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PHYTOTOXINS AND THEIR ROLE IN DEVELOPMENT OF *Fusarium* WILT IN CHICKPEA

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ABSTRACT

Phytotoxins are low molecular weight metabolites produced by plant pathogens that cause obvious damage to plant tissues and are known to be involved in plant disease. Phytotoxins from various formae speciales of *Fusarium oxysporum* such as fusaric acid from the banana pathogen *F. oxysporum* f. sp. *cubense*, beauvericin from the muskmelon pathogen *F. oxysporum* f. sp. *melonis*, and bikaverin and norbikaverin from the cotton pathogen, *F. oxysporum* f. sp. *vasinfectum* have been reported to cause wilt symptoms in their host plants. *Fusarium* wilt, caused by *Fusarium* sp. one of the serious disease of chickpea, is responsible for losses up to 100 per cent when conditions favour the disease. Chlorosis and wilting are common symptoms on the chickpea plants infected with *Fusarium* sp. These symptoms suggest that phytotoxins are involved in the *Fusarium* wilt disease of chickpea. Filtrates from cultures of *Fusarium acutatum*, caused permanent wilting of chickpea cuttings and killed cells in a bioassay. The phytotoxin from the culture filtrate was identified as 8-*O*-methyl-fusarubin. Knowledge of such phytotoxic metabolites provides insights into disease syndromes and may be exploited by conventional and molecular breeding to obtain crops resistant to plant disease.

KEYWORDS: Phytotoxins, *Fusarium* wilt, chickpea, disease development

INTRODUCTION

Chickpea (*Cicer arietinum* L) is the third most important pulse crop after bean (*Phaseolus vulgaris*) and pea (*Pisum sativum*) on a world basis but of first importance in the Mediterranean basin and South Asia. It is grown in 33 countries on an area of about 11.5 million hectares (Bidyarani *et al.,* 2016) and India accounts for about 65 per cent of the world's chickpea production (FAOSTAT, 2014).Cultivated chickpea are divided into two major groups "*desi*" and "*kabuli*". Chickpea seed is mainly used as food because of its high protein (12-31 %) and carbohydrate (52-71 %) contents (Awasthi *et al.,* 1991). Global yields of chickpea (968 kg ha^{-1}) have been relatively stagnant (FAOSTAT, 2013) for the last five decades in spite of using various advanced and molecular breeding approaches, extensive use of synthetic fertilizers and pesticides that in addition created environmental and health concerns. Productivity may be considerably improved if the adverse effects of abiotic and biotic stresses are reduced. The major abiotic stresses are cold, heat and drought. Of these, drought is the major limiting factor as chickpea is grown on residual soil moisture as a post-rainy season crop. Advancing sowing dates in certain regions can alleviate the effect of moisture stress and thereby increasing the yield. Chickpea is also sensitive to salinity and this is an important problem in India and Pakistan. Numerous studies have shown that soil salinity inhibits legume growth and development and decreases nodulation and nitrogen fixation (Mensah and Ihenyen, 2009; Egamberdieva *et al.,* 2013). Salt tolerant genotypes are available but these lines do not generally yield well. Lowering the water table through improved drainage can be effective in areas where it is high (ICRISAT, 1997).

Chickpea suffers from about 172 pathogens consisting of fungi, bacteria, viruses and nematodes of which 38 are soil-borne. *Rhizoctonia solani*, *Sclerotium rolfsii* and *Fusarium oxysporum* f. sp. *Ciceri* (FOC) are the most serious and are responsible for wet root rot, collar rot and wilt, respectively, and cause losses as high as 60 to 70 per cent when conditions favour disease (Anjaiah *et al.,* 2003). The foliar diseases which may damage chickpea are blight caused by *Ascochyta rabiei* and grey mould caused by *Botrytis cinerea*. Bacterial blight caused by *Xanthomonas cassiae* was also found damaging in India (Nene, 1980). Important viral diseases include stunt, chlorosis and dwarfing, mosaic, proliferation and necrosis caused by Pea Leaf Roll Virus, Chickpea Chlorotic Dwarf Virus, Alfalfa Mosaic Virus, Cucumber Mosaic Virus and Lettuce Necrotic Yellow Virus, respectively (Horn and Reddy, 1996). Among the nematodes, *Meloidogyne* spp.,

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Heterodera spp. and *Pratylenchulus* spp. cause heavy losses of the crop in several countries (Ansari *et al.,* 2002). *Fusarium* wilt and *Ascochyta* blight are considered to be the two most devastating diseases of chickpea (Hamid *et al.,* 2001).

Fusarium wilt of chickpea

Fusarium oxysporum is the causal agent of wilt of many plant species. All strains may exist saprophytically and some are considered to be non-pathogenic but many are well known for inducing wilt on a variety of plants (Fravel *et al.,* 2003). Often isolates are specific to particular hosts for example, *F. oxysporum* f. sp. *lycopersici* infects tomato and *F. oxysporum* f. sp. *cubense* infects banana (Fravel *et al.,* 2003).Wilt of chickpea is normally considered to be caused by *F. oxysporum* f. sp. *ciceri* (Padwick) Snyd. and Hans, hereafter designated as FOC. Initially it was believed that formae speciales were specific to one host and hence the name was taken from the host. However, other species and formae speciales of *Fusarium* also cause wilt in chickpea (Di Pietro *et al.,* 2003; Gopalakrishnan and Strange, 2005). *Fusarium* wilt is prevalent in all chickpea-growing areas of the world, including India, Pakistan, Spain, Iran and Tunisiaand is important where the chickpea-growing season is dry and warm (Dubey *et al.,* 2010). This disease causes yield losses up to 100 per cent under favorable conditions in chickpea (Anjaiah *et al.,* 2003; Landa *et al.,* 2004). Symptoms of *Fusarium* wilt in chickpea consist of epinasty, chlorosis of leaves, discoloration of vascular tissue and ultimately collapse of the whole plant (Hamid *et al.,* 2001). The disease may be diagnosed by sudden drooping of leaves and petioles, which may turn yellow and browning of vascular bundles and its colonisation by fungal hyphae, which are apparent when the stem is split open (ICRISAT, 1995). Seven races of FOC (0, 1, 2, 3, 4, 5 and 6) have been reported worldwide (Cachinero *et al.,* 2002).

Management of *Fusarium* wilt

FOC may be eliminated from the seed using the fungicide Benlate T (30% Benomyl + 30% Thiram) at 0.25% (Mandeel, 1996). FOC can survive in the soil for more than 6 years and also in symptomless carriers (Haware and Nene, 1982). Therefore it is not possible to control the disease by normal crop rotation. Soil solarisation reduced FOC population and incidence of wilt (Chauhan *et al.,* 1988) however; cost considerations would limit the use of this technique in the commercial farming. Sterilisation of the soil by methyl bromide is not an option as it is both costly and environmentally damaging (Fravel *et al.,* 2003). Date of sowing seems to have an effect on the incidence of wilt by lowering the fungal attack but also yield.

Disease resistance is another way to control plant disease if satisfactory levels of long-lasting resistance can be incorporated into culturally desirable crop plants. Maintenance of high levels of resistance to disease is normally achieved by selection and hybridisation. Selection involves exposing plant populations to high disease pressure and selecting individuals that survive. Resistance can be also developed by mutagenesis using chemicals such as methyl or ethyl-methanesulphonate, diethyl sulphate or ionising radiation such as X or gamma rays. Generation of resistance by gamma radiation has been reported for diseases including wilt, blight, stunt and root rot of chickpea but none of these has yet reached commercial application. Although varieties of plants that are resistant to some fusarial diseases are known, e.g., tomato grown in greenhouses are resistant to common races of *F. oxysporum* f. sp. *lycopersici* (Fravel *et al.,* 2003), but there are several plants for which for no dominant gene for disease resistance to *Fusarium* is known e.g. carnation, cyclamen and flax. Despite the presence of races of the fungus, chickpea in relation to FOC appears to fall into this category. Several workers have observed different patterns in the development of wilting symptoms when chickpea is infected with FOC. For e.g., Sharma *et al.* (2012) identified moderate level of resistance against *Fusarium* wilt on three breeding lines (ICCV 05527, ICCV 05528 and ICCV 96818) and one germplasm accession (ICC 11322).

Biological control of plant diseases usually occurs by one or more of several distinct mechanisms. These include competition for nutrients, parasitism, antibiotics production and induced systemic resistance (Van Loon *et al.,*1998). Biological control of the soil and seed-borne plant pathogenic fungi have been addressed using bacterial and fungal antagonists, to certain extent. Strains of *Bacillus* spp., *Pseudomonas* spp. *Trichoderma* spp. and non-pathogenic isolates of *F. oxysporum* were found not only to control FOC but also in helping the chickpea plants to mobilize and acquire nutrients (Postma *et al.,* 2003; Perner *et al.,* 2006; Gopalakrishnan *et al.,* 2015). Saprophytic *Fusarium* are able to suppress populations of pathogenic *Fusarium* spp. by competing for nutrients in the soil, infection sites on the root and also in inducing systemic resistance (Fravel *et al.,* 2003). In wilt sick plot, Landa *et al.* (2004) reported that biocontrol agents, *Bacillus subtilis* GB02 and *Pseudomonas fluorescens* RG26, when applied alone and in combination with non-pathogenic *F. oxysporum* Fo 90105 delayed the disease onset and suppressed *Fusarium* wilt.*Trichoderma harzianam* and *Pochonia chlamydosporia* were found effectively controlled *Fusarium* wilt in chickpea (Khan *et al.,* 2011). *Streptomyces* spp. isolated from national parks in Kenya were shown to have antifungal activity against FOC (Nonoh *et al.,* 2010).Five strains of *Streptomyces* spp., isolated from herbal vermi-compost, were reported as having potential for biocontrol of *Fusarium* wilt in chickpea (Gopalakrishnan *et al.,* 2011). Although biological control often appears promising in specialised environments, disappointing results frequently are obtained in the field as several factors determine the survival and delivery of the antagonist. Therefore, the strategy to combat the disease should be to integrate different methods of control including cultural practices, use of resistant cultivars, biological control and chemical control. For instance, Singh *et al.* (2003) showed that two strains of *P. fluorescens* in combination with thiram @ 1.5 g kg^{-1} effectively controlled collar rot of chickpea caused by *S. rolfsii* in both greenhouse and field experiments. There is a growing interest in the use of secondary metabolites, such as toxins, proteins, hormones, amino acids and antibiotics from microorganisms for the control of plant pathogens as these are readily degradable, highly specific and less toxic to nature (Doumbou *et al.,* 2001). Hence, metabolites from microorganisms may be exploited for the control of *Fusarium* wilt.

Phytotoxins (metabolites) of microorganisms

Phytotoxins are low molecular weight compounds produced by microorganisms that cause obvious damage to plant tissues and are known with confidence to be involved in plant disease (Scheffer, 1983). Such damage may include wilting, water soaking, chlorosis and necrosis (Strange, 2003). For instance, the strawberry pathotype of *Alternaria alternata* produced AF toxin correlated with the pathogenicity of the isolates (Akamatsu *et al.,* 1997). Coriander seeds soaked in spore suspension of *F. oxysporum* f. sp. *corianderi* and partially purified toxins significantly lowered the seed germination and reduced the shoot and root lengths over the un-inoculated control (Gandhikumar and Raguchander, 2001).

Phytotoxins have been described in a number of well-documented reports as integral factors in disease development (Yoder, 1980; Scheffer, 1983) and have proved to be useful tools in the selection of resistant/tolerant plants (Daub, 1986).Phytotoxins may be classified as host-selective (host specific) or non-selective (non-specific). Host-selective phytotoxins are toxic to those plant species or cultivars that serve as hosts for the toxin-producing pathogen and lack toxicity towards non-hosts. A non-selective toxin may exhibit differential toxicity towards various plant species but toxicity is not highly correlated with the toxin-producer's host range (Knoche and Duvick, 1987). Host-selective toxins are found principally in species of *Alternaria* and *Cochliobolus* and non-selective toxins in species of *Fusarium*, *Ascochyta*, *Leptosphaeria* and also some species of *Pseudomonas* and *Xanthomonas* (Tables 1 and 2).

Plant pathogens produce a variety of secondary metabolites in culture that show phytotoxic activity but only a small proportion of these have a demonstrated role in plant disease. This is because of their low water solubility and the extreme sensitivity of the plants to solvents used to dissolve these compounds. Many of these phytotoxic compounds dissolve in solvents such as methanol, ethanol, dimethyl sulfoxide and acetone at a concentration of two to five per cent, which are extremely damaging to crop seedlings. These solvents upon further dilution usually causes the compound to precipitate, leaving a negligible concentration of the solution. However, determination of the role of phytotoxic compounds in pathogenesis (ability to cause disease) or virulence (severity of disease) is critical and hence pathogenicity studies should precede any effort to correlate toxin production with pathogenicity and virulence (Strange, 2007).

Purification of phytotoxins

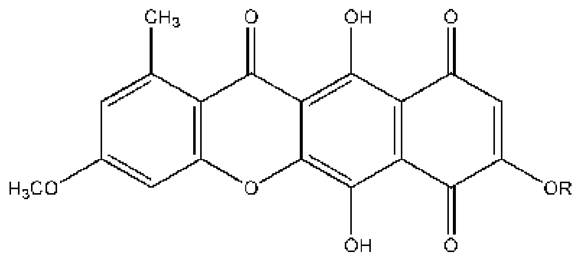
Although phytotoxins are thought to play a role in plant disease syndrome, particularly if the symptoms are expressed at the site of infection, they are usually difficult to extract from the infected plant. Phytotoxins which are of importance in plant disease syndromes are usually isolated from axenic cultures of pathogens. For examples, isolates of *Ascochyta rabiei*, the causal agent of blight in chickpea, produced the toxins, solanopyrones A and C when grown in Czapek Dox liquid medium (CDLM) supplemented with chickpea seed extract (Alam *et al.,* 1989) and also solanapyrone B when grown on CDLM

Table 1. Examples of host-selective toxins

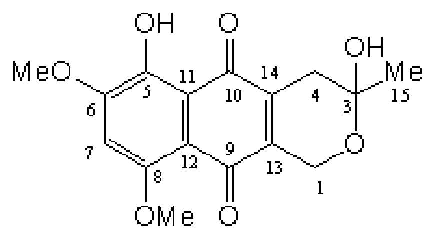
Pathogen	Host	Toxin	Chemical class
Alternaria alternata	Japanese pear	AK-toxin	Epoxy-decatrienoic esters
	Strawberry	AF-toxin	Epoxy-decatrienoic esters
	Tangerine	ACT-toxin	Epoxy-decatrienoic esters
	Apple	AM-toxin	Cyclic tetrapeptide
	Tomato	AAL-toxin	Aminopentol esters
	Rough Lemon	ACR(L)-toxin	Terpenoid
Bipolaris sacchari	Sugarcane	HS-toxin	Glycosylated sesquiterpene
Cochliobolus carbonum	Corn	HC-toxin	Cyclic tetrapeptide
Cochliobolus heterostrosphus	Corn	T-toxin	Linear polyketols
Cochliobolus victoriae	Oats	Victorin	Cyclized chlorinated peptide
Mycosphaerella zeae-maydis	Corn	PM-toxin	Linear polyketols
Periconia circinata	Sorghum	Peritoxin	Peptidyl chlorinated polyketide
Pyrenophora tritici-repentis	Wheat	Ptr ToxA Ptr ToxB	13.2-kDa protein 6.6-kDa protein

Table 2. Examples of non-host-selective toxins (Strange, 2003)

Pathogen	Host	Toxin	Chemical class
Streptomyces scabies	Potato	Thaxtomins	4-nitotryptophan and phenylalanine groups linked in an L, L-configured cyclodipeptide
Pseudomonas syringae pv. *tabaci*	Tobacco	Tabtoxin	Dipeptide of either threonine or serine linked to tabtoxinine-β-lactam
Xanthomonas albilineans	Sugarcane	Albicidin	Low molecular wt. compound with several aromatic rings
Fusarium graminearum	Wheat	Trichothecene	Trichothecenes are derived from farnesyl pyrophosphate, which is cyclized to form trichodiene and trichothecenes
Fusarium moniliforme	Maize	Fumonisins	Aminopentol esters
Ascochyta rabiei	Chickpea	Solanapyrones	Polyketide



Bikaverin: R = $-CH_3$
Norbikaverin: R = -H



8-O-Methyl-fusarubin

Fig. 1. Structures of bikaverin and norbikaverin (toxins from *F, oxysporum* f. sp. *vasinfectum*) and 8-O-methul-fusarubin (Toxins from *F. acutatum*)

supplemented with metal cations, Zn, Ca, Cu, Co and Mn (Chen and Strange, 1994). These toxins were isolated by solvent partitioning with ethyl acetate and flash chromatography of the organic fraction on silica gel. The compounds were identified in the flash fractions by their characteristic UV spectra and those with similar spectra were combined. Purity of the compounds in the combined fractions was monitored by HPLC on an analytical C_{18} column with aqueous mixtures of methanol, acetonitrile and tetrahydrofuran as mobile phases (Hamid and Strange, 1997).

