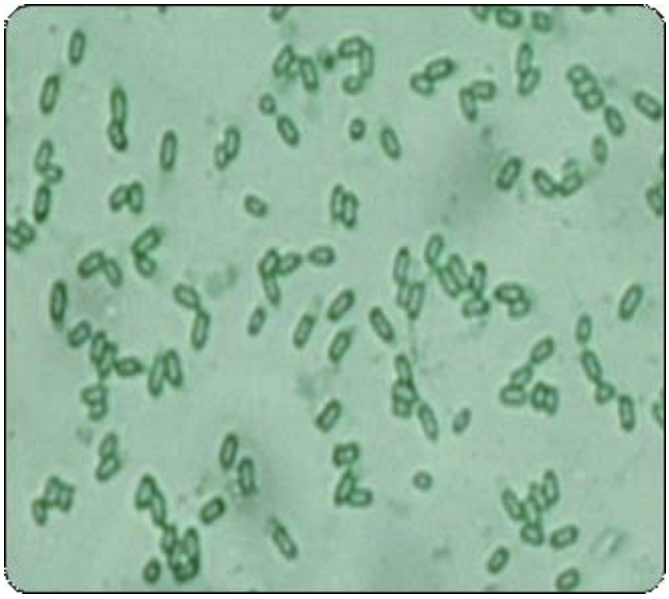

Fig. 4. Microscopic observations of endospore stained cultures (Magnification X 1000)

positive samples of fodder crops produced highest per cent endospores (60.00%), compared to 47.82, 45.45, 43.47, 36.36 and 33.33 per cent in horticultural crops, agro-forest crops, virgin soils, wastelands and field crops (Table 2). The endospores were ellipsoidal and lie in the sub terminal position and most of them released freely from the cells while observed under phase contrast microscope.

Among the 32 *B. thuringiensis* crystal positive strains tested for the presence of parasporal inclusions or crystal proteins, soil samples from fodder crops harboured high frequency of 60.00 per cent crystal positive *B. thuringiensis* strains (3/5), followed by 54.54 per cent in wastelands (6/11), 43.40 per cent in horticultural crop ecosystems (10/23), 22.22 per cent in field crop ecosystem (6/27), 21.73 per cent in virgin soils (5/23) 18.18 per cent in agro-forest ecosystem (2/11) (Table 3). The variation in *B. thuringiensis* positive strains from different environments may be due to biotic and abiotic factors *viz*., micro-organisms in the soil, type of insect fauna associated with the sampling areas besides abiotic factors such as the soil pH, soil texture, nutritional status, soil aeration, temperature and humidity *etc*. Armengol *et al*., 2007 characterized 445 strains of *B. thuringiensis* based on crystal morphology, insecticidal ability, type of *cry* genes and protein profiling and observed that 60 per cent of strains are with bipyramidal crystals. Reyaz *et al*., 2017 found 4 types of crystal toxins including bipyramidal (5.88%), spherical plus rod (4.41%), spherical plus bipyramidal (2.94%) and cuboidal (2.94%).

CONCLUSION

This study demonstrated that soil samples collected from undisturbed soils (virgin soils, wastelands, forest crop soils) harboured more *B. thuringiensis* than cultivated soils. A future study related to serological characteristics and insecticidal activity of *B. thuringiensis* isolates would likely to give more definitive results about the biodiversity of *B. thuringiensis* strains in varied regions in Tirupati.

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