Detection of an unknown toxin can be achieved by a suitable bioassay; preferably the assay should be rapid to perform, simple, sensitive and give quantitative results (Strange, 2003). Shohet and Strange (1989) suggested a bioassay technique in which cells were isolated from leaves of pigeonpea by a combination of enzyme digestion and mechanical agitation followed by incubation with culture filtrates of *Phytophthora drechsleri* f. sp. *cajani*. Phytotoxic compounds from *P. citrophthora* were assayed with tomato (non-host) and lemon (host) seedlings (Breiman and Barash, 1981) whereas tomato cuttings were used to assay toxins produced by *P. cactorum* in culture (Pligh and Rudnicki, 1979).

Phytotoxins from *Fusarium* species

Fusarium species produce complex mixtures of toxins that probably serve a variety of functions in allowing them to compete with other microorganisms and dominate their habitats. Species of *Fusarium* are known to produce mycotoxins, phytotoxins and some of the toxins, such as the trichothecenes, are toxic to both animals and plants (Desjardins *et al.,* 1992 and 1995). Bosch *et al.* (1989) reported that out of 62 isolates of *Fusarium*, obtained from pasture grass and soil from New Zealand, 82 per cent of the isolates were toxic to rats in feeding tests and of them 24 per cent were found severely toxic and caused haemorrhages of stomach, intestine, haematuria and finally death. Some of the compounds produced such as the trichotecene toxins, deoxynivalenol (DON), T-2 toxin and diacetoxyscirpenol (DAS) as well as zearalenone (ZEN) and the fumonisins have mammalian toxicity (Cawood *et al.,* 1991; Hussein and Brasel, 2001; L'vova *et al.,* 2003). Fumonisin mycotoxins (FB1 and FB2) produced by the fungus *Fusarium moniliforme* were extracted from the cultures of the fungus on maize meal with methanol/water (3:1) and further purified using Amberlite XAD-2, silica gel and reversed phase C_{18} chromatography (Cawood *et al.,* 1991). Schaafsma *et al.* (1998) demonstrated a cheapest and reliable method for identifying and quantifying DON (produced by *Fusarium graminearum* and *F. culmorum* in maize) and zearalenone (produced by *F. graminearum* in stored grain) with thin layer chromatography. Several toxins from various formae speciales of *F. oxysporum* have been described as causing wilt symptoms in their host plants. These toxins include fusaric acid from the banana pathogen *F oxysporum* f. sp. *cubense*, beauvericin from the pathogen of muskmelon *F. oxysporum* f. sp. *melonis*, and several polyketide toxins (including bikaverin and norbikaverin) from the cotton pathogen, *F. oxysporum* f. sp. *vasinfectum* (Thangavelu *et al.,* 2001; Moretti *et al.,* 2002; Bell *et al.,* 2003).

Phytotoxins from *Fusarium* species causing wilt in chickpea

Chlorosis and wilting are common symptoms of toxicosis and these symptoms are characteristic of the phenotypes of chickpea plants infected with FOC (Gopalakrishnan and Strange, 2005). Other symptoms of toxicosis on chickpea are epinasty of the leaves, discoloration of the vascular tissue and ultimately collapse of the plant (Hamid *et al.,* 2001). These symptoms suggest that phytotoxins are involved in the disease. Kaur *et al.* (1987) found that partially purified toxin from FOC inhibited callus growth in chickpea. Rao and Padmaja (2000) reported that crude culture filtrates of FOC, when diluted to 30 per cent with water, caused wilting of 1-week-old chickpea seedlings in 4-5 days.An isolate of FOC from Thal region of Pakistan, identified based on its morphology and pathogenicity, was further identified as *Fusarium acutatum* in the 16S rDNA analysis (Gopalakrishnan and Strange, 2005). Filtrates from cultures of *F. acutatum* grown on a defined liquid medium caused permanent wilting of chickpea cuttings and killed cells, isolated enzymatically from healthy plants, in a bioassay (Gopalakrishnan *et al.,* 2005).

Purification of thephytotoxins from the culture filtrates of *F. acutatum*

Toxic activity from the culture filtrates of *F. acutatum* was retained by a cyano solid phase extraction cartridge and the toxin was isolated by elution from the cartridge in acetonitrile and Si-gel thin layer chromatography of the eluate. Bioassay of the fractions were done as per the protocols of Hamid and Strange (2000). In brief, filtrates of cultures were tested for their toxicity to cells isolated from chickpea leaflets using fluorescein diacetate to differentiate live and dead cells. This compound readily enters the live cells with intact plasma-membranes and, once inside the cell, is metabolised by esterases to give free fluorescein. As plasma-membranes are impermeable to fluorescein, the compound accumulates and imparts a yellow-green fluorescence to such cells, which may be viewed under fluorescent microscope.

Analytical HPLC of the compound on a cyano column with diode array detection gave a single peak with a homogenous spectrum and λ_{max} 224 and 281 nm whereas NMR and mass spectrum studies showed that toxin was 8-*O*-methyl-fusarubin (Gopalakrishnan *et al.,* 2005). Naphthazarin toxin, produced by species of *Fusarium*, of which 8-*O*-methyl-fusarubin is one, have been implicated in disease syndromes in citrus (van Rensburg *et al.,* 2001) and cotton (Bell *et al.,* 2003). Such compounds attack membranes and could be responsible for the loss of the semi-permeability of the plasma-membrane as found in the cell assay reported by Hamid and Strange (2000). An attack on plasma-membranes could also explain wilting as chickpea is likely to depend in part of the turgor of parenchyma cells surrounding the stele for support.

CONCLUSION

There is a need to develop new control strategies for *Fusarium* wilt because of the increasing importance of *Fusarium* wilt in chickpea production. For instance, the Round Ready™ (RR) gene from *Agrobacterium* spp. strain CP4 is now used widely in soybean and cotton to prevent toxicity from the widely used herbicide glyphosate (Bell, 2003). Similar approaches could be used against toxins of FOC that are crucial for either pathogenesis or increased virulence. Foreign genes could also be introduced into biocontrol organisms to protect them from FOC toxins and further allow destruction of toxins in the rhizosphere. Hence, a holistic approach to FOC toxins should facilitate development of new control practices for *Fusarium*wilt of chickpea.

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PRODUCTIVITY OF CLUSTERBEAN AS INFLUENCED BY FERTILIZER MANAGEMENT IN RAINFED ALFISOLS

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ABSTRACT

A field experiment was conducted to study fertilizer management in clusterbean in alfisols of Scarce Rainfall Zone under rainfed conditions for three years during kharif, 2013-14, 2014-15 and 2015-16 at Agricultural Research Station, Ananthapuramu, Andhra Pradesh. Pooled analysis of data revealed that number of pods per plant, seed yield, gross returns, net returns and B:C ratio was not significantly influenced by different fertilizer management practices. However, the highest mean number of pods per plant was resulted with application of 20 kg K ha^{-1}, seed yield was registered with 20 kg N + 20 kg P + 20 kg K+ 3 kg Bo ha^{-1}. Higher gross returns were realized with 20 kg N + 20 kg P + 20 kg K+ 3 kg Bo ha^{-1}, highest net returns obtained with 20 kg N ha^{-1} and highest benefit cost ratio was realized with 20 kg N ha^{-1}. Application of 20 kg N ha^{-1} can be recommended to Scarce Rainfall Zone of Andhra Pradesh of for maximization of profits in clusterbean crop.

KEYWORDS: Clusterbean, fertilizer management, rainfed alfisols

INTRODUCTION

Clusterbean, popularly known as guar is a *kharif* legume crop, very drought tolerant, sun-loving but susceptible to frost and requires only 300-400 mm annual rainfall. Recently it has been classified under arid legume group and is grown for vegetable, green fodder, green manure and for grain. The crop survives best even under conditions moderate salinity and alkalinity. Clusterbean tolerates high temperatures and dry conditions and is adapted to arid and semi-arid climates (Undersander *et al*., 1991). It is a principal source of galactomannan (28-33% guar gum) and has numerous food and industrial uses *viz.,* textiles, paper, petroleum, pharmaceuticals, food processing, cosmetics, mining explosives, oil drilling etc. India is leading producer of cluterbean in the world contributing to around 75–82 per cent of the total production. The consumption pattern of its seed is largely influenced by the demands from the petroleum industries in USA and oil fields in the Middle East. The trend of consumption has also increased in rest of the world that has led to its introduction in many countries. India is a leading exporter of guar gum with 80 per cent of world production, followed by Pakistan. Rajasthan is the largest clusterbean producing states in the world as it dominates the Indian production scenario contributing to 70 per cent of the total production in India followed by Haryana (12%) and Gujarat (11%). Clusterbean basically grown under arid rainfed conditions and there was huge year to year huge yield fluctuations due to erratic rainfall (Pathak *et al*., 2009; Singh *et al*., 2003 and 2005).

Clusterbean responds well to phosphorus rather than nitrogen. As N fixing legume usually require more P than N because P plays a very vital role in the nodule development and their activity (Serraj *et al*., 2004). In recent years, the continuous application of only N and P led to the deficiency of micronutrients in arid soils. Deficiency of micro nutrients has more detrimental effects on metabolic pathways, enzyme activities, performance of crops and uptake of macronutrients. Zinc application significantly increased the nitrogen activity, carbohydrate and protein content in clusterbean (Nandwal *et al*., 1990). Potassium also plays a critical role under moisture stress conditions through its influence on maintenance of turgor potential photosynthesis, translocation of photosynthates, starch synthesis and activation of number of enzymes. Vyas *et al*. (2001) observed increase in seed yield of arid legumes with increasing K levels even under low levels of soil moisture availability. The soil organic matter turnover and fertilizer use efficiency is very low due to moisture scarcity (Garg and Uday Burman, 2011).

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After seeing great revenues with the crop during previous years by Rajasthan farmers, farmers in Ananthapuram, Guntur, Kurnool, Karimnagar, Nellore, Prakasam and Ranga Reddy districts of undivided Andhra Pradesh have also started the cultivation of clusterbean for seed in more than 1000 ha (NRAA, 2014). Ananthapuram is the second most drought - affected district of India. It receives around 500 mm rainfall annually. The agriculture is predominantly dependent on rainfall which is very erratic and uncertain. Being located in the Scarce Rainfall Zone of Andhra Pradesh does not get the full benefit of either the south west or north east monsoon. Rainfed agriculture in Anantapuram district is greatly influenced by water shortage caused by low, highly variable and erratic rainfall. As the information on fertilizer management in cluterbean is meagre for Scarce Rainfall Zone of Andhra Pradesh the present study was initiated.

MATERIAL AND METHODS

A field experiment was conducted to study fertilizer management in clusterbean in alfisols of scarce rainfall zone of Andhra Pradesh under rainfed conditions for three years during *kharif*, 2013-14, 2014-15 and 2015-16 at Agricultural Research Station, Ananthapuram, Andhra Pradesh. The soil of the experimental site was red sandy loam with shallow depth, low in organic carbon (0.34%) and low in available nitrogen (138 kg ha^{-1}), medium in available phosphorous (28 kg ha^{-1}) and potassium (215 kg ha^{-1}). The experiment was laid out in randomized block design with three replications. The treatments consisted of eleven treatments viz., T_1: Control (No N, P and K), T_2: 20 kg N ha^{-1}, T_3: 20 kg P ha^{-1}, T_4: 20 kg K ha^{-1}, T_5: 20 kg N + 20 kg P ha^{-1}, T_6: 20 kg P + 20 kg K ha^{-1}, T_7: 20 kg N + 20 kg K ha^{-1}, T_8: 20 kg N + 20 kg P ha^{-1}+ 20 kg K ha^{-1}, T_9: T8 + 25 kg Zn SO_4 ha^{-1}, T_{10}: T8 + 3 kg Bo ha^{-1}, T_{11}: T8 + 25 kg Zn SO_4 ha^{-1} + 3 kg Bo ha^{-1}. The experimental field was prepared by working with a tractor drawn disc plough and then tractor drawn cultivator was drawn along the field. The individual plots were laid out according to the layout plan. Healthy seeds of clusterbean (var. RGC 1025) with good germination percent (95%) was used for sowing purpose As per the treatments, N, P_2O_5 and K_2O was applied at the time of sowing through urea, single super phosphate and muriate of potash respectively. All other cultural practices were kept normal and uniform for all treatments. At harvest, five plants were randomly selected from each treatment for recording growth parameters such as plant height, number of pods per plant, number of seeds per pod and test weight. The grain and haulm yield from the net plot (5 m x 5 m) of each treatment was recorded and expressed in kg ha^{-1}. Labour wages and cost of inputs were worked out to compute the cost of cultivation. Gross returns were calculated based on the prices in the local market prices for clusterbean and net returns were worked out by subtracting the total cost of cultivation from gross returns.

RESULTS AND DISCUSSION

Rainfall and crop performance

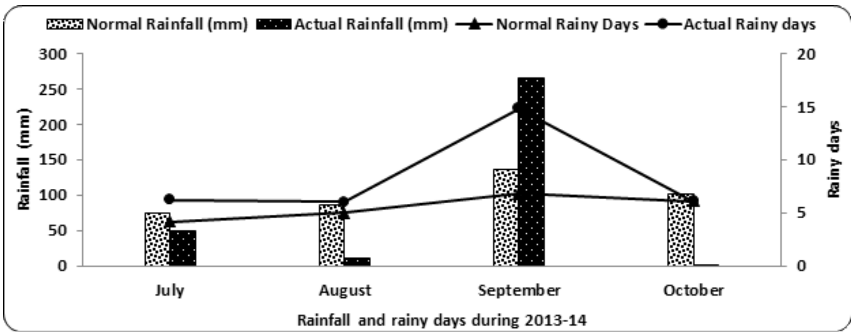
In 2013-14, annual rainfall received (431.8 mm) in 23 rainy days was 75.7 per cent of normal annual rainfall (570 mm). During 2013-14, crop was sown on 12-7-2013 and harvested on 4.10.2013 with crop duration of 85 days. During the crop period 328.4 mm rainfall was received in 11 rainy days (Table 1). In 2014-15, annual rainfall 375.2 mm received in 26 rainy days it was 65.8 per cent of normal annual rainfall (570 mm). During 2014-15, crop was sown on 16-7-2014 and harvested on 10-10-2014 with 86 days crop duration. During this period 160.6 mm rainfall was received in 10 rainy days. In 2015-16, annual rainfall 641 mm received in 44 rainy days it was 108 per cent of normal annual rainfall (590.6 mm). During 2015-16, crop was sown on 19-6-2015 and harvested on 11-9-2015 with a crop duration of 84 days. During this period 212.6 mm rainfall was received in 14 rainy days. The average seed yield during 2015 was higher by 40 per cent and 25 per cent compared to 2013 and 2014 respectively and was attributed to optimum soil moisture resulted through sufficient rainfall received in 14 rainy days during different phenophases especially during pod initiation to pod development and pod development to maturity whereas in 2013, 267.1 mm rainfall received in 8 rainy days during pod development to maturity resulted in excess moisture in soil profile which hindered pod development resulting in less test weight and seed yield. Higher seed yield during 2015 compared to 2013 and 2014 was also attributed to fairly higher test weight.

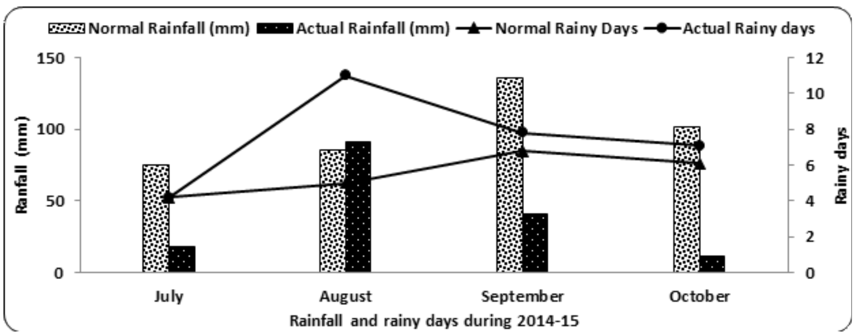
Growth

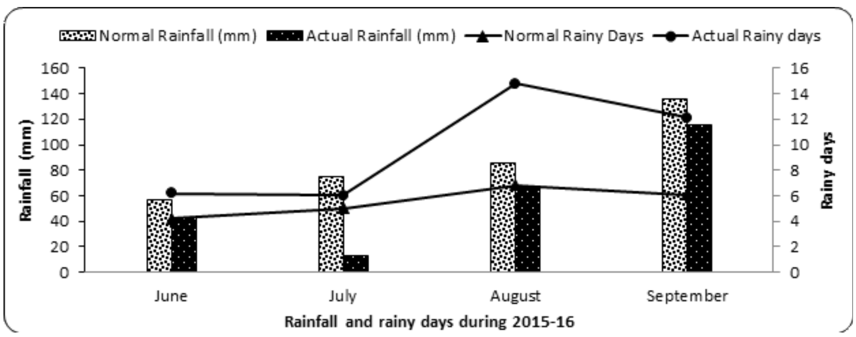
The data pertaining to plant height and yield attributes of clusterbean as influenced by fertilizer management practices was presented in Table 2. Plant height of clusterbean measured at harvest was not significantly influenced by different fertilizer management practices during three years of study. However, tallest plants were

Table 1. Rainfall and rainy days during crop growth period

Parameter	2013-14	2014-15	2015-16
Date of sowing	12-07-2013	16-07-2014	19-06-2015
Date of harvesting	04-10-2013	10-10-2014	11-09-2015
Crop duration (days)	85	86	84
Normal annual rainfall (mm)	573	570	591
Actual annual rainfall (mm)	431.8	375.2	641
Rainfall during crop period (mm)	328.4	160.6	212.6
Number of rainy days during the year	23	26	44
Number of rainy days during crop period	11	10	14







noticed with control, application of 20 kg N ha^{-1} and 20 kg K ha^{-1} in 2013, 2014 and 2015 respectively. The trend was not similar during three years of experimentation. Pooled analysis of data also indicated that fertilizer management practices had no significant influence on plant height of clusterbean. However, the highest mean plant height was observed with application of 20 kg K ha^{-1}. These results are in agreement with Ayub *et al.* (2012) who reported that application of P alone could not produced significantly higher plant height over control treatment.

Yield attributes

Different fertilizer management practices had no significant influence on number of pods per plant in 2013 and 2015 where as in 2014 significant variation was noticed (Table 2). The highest number of pods per plant was obtained with control, 20 kg K ha^{-1} in 2013 and 2015 respectively. Whereas in 2014 highest number of pods per plant was noticed with 20 kg P ha^{-1} which was significantly comparable with other treatments and superior to control, 20 kg N + 20 kg K ha^{-1}, 20 kg N + 20 kg P + 20 kg K+ 3 kg Bo ha^{-1} and 20 kg N + 20 kg P + 20 kg K + 25 kg Zn So_4+ 3 kg Bo ha^{-1} treatments. Pooled analysis of data revealed that number of pods per plant was not significantly influenced by different fertilizer management practices. However, the highest mean number of pods per plant was resulted with application of 20 kg K ha^{-1}.

Number of seeds per pod did not varied significantly due to adopted fertilizer management practices during all the three years of investigation. However, the highest number of seeds per pod was recorded with 20 kg N ha^{-1}, 20 kg N + 20 kg P ha^{-1} and 20 kg N + 20 kg P ha^{-1} treatments in 2013, 2014 and 2015 respectively. The trend was similar only during second and third year of study. Pooled analysis of data also indicated that fertilizer management practices had no significant influence on number of seeds per pod. However, the highest number of seeds per pod was noticed with 20 kg N + 20 kg P ha^{-1}. These results are contradictory with the findings by Burman *et al.* (2007) who reported that application of nitrogen (20 kg ha^{-1}) in association with P (20 kg ha^{-1}) significantly enhanced yield attributes of clusterbean under rainfed condition of Jodhpur in a two years study. Raj Singh and Khan (2002) found that application of 20 kg N and 40 kg P ha^{-1} increased yield attributes of clusterbean under rainfed conditions.

During the three years of study, there was no significant difference in test weight of clusterbean due to different fertilizer management practices. However, the highest test weight was attained with 20 kg N + 20 kg P + 20 kg K + 25 kg Zn SO_4 ha^{-1}, 20 kg N + 20 kg K ha^{-1}, 20 kg K ha^{-1} treatments in 2013, 2014 and 2015 respectively. The trend was not similar during three years of study. Pooled analysis of data also indicated that fertilizer management practices had no significant influence on test weight. However, the highest test weight was obtained with 20 kg N + 20 kg P + 20 kg K + 25 kg Zn SO_4 ha^{-1} .

Seed and haulm yield

Data pertaining to seed yield, haulm yield and economics of clusterbean as influenced by fertilizer management practices is presented in Table 3. Seed yield of clusterbean was not significantly differed due to different fertilizer management practices during all three years of experimentation. However, the highest seed yield was recorded with 20 kg N + 20 kg P + 20 kg K+ 3 kg Bo ha^{-1}, 20 kg P ha^{-1}, 20 kg N + 20 kg K ha^{-1} treatments in 2013, 2014 and 2015 respectively. The trend was not similar during three years of study. Pooled analysis also indicated that mean seed yield was not influenced significantly due to different fertilizer management practices. However, the maximum mean seed yield was registered with 20 kg N + 20 kg P + 20 kg K+ 3 kg Bo ha^{-1} followed by 20 kg N ha^{-1} treatment. Raj Singh and Khan (2002) found that application of 20 kg N and 40 kg P ha^{-1} increased seed yield of clusterbean under rainfed conditions. Burman *et al.* (2007) found that application of nitrogen (20 kg ha^{-1}) in association with P (20 kg ha^{-1}) significantly enhanced the seed yield of clusterbean under rainfed conditions of Jodhpur in a two years study. The contradictory results might have been due to differences in fertility status of soil. Under moisture stress conditions the plant response to applied fertilizers is frequently reduced (Bradford and Hsiao, 1992). It is agreed that plant response to applied nutrients by rainfed crops is not assured and sometimes may not be profitable unless proper soil moisture is available. However, the degree of yield response varied with rainfall pattern, intensity of drought, native soil fertility and crop species. Application of P was observed to enhance drought tolerance under different intensities of water stress in clusterbean genotypes (Burman *et al.*, 2009). Efficient translocation of accumulated assimilates to the reproductive parts under comfortable nitrogen nutrition might be responsible for

Table 2. Plant height and yield attributes of clusterbean as influenced by fertilizer management practices in rainfed alfisols

Treatments	Plant height (cm)				Number of pods per plant				Number of seeds per pod				Test weight (g)			
	2013	2014	2015	Mean	2013	2014	2015	Mean	2013	2014	2015	Mean	2013	2014	2015	Mean
T_1: Control (No N, P and K)	40.3	36.7	23.5	33.5	33.6	11.7	15.4	20.2	6.6	6.0	6.3	6.3	28.4	35.0	32.6	32.0
T_2: 20 kg N ha^{-1}	37.7	42.3	23.4	34.5	26.6	16.6	14.1	19.1	6.7	6.1	6.4	6.4	30.3	33.3	34.4	32.7
T_3: 20 kg P ha^{-1}	36.5	41.3	25.4	34.4	23.9	22.0	19.5	21.8	6.5	6.3	6.4	6.4	29.7	35.1	32.9	32.6
T_4: 20 kg K ha^{-1}	36.8	40.4	30.3	35.8	27.8	19.5	21.9	23.1	6.5	6.3	6.3	6.4	29.8	34.9	37.2	34.0
T_5: 20 kg N + 20 kg P ha^{-1}	33.1	42.0	28.3	34.5	28.0	18.8	19.7	22.2	6.6	6.5	7.6	6.9	29.9	34.5	33.1	32.5
T_6: 20 kg P + 20 kg K ha^{-1}	38.7	35.0	28.2	33.9	28.1	20.3	15.7	21.4	6.3	6.1	6.6	6.3	30.7	33.5	35.3	33.2
T_7: 20 kg N + 20 kg K ha^{-1}	33.9	36.6	25.3	31.9	27.7	13.9	18.3	20.0	6.4	6.2	7.0	6.5	30.6	37.0	31.5	33.1
T_8: 20 kg N + 20 kg P ha^{-1} + 20 kg K ha^{-1}	38.3	37.1	26.7	34.0	28.5	20.1	18.4	22.4	6.7	6.2	6.6	6.5	30.0	34.0	32.1	32.0
T_9: T8 + 25 kg Zn SO_4 ha^{-1}	36.7	40.7	27.0	34.8	21.7	20.3	19.1	20.4	6.2	6.1	7.0	6.5	35.4	34.2	32.8	34.1
T_{10}: T8 + 3 kg Bo ha^{-1}	39.0	37.6	27.2	34.6	26.1	14.3	20.5	20.3	6.5	6.2	6.0	6.3	29.7	34.4	36.7	33.6
T_{11}: T8 + 25 kg Zn SO_4 ha^{-1} + 3 kg Bo ha^{-1}	35.4	39.2	27.0	33.9	32.4	14.2	17.3	21.3	6.5	6.1	6.9	6.5	29.6	34.3	37.0	33.6
S.Em $\pm$	1.78	3.01	2.32	1.45	2.59	2.14	2.35	2.01	0.16	0.27	0.34	0.16	1.38	0.94	2.27	1.07
CD at 5%	NS	NS	NS	NS	NS	6.35	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3. Yield and economics of clusterbean as influenced by fertilizer management practices in rainfed alfisols

Treatments	Seed yield (kg ha^{-1})				Haulm yield (kg ha^{-1})				Gross Returns (₹ ha^{-1})				Net Returns (₹ ha^{-1})				B : C ratio			
	2013	2014	2015	Mean	2013	2014	2015	Mean	2013	2014	2015	Mean	2013	2014	2015	Mean	2013	2014	2015	Mean
T_1: Control (No N, P and K)	591	665	643	633	1726	761	1459	1315	20694	21960	19279	20644	11394	12660	9979	11344	1.23	1.36	1.07	1.22
T_2: 20 kg N ha^{-1}	668	709	689	689	2002	954	1709	1555	23368	23412	20674	22484	13809	13853	11115	12926	1.44	1.45	1.16	1.35
T_3: 20 kg P ha^{-1}	459	733	718	637	1723	1089	1451	1421	16048	24191	21552	20597	5773	13916	11277	10322	0.56	1.35	1.10	1.00
T_4: 20 kg K ha^{-1}	664	599	755	673	1664	790	1667	1374	23245	19761	22650	21885	13374	9889	12779	12014	1.35	1.00	1.29	1.22
T_5: 20 kg N + 20 kg P ha^{-1}	556	513	779	616	1592	811	1648	1350	19455	16919	23363	19912	8921	6385	12830	9379	0.85	0.61	1.22	0.89
T_6: 20 kg P + 20 kg K ha^{-1}	505	659	753	639	1441	1009	1286	1245	17660	21747	22579	20662	6813	10900	11733	9816	0.63	1.00	1.08	0.90
T_7: 20 kg N + 20 kg K ha^{-1}	501	598	908	669	1424	1118	1708	1417	17518	19745	27240	21501	7388	9616	17110	11371	0.73	0.95	1.69	1.12
T_8: 20 kg N + 20 kg P ha^{-1} + 20 kg K ha^{-1}	533	520	891	648	1514	717	1415	1215	18642	17163	26719	20841	7537	6059	15614	9737	0.68	0.55	1.41	0.88
T_9: T8 + 25 kg Zn SO_4 ha^{-1}	466	639	856	654	1378	1089	1510	1326	16315	21074	25676	21022	3760	8520	13121	8467	0.30	0.68	1.05	0.67
T_{10}: T8 + 3 kg Bo ha^{-1}	674	612	854	713	1827	929	1406	1387	23577	20211	25629	23139	11722	8357	13774	11284	0.99	0.70	1.16	0.95
T_{11}: T8 + 25 kg Zn SO_4 ha^{-1} + 3 kg Bo ha^{-1}	524	600	751	625	1551	855	1710	1372	18352	19799	22520	20224	5347	6794	9516	7219	0.41	0.52	0.73	0.56
S.Em ±	64.2	73.4	85.8	51.4	183	123	198	95	2248	2421	2574	1667	2248	2421	2574	1667	0.19	0.22	0.24	0.16
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.59	0.64	NS	NS

the beneficial effect on elevating the stature of all the yield attributes. Similar results were also reported by Singh and Singh (1989) and Sharma and Nehara (2004). Higher guar yield with application of nitrogen, as noticed in the present investigation confirms the documented evidence of Bamboo and Rana (1995), Patel *et al*. (2005), Sharma and Nehara (2004) and Rathore *et al*. (2007). The studies of Vyas *et al*. (2001) also indicated that seed yield of arid legumes increased with increasing K levels even under low levels of soil moisture availability.

The haulm yield was not significantly varied due to various fertilizer management practices during three years of experimentation. The highest haulm yield was recorded with 20 kg N ha^{-1}, 20 kg N + 20 kg K ha^{-1}, 20 kg N ha^{-1} treatments in 2013, 2014 and 2015 respectively. Pooled analysis also indicated that there was no significant difference in mean haulm yield due to different fertilizer management practices. Highest mean haulm yield was obtained with 20 kg N ha^{-1} treatment.

Economics

Gross returns, net returns and B:C ratio for different fertilizer management practices were calculated, analyzed statistically and presented in Table 3. During three years of experimentation, gross returns were not significantly influenced by various fertilizer management practices. However, highest gross returns were realized with 20 kg N + 20 kg P + 20 kg K+ 3 kg Bo ha^{-1}, 20 kg P ha^{-1}, 20 kg N + 20 kg K ha^{-1} treatments in 2013, 2014 and 2015 respectively. Pooled analysis revealed that gross returns were not significantly influenced by various fertilizer management practices. Net returns obtained by different fertilizer management practices were not differed significantly during three years of experimentation. However, higher net returns were obtained with 20 kg N ha^{-1}, 20 kg P ha^{-1}, 20 kg N + 20 kg K ha^{-1} during 2013, 2014 and 2015 respectively. . Pooled analysis indicated that net returns were not significantly influenced by different fertilizer management practices. Benefit cost ratio was significantly influenced by fertilizer management practices during 2013 and 2014 and significantly comparable during 2015. During year 2013 higher benefit cost ratio was registered with 20 kg N ha^{-1} treatment which was significantly on par with 20 kg K ha^{-1}, control, 20 kg N + 20 kg P + 20 kg K + 25 kg Zn SO_4+ 3 kg Bo ha^{-1}, 20 kg N + 20 kg P ha^{-1} treatments and significantly superior to other treatments. During 2014, highest benefit cost ratio was realized with 20 kg N ha^{-1} treatment which in turn was comparable with control, 20 kg P ha^{-1}, 20 kg K ha^{-1}, 20 kg P + 20 kg K ha^{-1}, 20 kg N + 20 kg K ha^{-1} and significantly superior to other treatments. During the year 2015 the benefit cost ratio was not significantly influenced by fertilizer management practices. However, the highest benefit cost ratio was obtained with 20 kg N + 20 kg K ha^{-1}. In pooled analysis also, benefit cost ratio was not significantly influenced by various fertilizer management practices. However the highest benefit cost ratio was realized with 20 kg N ha^{-1} followed by control and 20 kg K ha^{-1}.

From the results, it is concluded that application of 20 kg N ha^{-1} is recommended for Scarce Rainfall Zone of Andhra Pradesh to obtain higher net returns in clusterbean.

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EFFECT OF PLANT GROWTH REGULATORS ON GROWTH, YIELD AND YIELD ATTRIBUTES OF FRENCH BEAN (*Phaseolus vulgaris* L.) CV. ARKA KOMAL

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ABSTRACT

A field experiment was conducted to study the effect of plant growth regulators on growth, flowering, yield and quality of French bean cv. Arka Komal at student's farm, College of Agriculture, Rajendranagar, Telangana. Different concentrations of the plant growth regulators *viz.,* GA, NAA and CCC were sprayed at 20 and 40 days after sowing. The results showed that foliar spray of GA_3 @ 250 ppm increased number of branches, number of leaves, intermodal length and leaf area index resulting in increased number of pods per plant, pod length, weight of 10 pods which significantly increased the yield/plant and yield/ha.

KEYWORDS: French bean, GA_3, NAA, CCC

INTRODUCTION

French bean (*Phaseolus vulgaris* L.) is an important, highly nutritive leguminous vegetable crop grown in India. Despite high yield potential, the actual yields of French bean is low because of many physiological reasons such as reduced photosynthesis, bud abscission, bloom drop etc. (Kay, 1979). The use of plant growth promoters activate growth along the longitudinal axis, increase number of leaves, leaf area which subsequently contributes towards higher plant production and productivity. Plant growth retarding substances not only decreases plant height but also facilitates branching, early flowering and yield. The present investigation was therefore undertaken to determine the effect of plant growth regulators on growth, yield and yield attributes of French bean cv. Arka Komal.

MATERIALS AND METHODS

The experiment was conducted at Students farm, College of Agriculture, Rajendranagar, Telangana during October to January 2010, in Randomized Block Design with three replications. The French bean variety selected for the study was Arka Komal. The seeds were sown at a depth of five cm and spaced 50 cm between the rows and 30 cm within the row. The experiment comprised of 10 treatments including water spray as control. The treatments were Gibberllic Acid (GA_3) @150 ppm, 200 ppm and 250 ppm, Naphthelene Acetic Acid (NAA) @10 ppm, 15 ppm and 20 ppm and Cycocel (CCC) @250 ppm, 300 ppm and 350 ppm. Different concentrations of the plant growth regulators were sprayed at 20 and 40 days after sowing. The observations on growth, yield and yield attributes were recorded from five randomly selected plants. The data was statistically analyzed as per the method described by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Foliar spray of GA_3 250 ppm recorded more plant height (55.66 cm) compared to its lower concentrations as well as NAA, Cycocel and control (water spray) (Table 1). The increase in plant height could be attributed to enhancement of cell division and cell elongation in the growing portion of plants (Pandita *et al*., 1980). Minimum plant height of 26.66 cm was recorded in treatment with Cycocel 350 ppm. The reduced plant height could be due to reduction in cell expansion and synthesis of diffusible endogenous growth substances (Cathey, 1964). These results are in conformity with the results reported by Kokare *et al.* (2006) in okra, Rajendra Prasad and Srihari (2008) in okra, Sharma and Lashkari (2009) in cluster bean.

Maximum number of branches per plant (15.08) was recorded with foliar spray of GA_3 250 ppm which was on par with GA_3 200 ppm (14.00) (Table 1), which could be due to rapid cell division and cell elongation in growing portion of plants and increased uptake of nutrients which might have resulted in maximum plant height, leading to the production of more number of branches. Minimum

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Table 1. Effect of plant growth regulators on growth attributes of French bean cv. Arka Komal

Treatments	Plant height (cm)	Number of branches per plant	Number of leaves per plant	Leaf area Index
GA_3 150 ppm	40.66	13.00	38.00	0.701
GA_3 200 ppm	53.16	14.00	42.00	0.738
GA_3 250 ppm	55.66	15.08	46.50	0.790
NAA 10 ppm	28.50	10.00	27.00	0.604
NAA 15 ppm	33.00	10.54	29.33	0.616
NAA 20 ppm	33.25	12.68	36.00	0.690
CCC 250 ppm	31.00	9.50	27.00	0.520
CCC 300 ppm	30.00	11.62	32.00	0.500
CCC 350 ppm	26.66	11.75	34.00	0.564
Control (water spray)	31.75	9.99	30.00	0.410
SE(m)	1.50	0.68	1.58	0.003
CD (P=0.05)	4.56	2.03	4.74	0.010

Table 2. Effect of plant growth regulators on yield and yield attributes of French bean cv. Arka Komal

Treatments	Number of pods/plant	Pod length (cm)	Pod diameter (cm)	Weight of 10 pods (g)	Yield per plant (g)	Yield per ha (q)
GA_3 150 ppm	12.31	11.20	0.98	48.83	59.77	33.44
GA_3 200 ppm	12.23	11.43	1.02	49.56	61.41	35.54
GA_3 250 ppm	12.53	11.68	1.06	52.33	67.21	40.44
NAA 10 ppm	10.72	10.26	0.96	43.06	45.90	31.96
NAA 15 ppm	11.91	10.53	0.98	46.20	54.74	32.18
NAA 20 ppm	12.01	10.85	1.04	47.16	57.46	34.44
CCC 250 ppm	10.51	10.30	0.98	35.26	37.50	28.18
CCC 300 ppm	11.46	9.60	1.04	36.23	41.96	30.10
CCC 350 ppm	11.91	9.41	1.07	42.00	49.10	33.29
Control (water spray)	10.02	10.37	1.02	37.33	37.18	28.10
SE(m)	0.08	0.14	0.015	1.65	0.50	1.79
CD (P=0.05)	0.26	0.43	0.046	4.95	1.52	5.37

number of branches (9.50) was recorded in treatment with Cycocel 250 ppm.

The highest number of leaves per plant (46.50) was recorded in treatment with GA_3 250 ppm. Minimum number of leaves per plant was recorded in treatment with NAA 10 ppm and Cycocel 25 ppm (27.00) (Table 1). The increase in number of leaves by the application of GA_3 could be due to delayed senescence that could be attributed to mobilization of metabolites to the leaves. This may be the reason of maintenance of higher number of leaves up to the maturity of the plant. These results are in conformity with the results reported by Kokare *et al.* (2006) in okra, Sharma and Lashkari (2009) in clusterbean.

Foliar spray of GA_3 250 ppm recorded maximum leaf area index (0.790) (Table 1) and lower leaf area index (0.410) was recorded with control (water spray). These results are in conformity with the results obtained by Nawalagatti *et al.* (2008) in French bean.

The maximum number of pods per plant (12.53) was obtained with GA_3 250 ppm which was on par with GA_3 200 ppm (12.31) (Table 2). This might be due to the fact that GA_3 at higher concentrations recorded increased number of branches and fruiting points, which lead to better utilization of sunlight and higher current photosynthesis which resulted developing more number of pods per plant. Among the treatments studied control had recorded minimum number of pods per plant (10.02).

Maximum pod length (11.68 cm) was recorded in treatment with GA_3 250 ppm which was on par with GA_3 200 ppm (11.43 cm) (Table 2). Application of GA_3 at higher concentrations might have promoted rapid cell division and increased elongation of individual cell that resulted in increase in pod length. These results are in conformity with Pandey *et al.* (2004) in garden pea, Rai *et al.* (2004) in French bean and Panchbhai *et al*. (2005) in spine gourd. Foliar spray of Cycocel 350 ppm recorded minimum pod length (9.41 cm) (Table 2).

Maximum pod diameter (1.07 cm) was recorded in treatment with Cycocel 350 ppm. Lesser pod diameter (0.96 cm) was recorded in treatment with with NAA 10 ppm (Table 2). The increase in pod diameter by the application of Cycocel might be due to retarded cell elongation. These findings are in conformity with Kokare *et al*. (2006) in okra.

Among the different plant growth regulators treatment with GA_3 250 ppm recorded maximum weight of 10 pods (52.33 g) (Table 2). This might be due to increased size of photosynthetic apparatus in terms of leaf area and leaf area index which increased assimilation rate contributing for better pod weight. Lower weight of 10 pods (35.26 g) was recorded in treatment with Cycocel 250 ppm.

Application of GA_3 250 ppm recorded significantly increased yield/plant (67.21 g/plant) and yield/ha (40.44 q/ha) compared to its lower concentrations, other plant growth regulators and control (yield/plant (37.18 g/plant) and yield/ha (28.10 q/ha)) (Table 2). This significant improvement in yield could be due to increased net photosynthetic rate by increase in number of branches, number of leaves and leaf area index which might have resulted in increased number of pods, pod length and pod diameter resulting in increased pod yield per plant and pod yield per ha. Similar results were reported by Medhi (2000) in French bean, Pandey *et al*. (2004) in garden pea, Nawalagatti *et al.* (2008) in French bean. Whereas control (water spray) had recorded lower yield/plant (37.18 g/plant) and yield/ha (28.10 g.ha).

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EFFICIENCY INDICES OF WEED MANAGEMENT IN COTTON

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ABSTRACT

Weeds are considered as a major biotic constraint for high production. The weeds which germinate before or simultaneously with the crop are frequently capable of forming a leaf canopy over cotton. To manage the weeds effectively the present study was taken during winter seasons of 2008-09 and 2009-10 at Tamil Nadu Agricultural University, Coimbatore. Field trials were laid out in randomized block design with treatments replicated thrice. In the present study, various weed management practices *viz*., pre-emergence pendimethalin 38.7 per cent EC at 1.5, 2.0, 2.5 and 4.0 kg ha^{-1} + hand weeding, pendimethalin 30% EC at 1.0 kg ha^{-1} + hand weeding, Early post emergence trifloxysulfuron at 10g ha^{-1} + hand weeing, pre emercence pendimethalin 30% EC at 1.0 kg ha^{-1} + power weeder weeding, pendimethalin 30% EC at 1.0 kg ha^{-1} + crop residue mulching + hand weeding, power weeder weeding on 25 and 45 DAS, hand weeding twice, weed free and unweeded checks were included. The results showed that weed control efficiency (WCE) was maximum under pre-emergence application of pendimethalin (38.7%) at 4.0 kg ha^{-1} at 25 and 45 DAS. Pre-emergence application of pendimethalin registered higher WCE ranging between 93.45 and 65.8 per cent. The weed free check with maximum yield was taken as the base to work out the weed index that gives the magnitude of yield reduction due to weed competition in other treatments. The highest yield reduction of 51.7 and 103 per cent occurred under unweeded control during winter 2008-09 and winter 2009-10, respectively.

Keywords: Cotton, Pendimethalin, Weed control efficiency, Weed Index, SDR

INTRODUCTION

Cotton the "*white gold* or the *king of fibres"* is one of the most important commercial crops in India. Cotton is known for the fibre and oil from seed, which plays a prominent role in the national and international economy. In India, cotton cultivation provides livelihood for over 4 million farming families. It produces only 3.95 million bales of lint every year with a productivity of 567 kg ha^{-1} (Anonymous, 2008). The key role that cotton plays in our country can be gauged from the fact that nearly 15 million farmers spread out in more than 10 states are dependent on cotton cultivation (Prasad and Prasad, 2009). The density of weed species and duration of the population determine the competitive damage of cotton. The more competitive species with the greatest density and longest duration will cause the most significant reduction in cotton production. Cotton must be kept weed free for a period after emergence in order to avoid crop loss (Coble and Byrd, 1992). Pendimethalin is now commercially available as 30% EC in market and with increase in active ingredient percentage, it is necessary to evaluate its effect on weeds and crops.

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MATERIALS AND METHOD

Field experiments were laid out in Field No. 73 and 36C during winter seasons of 2008-09 and 2009-10, respectively in Eastern Block farm of Tamil Nadu Agricultural University, Coimbatore. The farm is situated at 11° North latitude and 77° East longitude at an altitude of 426.72 m above Mean Sea Level. The soils of the experimental sites were sandy clay loam in texture with low in available nitrogen, medium in available phosphorus and high in available potassium. Cotton (*Gossypium hirsutum* L.) variety MCU 13 was raised during winter season of 2008-09 and Bunny *Bt* during 2009-10.

Field trials were laid out in randomized block design with treatments replicated thrice. In the present study, various weed management practices *viz*., pre-emergence pendimethalin 38.7% EC at 1.5, 2.0, 2.5 and 4.0 kg ha^{-1} + HW, pendimethalin 30% EC at 1.0 kg ha^{-1} + HW, EPOE trifloxysulfuron at 10g ha^{-1} + HW, PE pendimethalin 30% EC at 1.0 kg ha^{-1} + PWW, pendimethalin 30% EC at 1.0 kg ha^{-1} + CRM + HW, PWW on 25 and 45 DAS, hand weeding twice, weed free and unweeded checks were included.

The following efficiency indices were calculated

Relative density

The relative density (RD) of weeds was worked out by using the following formula

$$RD\,\% = \frac{\text{No. of weeds of individal species}}{\text{Total no. of weeds}} \times 100$$

Relative dry weight

The relative dry weight (RD_{wt}) of individual weed species was worked out by using the following formula and expressed as per cent.

$$RD_{wt} = \frac{\text{Dry weight of weeds of individual species (g m}^{-2}\text{)}}{\text{Total dry weight of weeds (g m}^{-2}\text{)}}$$

Weed control efficiency

Weed control efficiency (WCE) was calculated as per the procedure given below

$$WCE\,\% = \frac{WD_c - WD_t}{WD_c} \times 100$$

where,

WCE - weed control efficiency (per cent)

WD_c - weed biomass (g m^{-2}) in control plot.

WD_t - weed biomass (g m^{-2}) in treated plot.

Summed dominance ratio

The summed dominance ratio for individual weed species was worked out by using the following formula

$$SDR = \frac{RD + RD_{wt}}{2}$$

RD = Relative density (no. m^{-2})

RD_{wt} = Relative dry weight (g m^{-2})

Weed index

Weed index (WI) was calculated as per the method given below

$$WI = \frac{X - Y}{X} \times 100$$

where,

X = yield (kg ha^{-1}) from minimum weed competition plot

Y = yield (kg ha^{-1}) from the treatment plot for which WI is to be worked out.

RESULTS AND DISCUSSION

Relative density

During winter 2008-09 season cotton crop, broad leaved weeds were dominant followed by grasses and sedges at early stages of crop growth, subsequently the grassy weeds dominated the weed flora followed by broad leaved weeds and sedges.

At 25 DAS, the relative density of grasses was relatively lesser with preemergecne application of pendimethalin (38.7%) at 2.0 kg ha^{-1}, whereas, the density of broad leaved weeds and sedges were lesser with trifloxysulfuron at 10 g ha^{-1}, while, the grassy weed density was more in this treatment. During 2009-10 crop season, broad leaved weeds were dominant followed by grasses and sedges at the early stages of crop growth and later on the grasses become the dominant weed flora followed by broad leaved weeds and sedges. The relative density of grasses was lesser with pendimethalin (38.7%) at 2.0 kg ha^{-1} whereas, the density of broad leaved weeds and sedges were lesser with trifloxysulfuron at 10 g ha^{-1} while, the grass weed density was more in this treatment at 25 DAS. Srinivasan *et al*. (1992) reported application of Thiobencarb (1 kg ha^{-1}) + 2, 4- DEE (0.5 kg ha^{-1}) in rice of rice-mung cropping system controlled weeds effectively than Anilophos (0.3 kg ha^{-1}) + 2,4-DEE (0.5 kg ha^{-1}) as it indicated by lower relative density and relative dry weight.

Relative dry weight

During winter 2008-09, at 25 DAS the relative dry weight of grassy weeds was higher followed by broad leaved weeds in unweeded (control) treatment. The relative dry weight of grassy weeds was lesser with pendimethalin (38.7%) at 2.0 kg ha^{-1}. During 2009-10 at 25 DAS, the relative dry weight of grassy weeds was higher followed by broad leaved weeds in unweeded plot. The relative dry weight of grassy weeds was lesser with pendimethalin (38.7%) at 2.0 kg ha^{-1}.

Table 1. Weed control efficiency (WCE) as influenced by weed management practices in cotton

Treatments	Weed control efficiency (%)					
	Winter 2008-09			Winter 2009-10		
	DAS			DAS		
	25	45	60	25	45	60
T_1 : Pendi 38.7% at1.5 kg ha^{-1} + HW	77.82	45.46	65.13	80.71	48.70	71.29
T_2 : Pendi 38.7% at 2.0 kg ha^{-1} + HW	86.12	62.48	74.94	87.93	63.46	79.20
T_3 : Pendi 38.7% at 2.5 kg ha^{-1} + HW	86.23	65.80	75.29	88.02	65.96	78.48
T_4 : Pendi 38.7% at 4.0 kg ha^{-1} + HW	86.40	52.47	75.09	88.17	52.24	79.22
T_5 : Pendi 30% at 1.0 kg ha^{-1} + HW	76.18	41.42	63.53	79.29	45.18	69.65
T_6 : EPOE Trifloxy at 10 kg ha^{-1} + HW	76.26	52.58	70.20	79.35	54.19	68.46
T_7 : Pendi 30% at 1.0 kg ha^{-1} + PWW	75.61	29.44	58.46	75.31	34.74	65.62
T_8 : Pendi 30% at 1.0 kg ha^{-1} + CRM + HW	76.36	63.29	74.74	79.44	61.14	65.59
T_9 : PWW on 25 and 45 DAS	6.85	18.10	35.49	7.85	33.69	32.11
T_{10} : HW on 25 and 45 DAS	12.10	48.37	74.10	13.65	61.28	79.96
T_{11} : Weed free check	98.18	97.50	97.46	98.42	98.41	97.58
T_{12} : Unweeded check	0.00	0.00	0.00	0.00	0.00	0.00

Table 2. Weed index as influenced by weed management practices in cotton

Treatments	Weed Index (%)	
	Winter 2008-09	Winter 2009-10
T_1 : Pendi 38.7% at 1.5 kg ha^{-1} + HW	23.90	49.50
T_2 : Pendi 38.7% at 2.0 kg ha^{-1} + HW	8.15	12.50
T_3 : Pendi 38.7% at 2.5 kg ha^{-1} + HW	16.19	30.8
T_4 : Pendi 38.7% at 4.0 kg ha^{-1} + HW	27.53	56.51
T_5 : Pendi 30% at 1.0 kg ha^{-1} + HW	17.24	36.62
T_6 : EPOE Trifloxy at 10 g ha^{-1} + HW	17.84	38.80
T_7 : Pendi 30% at 1.0 kg ha^{-1} + PWW	26.10	52.31
T_8 : Pendi 30% at 1.0 kg ha^{-1} + CRM +HW	26.65	50.67
T_9 : PWW on 25 and 45 DAS	28.14	64.42
T_{10} : HW on 25 and 45 DAS	10.63	14.51
T_{11} : Weed free check	0.00	0.00
T_{12} : Unweeded check	51.7	103.3

Table 3. Relative density (per cent) of weeds as influenced by weed management practices in cotton

Treatments	Relative density (per cent)						Relative dry weight (per cent)					
	Winter 2008-09			Winter 2008-09			Winter 2008-09			Winter 2008-09		
	Grasses	Sedge	BLW	Grasses	Sedge	BLW	Grasses	Sedge	BLW	Grasses	Sedge	BLW
T_1 : Pendi. (38.7%) at 1.5 kg ha^{-1} + HW	35.25	16.69	48.05	17.74	22.91	59.34	33.6	13.3	53.1	19.00	26.35	54.65
T_2 : Pendi. (38.7%) at 2.0 kg ha^{-1} + HW	29.29	17.00	53.71	17.82	23.14	59.04	32.2	12.5	55.3	20.28	26.17	53.54
T_3 : Pendi. (38.7%) at 2.5 kg ha^{-1} + HW	28.57	16.28	55.15	18.10	22.43	59.47	34.2	13.7	52.2	21.62	26.51	51.87
T_4 : Pendi. (38.7%) at 4.0 kg ha^{-1} + HW	30.91	16.63	52.45	20.38	20.97	58.65	31.3	20.5	48.2	21.28	25.59	53.13
T_5 : Pendi. (30%) at 1.0 kg ha^{-1} + HW	33.89	16.81	49.30	19.17	23.87	56.97	34.2	14.1	51.6	18.61	26.59	54.80
T_6 : EPOE Trifloxy. 10 g ha^{-1} + HW	64.71	10.11	25.19	38.92	18.23	42.85	58.9	6.1	35.0	90.74	5.40	3.86
T_7 : Pendi. (30%) at 1 kg ha^{-1} + PWW	43.37	14.39	42.24	20.20	22.96	56.84	35.0	12.9	52.1	19.27	26.72	54.01
T_8 : Pendi. (30%) at 1 kg ha^{-1} + CRM + HW	30.27	17.87	51.86	16.19	23.87	59.95	36.7	7.2	56.2	20.01	26.23	53.76
T_9 : PWW on 25 and 45 DAS	42.62	12.23	45.15	24.48	19.04	56.48	51.0	8.7	40.3	46.33	10.39	43.28
T_{10} : HW on 25 and 45 DAS	33.35	16.30	50.35	18.31	22.84	58.85	52.6	2.5	44.9	44.38	10.22	45.41
T_{11} : Weed free check	32.76	18.10	49.14	19.18	23.30	57.53	49.1	11.0	39.9	39.58	26.39	34.04
T_{12} : Unweeded control	45.07	13.54	41.39	32.18	19.15	48.68	49.1	9.9	41.1	46.45	10.35	43.21

Table 4. Summed dominance ratio of weeds as influenced by weed management practices in cotton

Treatments	25 DAS						45 DAS					
	Winter 2008-09			Winter 2009-10			Winter 2008-09			Winter 2009-10		
	Grasses	Sedge	BLW	Grasses	Sedge	BLW	Grasses	Sedge	BLW	Grasses	Sedge	BLW
T_1 : Pendi (38.7%) at 1.5 kg ha^{-1} + HW	36.02	18.75	45.23	24.36	24.09	51.56	54.28	9.17	36.55	52.27	7.22	40.52
T_2 : Pendi (38.7%) at 2.0 kg ha^{-1} + HW	36.57	17.46	45.97	22.82	23.75	53.43	54.52	7.53	37.95	53.56	6.05	40.39
T_3 : Pendi (38.7%) at 2.5 kg ha^{-1} + HW	36.01	19.21	44.78	23.61	23.59	52.80	53.43	7.80	38.77	53.28	6.05	40.67
T_4 : Pendi (38.7%) at 4.0 kg ha^{-1} + HW	35.01	21.86	43.14	23.56	23.40	53.04	55.49	9.42	35.09	52.62	5.83	41.54
T_5 : Pendi (30%) at 1.0 kg ha^{-1} + HW	36.43	19.10	44.47	24.16	24.50	51.34	54.73	9.64	35.63	52.17	7.30	40.53
T_6 : EPOE Trifloxy 10 g ha^{-1} + HW	67.63	7.26	25.11	80.79	6.58	12.64	74.40	4.54	21.06	76.37	3.47	20.17
T_7 : Pendi (30%) at 1 kg ha^{-1} + PWW	36.29	18.04	45.68	23.82	24.74	51.43	51.52	9.58	38.90	50.10	8.18	41.72
T_8 : Pendi (30%) at 1 kg ha^{-1} + CRM + HW	37.41	15.03	47.56	24.07	24.06	51.86	49.60	12.23	38.17	51.70	8.85	39.45
T_9 : PWW on 25 and 45 DAS	46.61	13.48	39.92	43.04	13.52	43.43	48.80	9.83	41.36	50.68	8.41	40.90
T_{10} : HW on 25 and 45 DAS	47.86	9.58	42.57	40.17	13.74	46.09	51.21	12.08	36.71	52.15	8.30	39.55
T_{11} : Weed free check	43.53	15.83	40.65	36.96	21.74	41.30	45.98	13.31	40.71	41.81	15.69	42.50
T_{12} : Unweeded control	45.53	13.38	41.09	43.03	13.30	43.67	45.69	10.05	44.26	44.86	10.81	44.33

Summed dominance ratio (SDR)

The summed dominance ratio (SDR) of weeds gives a clear picture of the dominance of the weed in the respective treatment and effectiveness of the weed control treatments. In the first crop, it was found that lesser values of SDR for grassy weeds were observed under pendimethalin (38.7%) at 2.0 kg ha^{-1} and pendimethalin (38.7%) at 2.5 kg ha^{-1} at 25 DAS. Similar results was also obtained by Mian *et al.* (2007) who computed SDR was the highest in grasses indicating principal dominancy as compared to other species. At 45 DAS lesser SDR values of broad leaved weeds and sedges were observed with trifloxysulfuron at 10 g ha^{-1} and higher values of SDR for broad leaved weeds were observed with pendimethalin applied treatments.

During 2009-10, lesser values of SDR for grassy weeds were observed with pendimethalin (38.7%) at 2.0 kg ha^{-1} + HW and pendimethalin (38.7%) at 2.5 kg ha^{-1} at 25 DAS. At 45 DAS lesser SDR values of broad leaved weeds and sedges were observed with trifloxysulfuron 10 g ha^{-1} followed by HW and higher values of SDR for broad leaved weeds were observed with pendimethalin applied treatments. The reduction of summed dominance ratio of *Echinochloa* spp. and *Cyperus difformis* in herbicide treated plots indicated their effectiveness in weed control (Ramanjaneyulu *et al*., 2006).

Effect of herbicides on weed control efficiency

Weed control efficiency (WCE) showed the maximum value under pre-emergence application of pendimethalin (38.7%) at 4.0 kg ha^{-1} at 25 and 45 DAS. Pre-emergence application of pendimethalin registered higher WCE ranging between 93.45 and 65.8 per cent. The results of the present study indicated that application of pendimethalin (38.7%) at different doses followed by hand weeding produced higher WCE throughout the crop period which was comparable with the conventional weeding at 45 DAS. The integrated weed management practice gave the broad spectrum weed control as a result of longer persistency in the soil profile. Manual weeding is usually rendered difficult especially during the monsoon seasons due to intermittent rains and consequently the moisture content of the soil would be too high for mechanical manipulation. Hence, application of pendimethalin (38.7%) at 2.0 to 4.0 kg ha^{-1} followed by hand weeding is a quite suitable option to overcome the weed problem in cotton. Similar finding was reported by Balasubramanian (1992) who found that the weed control efficiency was comparatively higher with the application of pendimethalin at 1.0 kg ha^{-1} as compared with 0.5 and 0.75 kg ha^{-1}.

Lower dose of pendimethalin 38.7% at 1.5 kg ha^{-1} and pendimethalin 30% at 1.0 kg ha^{-1} followed by hand weeding, power weeder weeding and crop residue mulch application resulted in higher WCE. However, it was not persistent throughout the cropping period. This might be possibly due to lower dose of herbicide which was not sufficient to break the metabolism of the weeds. Though it suppressed the weeds for shorter period, it took longer time to control the weeds as against higher doses.

Effect of treatments on seed cotton yield

Pendimethalin (38.7%) at 2.0 kg ha^{-1} + hand weeding recorded higher seed cotton yield of 58 and 32 per cent during winter 2008-09 and 2009-10 seasons, respectively over unweeded control. The next best treatment was the pendimethalin (38.7%) at 2.5 kg ha^{-1} + hand weeding. Application of pendimethalin at 1.0 kg ha^{-1} in combination with inter culturing plus hand weeding gave 19.4 per cent increase in seed cotton yield over untreated check was reported by Ali *et al*. (2005). Gnanavel and Babu, (2008) also reported maximum seed cotton yield with pendimethalin and fluchloralin combination coupled with hand weeding as compared with control. Hand weeding twice recorded lower seed cotton yield during winter season due to poor control of grasses and broad leaved weeds. Cotton being a wide spaced and slow growing crop is sensitive to weed competition at early stages of growth than at later stages. Due to heavy infestation of weeds under unweeded check, there was 32 to 58 per cent reduction in seed cotton yield. Weeds compete with crop for light, nutrients and water. Hence, the crop under unweeded control may not be able to obtain the above growth factors in optimum quantity resulting in reduced leaf area, dry matter production and number of leaves. This would have reflected in poor yield under unweeded control. Presence of weeds throughout the growing season caused poor crop growth and caused yield reduction in unweeded check (Bhoi *et al*., 2007).

CONCLUSION

The success of the weed control operations is dependent on the time of weed seedling emergence, weed species and stage of crop growth. Timely applications of effective herbicide are able to reduce losses when there is an occurrence of targeted weeds, optimize herbicides efficacy against weeds and also minimize production cost or protect crops against injury.

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EVALUATION OF SUGARCANE PLANTERS AVAILABLE IN ANDHRA PRADESH

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ABSTRACT

The sugarcane set cutter planter is a versatile implement and can do five operation viz., furrow opening, set cutting and placement, fertilizer & fungicide application and covering in single go. Similarly seedling transplanting machine available for bud-chip method of sugarcane planting which can do four operations like furrow opening, seedling placement along with water pour and press the seedling in soil; was considered for study and evaluated operating parameters. The row spacing for planting with both machines were adjustable and can be done from 90 cm to 165 cm. The machines also evaluated for intra row spacing of planting which was continuous or up to required spacing as it is monitored by the feeding of cane in sett cutting machine. Similarly, fertilizer quantity can be metered through machine from 0.02 g/m to 0.44 g/m run in the furrow, whereas fungicide placement need to be done with knob position and can be varied from 1172 ml to 1549 ml. In case of bud chip seedling planter intra row spacing can be varied from 30.4 cm to the maximum of 57 cm by changing suitable gear ratio in the power train and water pour quantity per plant can be monitored from 47.4 ml to 244 ml.

KEYWORDS: Sugarcane sett cutter planter, Sugarcane budchip seedling transplanter, field performance.

INTRODUCTION

Sugarcane (*Saccharum officinarum L.)* is the most important agro industrial crop next to cotton. In India, the cane cultivable area is 5.09 million hectares with a total production of 347.87 million tone during 2013-14 (Directorate of Economics and Statistics and Ministry of Agriculture, 2013-14). In Andhra Pradesh and Telangana the area under sugarcane is 0.18 m ha with a production of 139 million tone in 2014-15 (Indiastat.com).

The development of tractor operated sugarcane sett cutter planter in which the sugarcane set were fed by operator during operation. It was developed by the IISR, Lucknow (Srivastava, 1978). This is the semi automatic unit and the main difference of this machine was sett cutting mechanism. The existing unit is designed to open furrow placement of setts and fertilizer. Select application, fungicide application, covering of setts with loose and moist soil. Apart from the above machine and also to encourage bud chip planting and reduce cost of cultivation, ANGRAU have introduced two row bud chip planter in which bud chips are used to grow in nursery and nursery seedlings are used for planting. This method of planting engages maximum approximately 100 per cent surveillance of planted crop. Even though the information on available planters in the state of Andhra Pradesh known, the farmers are still dependent on expensive manual planting. To find the reasons for non-adoption and bottlenecks of the process, investigation on the available machinery was conducted, to suggest region specific recommendations and reduce dependency on manual labour in turn cost of operation.

MATERIALS AND METHODS

The planters were tested evaluated in Agriculture Research Station, Perumallipalle, Tirupati. The soil was with sandy loam in texture and red in colour. The planters used for the study was Sugarcane Budchip seedling transplanter and Sugarcane sett cutter planter. The variety of sugarcane was 2005 T16.

Evaluation of set cutter planter

A machine shown in Fig. 2 was used for evaluation. It was operated with tractor and attached with three point hitch system as mounted type implement. Sugarcane are fed into the feeding mechanism of planter and were cut with the help cutter mechanism and the setts dropped into the furrow opened by the furrow opener of the machine. Simultaneously fertilizer is dropped into the furrow and fungicide is sprayed over setts and then it pressed in to soil with the help of rollers (Fig. 1).

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Row spacing

The machine was designed with two row set cutter planter and can be adjusted for varied spacing. The given main frame and other braces and brackets were tested for its maximum and minimum row spacing and its tension.

Set cutter size

Machine was evaluated for its effectiveness with different engine speeds and its influence on size and cutting efficiency.

Intra row spacing

The set planting intra row spacing does not have any metering mechanism. It mainly depends on the skill of the subject who feeds the cane into the cutter. Since the speed of the operation is influencing the placement of sets, this was tested against different speeds of operation and uniformity coefficient was evaluated.

Fertilizer placement

The evaluation was done on metered quantities of fertilizer drilled in the field along with setts. It was also analyzed the uniformity of the placement and quantity evaluation against requirement.

Fungicide dripping

Since there was no metering mechanism for fungicide application, evaluation of knob adjustment for maximum and minimum quantities of dripping and its sufficiency was calculated and machine was calculated (Choochart *et al.,* 2015).

Evaluation of Sugarcane bud-chip Seedling Transplanter

A machine shown in Fig. 4 was used for transplanting sugarcane seedlings in the field. It was operated with tractor and attached with three point hitch system as mounted type implement. Budchip seedlings were fed into the planting mechanism of planter. During dropping in the furrow, it triggers watering latch and simultaneously water poured in furrows and seedling is placed. The covering and pressing from both sides was done with inclined pressing wheels (Manisha *et al.,* 2008) (Fig. 3).

Row spacing

The adjustable two furrow opening unit with respective main frame was adjusted with the help of U brackets fastened to main square frame. The maximum row spacing and minimum row spacing achievable was measured.

The machine was raised from the ground. The fasteners are dismantled and adjusted the brackets from maximum to minimum position on the main frame. The data was documented.

Intra row spacing

The machine was evaluated for its maximum and minimum intra-row spacing adjustment in placement of seedling this in two rows. This was adjusted with the help of gear ratios (set of gears provided by the manufacturer) used in the power train of seedling metering rotary mechanism. This is operated by the drive from ground wheels arranged in the front of metering mechanism.

Metering water quantity

The water delivered to per plant was measured at different positions of the adjusting knob to flow per drop of the seedling and triggering the latch. The quantity of the water per seedling can be adjusted with the knob control by lowering or bringing out the plunger ball in the barrel. The minimum and maximum water delivering quantity per seedling was evaluated. The range was tabulated.

Press roller adjustment

The press rollers were designed with roller spacing adjustment and was evaluated for the minimum and maximum spacing to accommodate the size of root mass of seedling.

Missing plant

Missing plant was measured at different gear system and time intervals. The number of plants missing in a row was evaluated.

RESULTS AND DISSCUSION

Sugarcane budchip seedling equipment:

The two row machine main frame have provision of adjusting furrow opener along with all components as mentioned in Table 1. The minimum spacing between rows attainable was 95 cm below which the component getting inferred and tangled with fixed brace collers. Similarly maximum row spacing attainable was 170 cm, the minimum water quantity was 47.4 ml and maximum was 244.0 ml, the minimum furrow opener depth was 6 cm and maximum depth was 12 cm (Bhal and Sharma, 2001).

Intra row spacing adjustment

Spacing of the planting greatly influences the production and productivity. To maintain recommended spac-

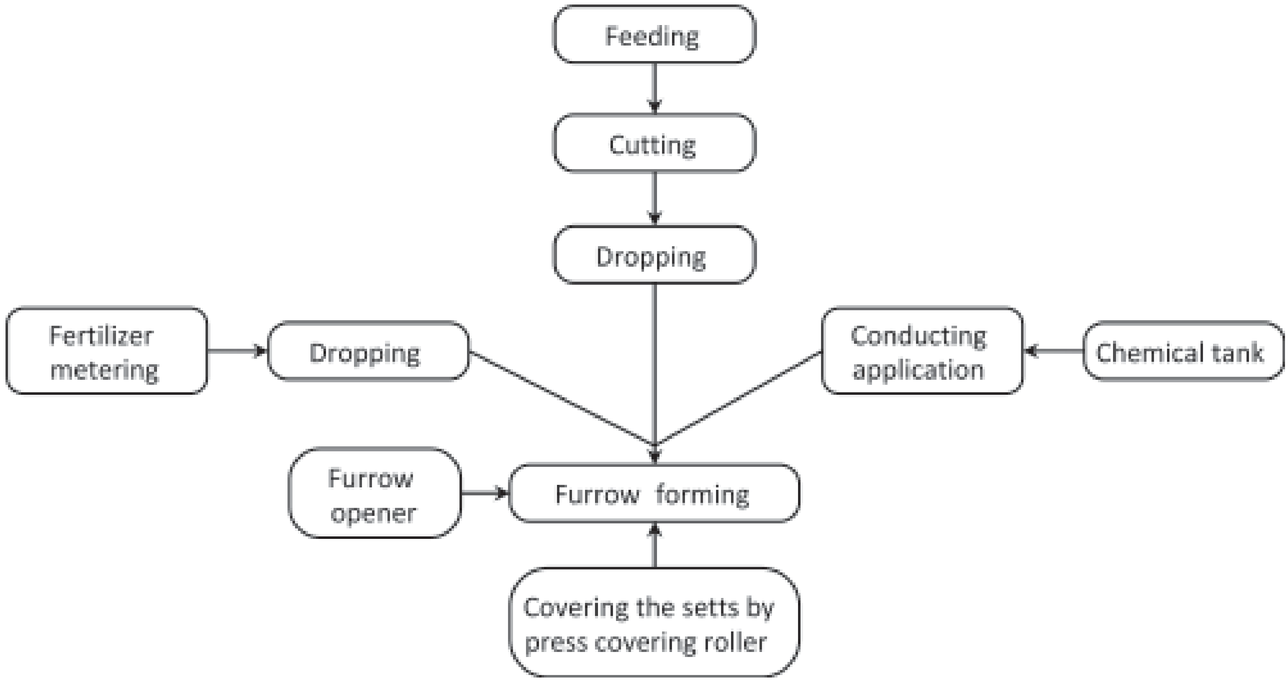

Fig. 1. Flowchart showing sequence of operations by sugarcane sett cutter planter

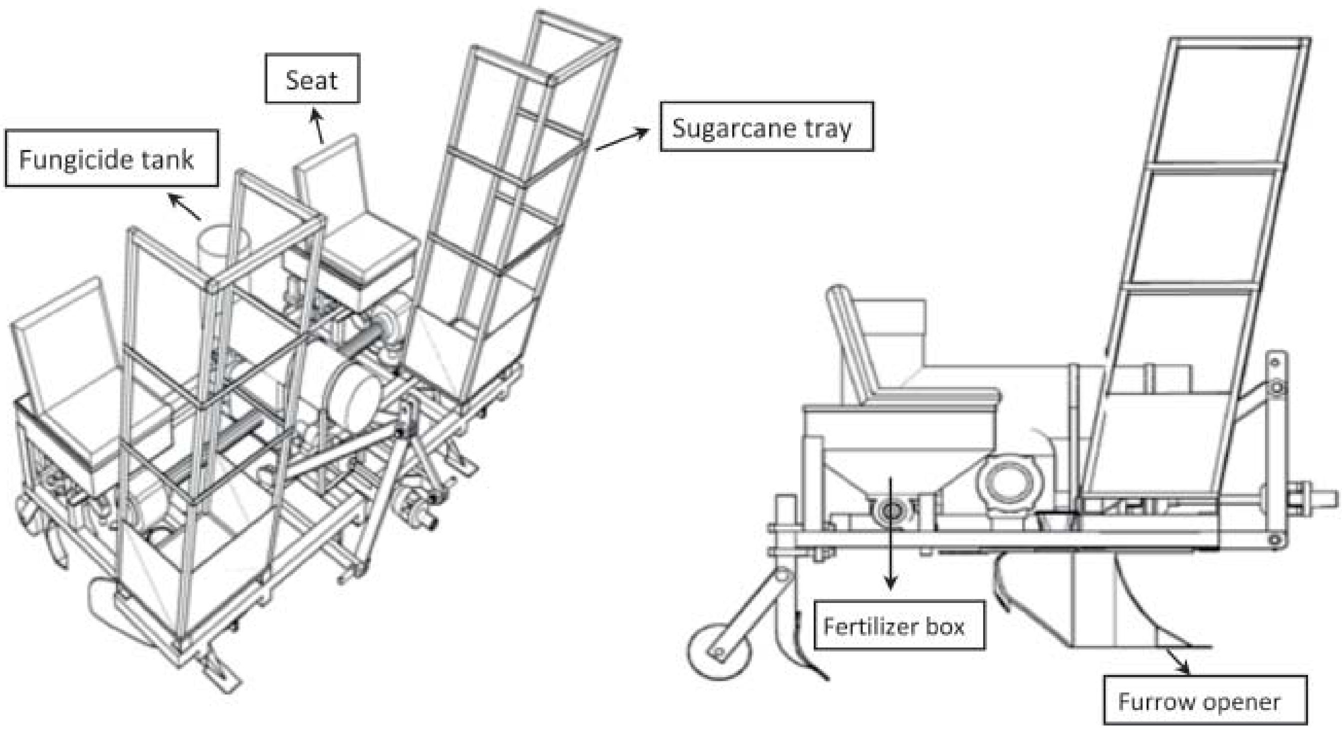

Fig. 2. Isometric and side view of sugarcane sett cutter planter

ing in the sugarcane planting is essential to have intra row spacing monitoring mechanism to adjust as per the recommendation. The results of the testing shown that the varying the gear ratio in the power train of the rotary mechanism significantly influences the intra row spacing. The variation of gear ratio from 12 × 10; 12 × 14; 12 × 16 and 12 × 18 teeth had increased intra row spacing of 30.4 cm, 45.9 cm, 50.8 cm and 57.0 cm respectively (Choochart *et al.,* 2015) (Fig. 4.1).

Variation of water distribution in the budchip seedling transplanter

The knob and control rack was designed to vary the water pour quantity depending upon soil type and the age of the seedling used for planting, which is a essential technical requirement for establishment of roots in the field there by reducing mortality. The seedling establishment and maintaining 100 per cent population is very important in the budchip seedling planting method.

Results of the test on watering capacity and its normality against water pump knob adjustment on threaded rack shows significant variation. The minimum mean quantity of water pour of 47.4 ± 0.89 ml at low position and maximum pour quantity was 244 ± 8.94ml at full open knob position. It was observed that intra pour variability was significantly high 8.94 ml in the full open position, where as it was significantly mean variation of 0.89 ml at low position. The water pour quantity at middle knob position on control rack was found to be 97.0 ± 1.41 ml (Umesh and Rajesh, 2007). The same was explained in Fig 5.

Variation analysis of the experiment was used to clarify the practical significances water measurement performance texted, as presented in the Fig. 5. The results from one-way ANOVA it is observed that there is significant difference among three treatments i.e high, medium and low knob position at 1 per cent level (p-value <0.01) with respect to knob position. This was a added advantage to the method of planting to meter the quality of water application along with nursery planting depending on the age of the sapling and its water requirement.

Missing of plants

The study also observed the missing plant during field operation. The results revealed that 5-8 per cent missing of plants observed after 20 min of operation. This was the result of non placement of seedling in rotary cups. This missing was mainly due to the continuous feeding without any break and monotonous operation leading to fatigue and causing missing feeding. It was also observed that the number of missing plants increased as the intra row spacing of the planting reduced and missing were significantly high and needs break (rest) in the feeding to maintain 100 per cent planting after 20 min (Marco and Tomaz, 2010).

Table 1. Sugarcane budchip seedling transplanter equipment and its adjustments

S. No.	Particulars	Adjustable	
		Min	Max
1	Row to row spacing (cm)	95	170
2	Water quality (ml)	47.4	244.0
3	Furrow depth (cm)	6	12

From Table 2 it was observed among 4 gear system, significantly higher missing plants was observed at high

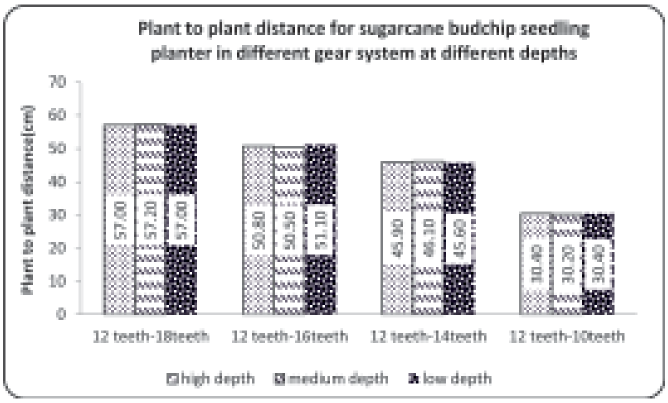

Fig. 4.1. Effect of plant to plant spacing in different depths depth

at 20-30 min in 12 teeth-10 teeth with 3.75 ± 0.957, significantly lower missing plants was observed at low at 0-10 min in 12 teeth-18 teeth and 12 teeth-16 teeth with 2.25 ± 0.500. This happens due to change in time and gear system.

Sugarcane set cutter planter

Sugarcane set cutter planter equipment and its adjustments

The two row machine main frame have provision of adjusting furrow opener along with all components as mentioned in Table 3. The minimum spacing between rows attainable was 90 cm below which the component getting infertangled and obstructed. Similarly maximum row spacing attainable was 165 cm, beyond which drive shaft (telescopic) not available, the minimum feeding unit was single node and maximum spacing was 4 nodes, the

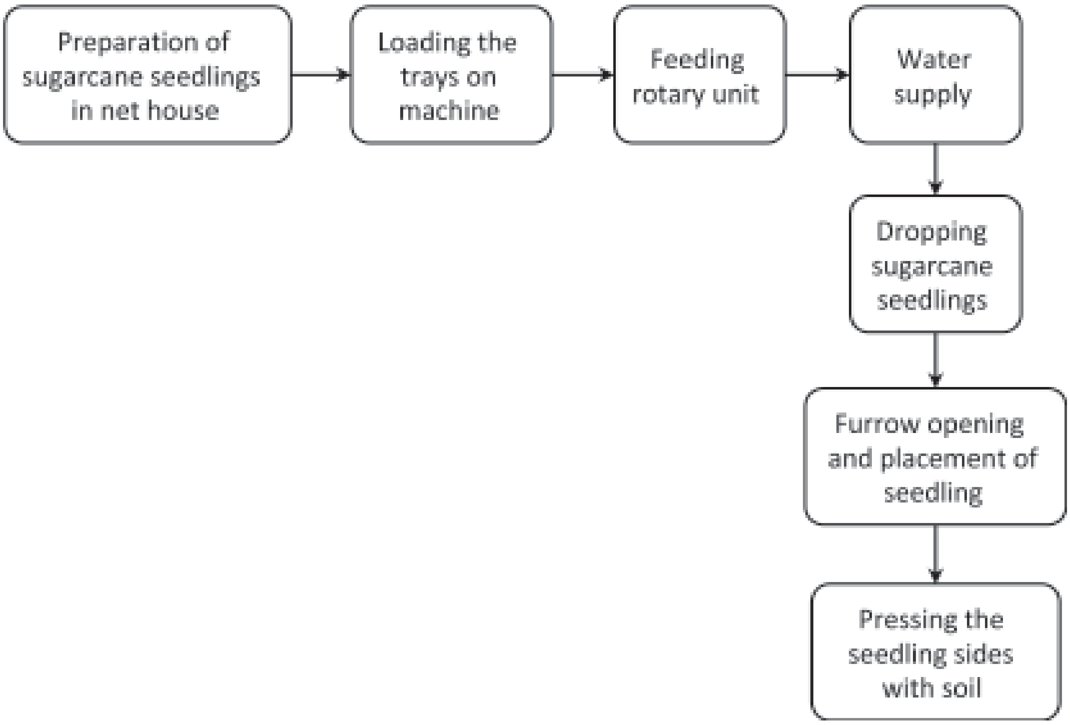

Fig. 3. Flowchart showing sequence of operations by sugarcane budchip seedling transplanter

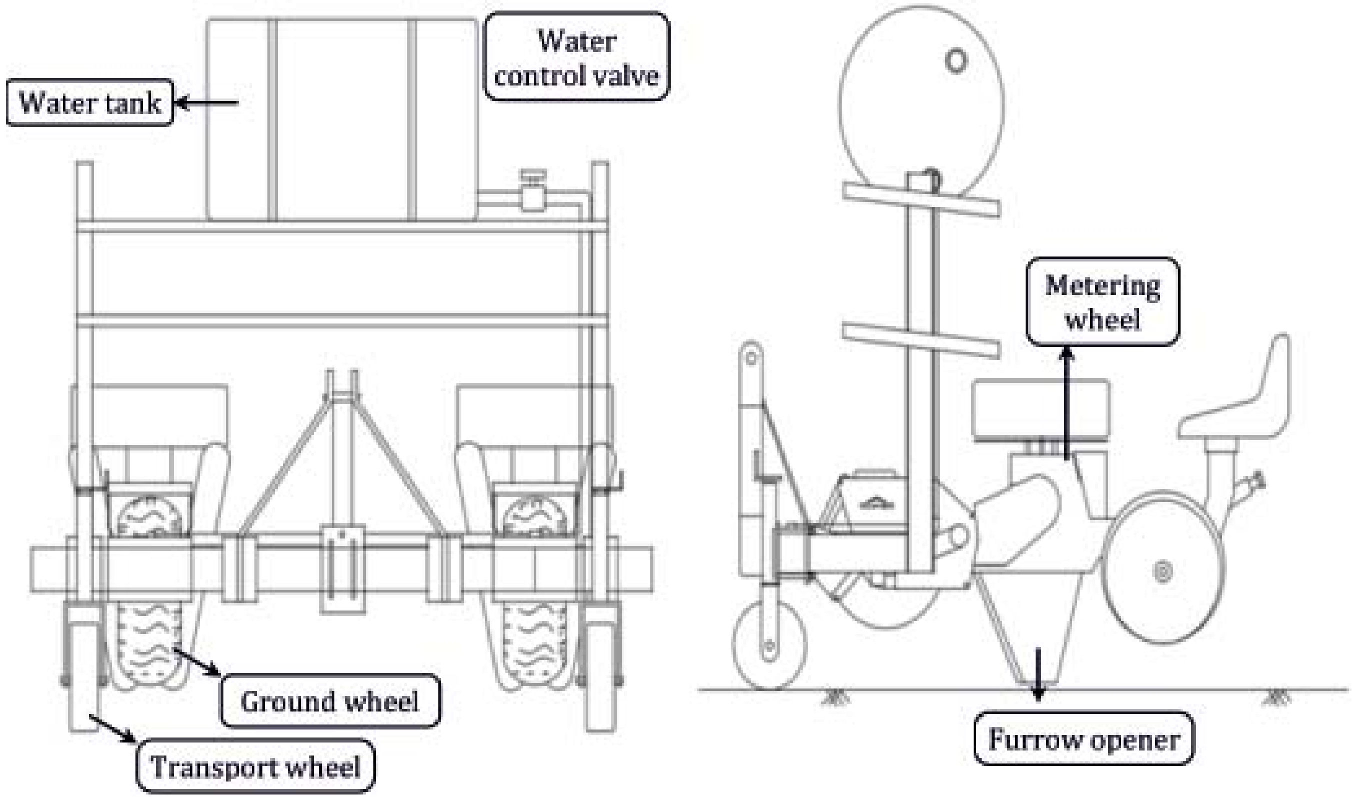

Fig. 4. Front and side view of sugarcane budchip seedling transplanter

Table 2. ANOVA analysis of effect on missing plants

Gear system with intra row distance	No. of replications	Planting duration					
		0-10 min		10-20 min		20-30 min	
		Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
12 teeth - 18 teeth (57 cm)	5	2.25	0.500	2.75	0.957	2.75	0.957
12 teeth - 16 teeth (50 cm)	5	2.25	0.500	2.50	0.577	3.25	0.500
12 teeth – 14 teeth (45 cm)	5	2.75	0.957	2.75	0.957	3.50	1.291
12 teeth – 10 teeth (30 cm)	5	2.50	0.577	2.75	0.500	3.75	0.957
Total	20	2.45	0.686	2.65	0.745	3.20	0.957

minimum fertilizer applied was 0.02 kg and maximum was 0.44 kg, the minimum fungicide applied was 1172 ml and maximum was 1549 ml, the minimum furrow opener depth was 6 cm and maximum depth was 12 cm (Manish and Tripathi, 2015).

Effects of blade speed on number of buds laid down from sugarcane 3 buded set cutter planter

From Table 4 it was observed among operational selected three speeds of cutting knives, speed significantly influenced the number of 1 or 2 or 3 budded setts. The maximum number of three budded setts (72.2%) attained from the machine at 30 rpm followed by 65.4 per cent at 47 rpm and 48 per cent at 67rpm. This evidently shows that the decrease of accuracy in feeding with the increase of speed,

CONCLUSIONS

1. Speeds of cutting knives, significantly influenced the number of 1or 2or 3 budded setts. The maximum number of three budded setts (72.2%) attained from the machine at 30 rpm followed by 65.4 per cent at 47 rpm and 48 per cent at 67rpm. This evidently shows that the decrease of accuracy in feeding with the increase of speed (Table 4).
2. In sugarcane budchip seedling transplanter, with varying gear ratio in the power train of the rotary mechanism of 12×10; 12×14; 12×16 and 12×18 teeth had increased intra row spacing of 30.4 cm, 45.9 cm, 50.8 cm and 57.0 cm respectively (Fig. 4.1).
3. Sugarcane budchip seedling transplanter water pour can be varied during the transplanting from 244 ± 8.94ml at full open knob position to 47.4 ± 0.89 ml at low position (Table 1).
4. The number of missing of plants increased as the intra spacing of the planting reduced as duration of planting exceeds 20 minute (Table 2).

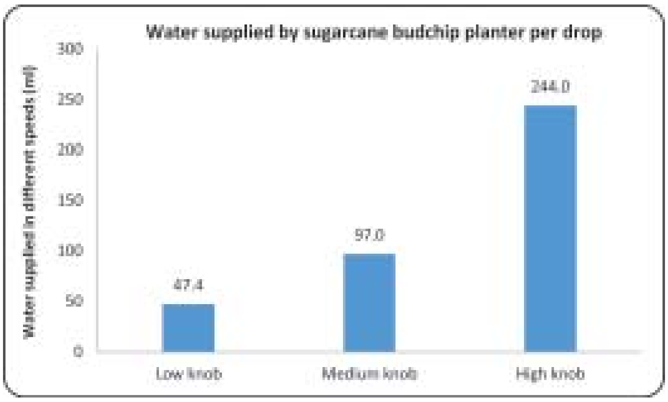

Fig. 5. Effect of knob position on water-pour during each drop of seedling

Table 3. Sugarcane set cutter planter equipment and its adjustments

S. No.	Particulars	Adjustable	
		Min	Max
1	Row to row spacing (cm)	90	165
2	Feeding unit (nodes)	Single	4
3	Fertilizer applier (kg)	0.02	0.44
4	Fungicide applicater (ml)	1172	1549
5	Furrow depth (cm)	6	12

Table 4. Association between speed of sugarcane cutter and number of buds laid down

Chi-square value	p-value	Number of buds				Total
13.368 *	0.038	1	2	3	4	
Speed	30 rpm	0	6	24	3	33
		0.0%	18.2%	72.7%	9.1%	100.0%
	47 rpm	0	5	17	4	26
		0.0%	19.2%	65.4%	15.4%	100.0%
	67 rpm	4	3	12	6	25
		16.0%	12.0%	48.0%	24.0%	100.0%
	Total	4	14	53	13	84
		4.8%	16.7%	63.1%	15.5%	100.0%

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ECONOMICS OF MEDICINAL AND AROMATIC PLANTS IN ANDHRA PRADESH AND TELANGANA STATES

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ABSTRACT

The economics of medicinal and aromatic plants *viz.*, coleus and palmarosa has been worked out using farm- level data from the districts of Chittoor and Mahabubnagar in Andhra Pradesh and Telangana states respectively. The net returns over total costs have been found ₹ 161547.58 ha^{-1} in coleus and ₹ 77815.70 from main crop and ₹ 42568.57, ₹ 38385.33 and ₹ 34772.22 for ratoon I, II and III respectively.

KEYWORDS: Medicinal and aromatic plants, coleus, palmarosa

INTRODUCTION

Medicinal and aromatic plants (MAPs) are receiving considerable attention across the world because they offer a wide range of safe and cost effective, preventive and curative therapies which are useful in achieving the goal of 'health for all'. Though there are a number of important medicinal and aromatic plants, this study is limited to two common plants, *viz.* Coleus (*Coleus forskolii*), palmarosa (*Cymbopogan martini*). Coleus is one of the most potential medicinal plants of the future due to its pharmaceutical properties. It is widely used in scenting of soaps, cosmetics and tobacco blending. Against this back ground. The present study has been taken up to estimate the economics of these two medicinal and aromatic plants coleus and palmarosa.

MATERIAL AND METHODS

The study was conducted in Chittoor and Mahabubnagar districts in Andhra Pradesh and Telangana states respectively. The list of growers cultivating the above said crops were collected from the selected villages and 30 farmers for each crop were selected randomly. The total sample represented 60 farmers. The primary data were collected through personal interview using a pre – tested schedule for the year 2014-2015.

RESULTS AND DISCUSSION

Cost of Cultivation

The profitability of any enterprise depends up on income generating capacity and cost structure. Generally, costs in any economic study are discussed under two categories *viz*., operational costs and fixed costs. In general, operational costs alone are reckoned as the cultivation costs by farmers ignoring the fixed costs. The profit and loss too worked out accordingly .But in any economic analysis of any business enterprise, the fixed costs are also taken in to account to arrive at total cost and compute net profits.

Coleus

The particulars of cost of cultivation coleus are presented in Table 1. On an average the total cost of cultivation of coleus was ₹ 90452.42. It was found that, the operational costs accounted for a major share in the total cost of cultivation. The total operational costs were ₹ 74755.60.

It is evident that, the cost of both owned, hired human labour was the major cost component among operational costs with an amount of ₹ 47968 accounting for 53.03. The next important operational cost was manures and fertilizers with an amount of ₹ 11701.56 (12.94%). The other items of expenditure in the order of importance were seed (5.52%), machine power (4.25%), cattle labour (2.31%), interest on working capital (2.11%) plant protection chemicals (1.51%), and, irrigation charges (0.97%).

Fixed costs per hectare were estimated at ₹ 15695.82 accounting for 17.36 per cent of total cost of cultivation. The rental value of owned land was the major cost item among the fixed costs which accounted for 11.06 per cent. Depreciation, interest on fixed capital and land revenue were other fixed cost items accounting for 4.27, 1.86 and

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Table 1. Cost of cultivation of coleus (component-wise per hectare)

S. No.	Item	Amount (₹)
I.	**Operational Costs**	
1.	**Human labour**	47968 (53.03)
	Owned	3436 (3.80)
	Hired	44532 (49.23)
2.	**Cattle labour**	2084 (2.31)
	Owned	282 (0.31)
	Hired	1802 (2.00)
3.	**Machine power**	3848 (4.25)
	Owned	1190 (1.31)
	Hired	2658 (2.94)
4.	Seed	4997.06 (5.52)
5.	Manures and fertilizers	11701.56 (12.94)
	a. Manures	6000 (6.64)
	b. Fertilizers	5701.56 (6.30)
6.	Plant protection chemicals	1368.87 (1.51)
7.	Irrigation charges	876 (0.97)
	Interest on working capital	1912.11 (2.11)
	Total Operational Costs	**74755.60 (82.64)**
II	**Fixed costs**	
1.	Land revenue	150 (0.17)
2.	Rental value of owned land	10000 (11.06)
3.	Depreciation	3865.02 (4.27)
4.	Interest on fixed capital	1681.80 (1.86)
	Total fixed costs	**15695.82 (17.36)**
	Total costs	**90452.42 (100)**

0.17 per cent respectively. The results were found in accordance with the findings of Guleria *et al.* (2014).

Palmarosa

It is evident from Table 2 that, the cost of both owned, hired human labour was the major cost component among operational costs with an amount of ₹ 43348 accounting for 57.66 per cent of cultivation on palmarosa for the main crop. The next important operational cost was manures and fertilizers with an amount of ₹ 13686.83 (18.20%) main crop. The other items of expenditure in main crop in the order of importance were seed (6.46%), machine power (5.59%), cattle labour (3.09%), irrigation charges (1.50%), interest on working capital (1.23%) and plant protection chemicals (0.97%).

Fixed costs for main crop stood at ₹ 3687.44 accounting for 4.90 per cent of total cost of cultivation. The rental value of owned land was the major cost item among the fixed costs which accounted for 3.32 per cent. Depreciation, interest on fixed capital and land revenue were other fixed cost items accounting for 1.00, 0.53 and 0.05 per cent respectively. The results were found in accordance with the findings of Ramsuresh *et al.* (2012).

For ratoon-I the cost of labour (both owned, and hired) was the major cost component among operational costs with an amount of ₹ 29442 accounting for 69.16 per cent of cultivation on palmarosa. The next important operational cost was fertilizers with an amount of ₹ 7200 (16.91%) on palmarosa. The other items of expenditure in the order of importance were irrigation charges (2.42%), protection chemicals (1.65%), and interest on working capital (1.20%) plant, and on palmarosa farms. Fixed costs per hectare were estimated for at ₹ 3687.44 accounting for 8.66 per cent of total cost of cultivation. The rental value of owned land was the major cost item among the fixed costs which accounted for 5.87 per cent. Depreciation, interest on fixed capital and land revenue were other fixed cost items accounting for 1.77, 0.93 and 0.09 per cent respectively.

In ratoon-II the cost of both owned, hired human labour was the major cost component among operational costs with an amount of ₹ 26144 accounting for 68.10 per cent of cultivation. The next important operational cost was fertilizers with an amount of ₹ 6500.70 (16.93%). The other items of expenditure in the order of importance were irrigation charges (2.53%), protection chemicals (1.64%), and interest on working capital (1.17%) plant. Fixed costs per hectare were estimated at ₹ 3687.44

Table 2. Cost of cultivation of palmarosa (component-wise per hectare)

(in rupees per hectare)

S. No	Particulars	Main crop	Ratoon - I	Ratoon – II	Ratoon - III
		Amount (₹)			
I.	**Operational costs**				
1.	Human labour	43348 (57.66)	29442 (69.16)	26144 (68.10)	23092 (66.41)
	Owned	2328 (3.10)	1928 (4.53)	1528 (3.98)	1402 (4.03)
	Hired labour	41020 (54.56)	27514 (64.63)	24616 (64.12)	21690 (62.38)
2.	Cattle labour	2324 (3.09)	-	-	-
	Owned	286 (0.38)	-	-	-
	Hired	2038 (2.71)	-	-	-
3.	Machine power	4502 (5.99)	-	-	-
	Owned	1746 (2.32)	-	-	-
	Hired	2756 (3.67)	-	-	-
4.	Seed	4852.87 (6.46)	-	-	-
5.	Manures and fertilizers	13686.83 (18.20)	-	-	-
	a. Manures	5823.53 (7.75)	-	-	-
	b. fertilizers	7863.30 (10.45)	7200.30 (16.91)	6500.70 (16.93)	5986.96 (17.22)
6.	Plant protection chemicals	727.94 (0.97)	698.84 (1.65)	630.94 (1.64)	598.26 (1.72)
7.	Irrigation charges	1128.98 (1.50)	1028.84 (2.42)	972.74 (2.53)	945.64 (2.38)
8.	Interest on working capital	926.24 (1.23)	576.16 (1.20)	516.42 (1.17)	467.27 (1.33)
	Total operational costs	71496.86 (95.10)	38881.13 (91.34)	34697.89 (90.40)	31084.78 (89.65)
II	**Fixed costs**				
1.	Land revenue	37.50 (0.05)	37.50 (0.09)	37.50 (0.09)	37.50 (0.10)
2.	Rental value of owned land	2500 (3.32)	2500 (5.87)	2500 (6.50)	2500 (7.19)
3.	Depreciation	754.86 (1.00)	754.86 (1.77)	754.86 (1.97)	754.86 (2.17)
4.	Interest on fixed capital	395.08 (0.53)	395.08 (0.93)	395.08 (1.03)	395.08 (1.14)
	Total fixed costs	3687.44 (4.90)	3687.44 (8.66)	3687.44 (9.60)	3687.44 (10.35)
	Total costs	75184.30 (100)	42568.57 (100)	38385.33 (100)	34772.22 (100)

Table 3. Cost concepts in coleus cultivation
(rupees per hectare)

S. No.	Costs	Coleus
1	**Cost A1/A2**	75334.62
3	**Cost B1**	77016.42
4	**Cost B2**	87016.42
5	**Cost C1**	80452.42
6	**Cost C2**	90452.42
7	**Cost C3**	99497.66

Table 5. Output and returns of coleus and farms per hectare
(rupees per quintal)

S. No.	Particulars	Coleus
1	Yield (in Quintals)	1800.00
2	Gross returns	252000
3	Total costs	90452.42
4	Net returns	161547.58
5	Returns per rupee of expenditure	1.78

Table 4. Cost concepts in palmarosa cultivation
(rupees per hectare)

S. No.	Costs	Main crop	Ratoon - I	Ratoon - II	Ratoon – III
1	Cost A1/A2	69961.22	37745.49	33962.25	30475.14
3	Cost B1	70356.30	38140.57	34357.33	30870.22
4	Cost B2	72856.30	40068.57	36857.33	33370.22
5	Cost C1	72684.30	40640.57	35885.33	32272.22
6	Cost C2	75184.30	42568.57	35385.33	34772.22
7	Cost C3	82702.73	46825.43	39223.86	38249.44

Table 6. Output and returns of palmarosa farms per hectare
(rupees per hectare)

S. No.	Particulars	Main crop	Ratoon - I	Ratoon - II	Ratoon – III
1	Yield (quintals)	700	700	700	700
2	Gross returns	154000	140000	119000	105000
3	Total cost	75184.30	42568.57	35385.33	34772.22
4	Net returns	78815.70	97431.43	83614.67	70227.78
5	Returns of rupee expenditure	1.04	2.28	2.36	2.02

accounting for 9.60 per cent of total cost of cultivation. The rental value of owned land was the major cost item among the fixed costs which accounted for 6.50 per cent. Depreciation, interest on fixed capital and land revenue were other fixed cost items accounting for 1.97, 1.03 and 0.09 per cent respectively.

In ratoon - III the cost of (both hired and owned), hired human labour was the major cost component among operational costs with an amount of ₹ 23092 accounting for 66.41 per cent. The next important operational cost was manures and fertilizers with an amount of ₹ 5986.96 (17.22%). The other items of expenditure in the order of importance were, irrigation charges (2.38%), protection chemicals (2.38%), and interest on working capital (1.33%) plant. Fixed costs were estimated at ₹ 3687.44 accounting for 10.35 per cent of total cost of cultivation (Ramsuresh *et al.,* 2014).

Cost Concepts

The cost of cultivation of coleus and palmarosa was estimated by adopting the cost concepts used in farm management studies *viz.,* Cost A_1, Cost A_2, Cost B_1, Cost B_2, Cost C_1, Cost C_2 and Cost C_3. Of all the cost concepts, Cost C_2 is the most comprehensive cost as it covers both operational costs and fixed costs. The total cost of cultivation of coleus and palmarosa according to cost concepts was worked out and presented in Table 3.

Coleus

It is clear that from Table 3 there was no leasing in activity among the selected farmers and hence cost A_1 and cost A_2 were the same. On an average, the total cost of cultivation (Cost C_2) of coleus per hectare was ₹ 90452.42.

Palmarosa

From Table 4 It is clear that there was no leasing in activity among the selected farmers and hence cost A_1 and cost A_2 were the same. On an average, the total cost of cultivation (Cost C_2) was ₹ 75184.30 in main crop and same for ratoon I, II, and III, were ₹ 42568.57, ₹ 35385.33, and ₹ 34772.22 respectively.

Output and Returns

Coleus

From the Table 5 it is clear that the coleus farm recorded a yield of 1800 quintals per hectare. The gross returns obtained by ₹ 2,52,000. The total cost 90452.42. The net returns obtained was ₹ 161547.58 and returns per rupee of expenditure are ₹ 1.78.

Palmarosa

From the Table 6 it is clear that the palmarosa farm recorded a yield of 700 quintals of crop per hectare for main crop and for subsequent- ratoons as well. The average gross returns obtained were ₹ 1,54,000 in main crop and the same for ratoons were ₹ 1,40,000, ₹ 1,19,000, ₹ 1,05,000 respectively. The net returns obtained in were ₹ 78815.70, ₹ 97431.43, 83614.67, and ₹ 70,227.78 and returns of rupee expenditure during said cropping periods were ₹ 1.04, ₹ 2.28, ₹ 2.36, and ₹ 2.02 respectively.

CONCLUSION

According to the cost concepts analysis, Cost A1/ A2, Cost B1, Cost B2, CostC1, Cost C2, and Cost C3 were ₹ 75334.62, ₹ 77016.42, ₹ 87016.42, ₹ 80452.42, ₹ 90452.42 and ₹ 99497.66 on coleus farm respectively.

On palmarosa farms, Cost A1/A2, Cost B1, CostB2, Cost C1 Cost C2, and Cost C3 were main crop ₹ 69961.22, ₹ 70356.30, ₹ 72856.30, ₹ 72684.30, ₹ 75184.30, ₹ 82702.73 for main crop.

The coleus yield per hectare was 1800 quintals. The gross returns were ₹ 252000. In palmarosa yield per hectare was 700 quintals in each from main crop ratoon I, II, and III respectively, while the gross returns for the corresponding period years were ₹ 154000, ₹ 140000, ₹ 119000 and ₹ 105000 respectively.

The net returns per rupee of expenditure were ₹ 1.78 in coleus and the same in palmarosa were ₹ 1.04, ₹ 2.28, ₹ 2.36 and ₹ 2.02 for main crop and ratoon I, II and III respectively.

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EFFECT OF ZINC FERTILIZER DOSAGES ON GROWTH AND YIELD OF SPECIALITY CORN

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ABSTRACT

A field experiment entitled "Biofortification of Speciality corn with zinc" was conducted on sandy loam soils of Maize Research Center, Agricultural Research Institute, Rajendranagar during *kharif*, 2013 to study the effect of zinc nutrition in speciality corn. The experiment comprised of 18 treatments *viz.,* combination of three types of speciality corn [Popcorn, Sweet corn and Quality protein maize (QPM)] and six zinc levels [both soil and foliar application). The results revealed that three different types of corn and zinc levels significantly influenced growth parameters such as plant height, leaf area index(LAI), dry matter production and yield attributes such as cob number, number of grains per cob, cob girth and yield. Better growth and yield was registered with 25 kg $ZnSO_4$ ha^{-1}as soil application along with two foliar sprays i.e. at tasseling and milking stage. Sweet corn registered significantly higher number of cobs, longer cobs and maximum cob girth compared to QPM and popcorn. Number of grain rows per cob of popcorn was superior to QPM and sweet corn. Number of grains per row of QPM was significantly superior over popcorn and sweet corn. Green cob yield of sweet corn was significantly high and higher and lower grain yields were recorded with QPM and popcorn respectively. Likewise, sweet corn produced maximum green fodder yield compared to stover yield of QPM and popcorn.

KEYWORDS: Biofortification, popcorn, speciality corn, sweet corn, QPM, Zinc

INTRODUCTION

Maize (*Zea mays L.*) is emerging as third important cereal crop in the world after wheat and rice. It is called as "Queen of Cereals" due to the high productiveness, ease to process, low cost than other cereals (Jaliya *et al.*, 2008), besides serving as human food and animal feed with wide industrial application.

Speciality corn such as popcorn and sweet corn are popular snack foods whereas Quality Protein Maize (QPM) is important since it is enriched with tryptophan and lysine which provide nutritious food and feed for poultry, cattle. It also forms the basis as food material for poor people particularly for those with maize as staple food, thereby providing food and nutritional security.

Continuous intensive cropping of high yielding crop varieties has further aggravated the depletion of soil zinc leading to low zinc concentration in edible grains. Biofortification is a process in which plants are allowed to take up the minerals (Zn) from the soils and immobilize them in the grains so as to produce nutritionally rich grains that support dietary requirement of humans. Maize is high nutrient demanding crop but sensitive to zinc (Zn) deficiency in soil. Zinc deficiency in crops is the common problem world over; therefore, zinc malnutrition has become a major health burden among the resource poor people (Singh and Sampath, 2011). Application of Zn fertilizers could be a viable option to fulfill the crop demand for Zn and also to increase its content in grains. A field experiment was formulated to study the influence of soil and foliar applied Zn on the growth and yield of the speciality corn.

MATERIAL AND METHODS

A field experiment entitled "Biofortification with zinc in Speciality corn" was conducted during *kharif* 2013 at Maize Research Centre, Acharya N.G Ranga Agricultural University, Rajendranagar, Hyderabad, Andhra Pradesh. The experimental soil was sandy loam in texture with pH (8.2), EC (0.56 dS m^{-1}) and OC (0.42 %). The soil was low in available nitrogen (196 kg ha^{-1}), high in phosphorus (31.21 kg ha^{-1}), high in potassium (201 kg ha^{-1}) and deficient in zinc (0.62 ppm).

The experiment was laid out in a Randomized Block Design and replicated thrice. The treatments comprised of three Speciality corn *viz.,* Popcorn, Sweet corn, QPM and six zinc levels *viz.,* Zn_0: Control (only recommended dose of fertilizer), Zn_1: 12.5 kg $ZnSO_4$ ha^{-1} as Soil

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application, Zn_2: 25 kg $ZnSO_4$ ha^{-1} as Soil application, Zn_3:Zn_1 + 2 Foliar sprays at tasseling and milking stage ($ZnSO_4$ application @ 2g l^{-1} of water), Zn_4:Zn_2 + 2 Foliar sprays at tasseling and milking stage ($ZnSO_4$ application @ 2g l^{-1} of water), Zn_5: 2 Foliar sprays ($ZnSO_4$ application @ 2g l^{-1} of water) at tasseling and milking stage. A uniform dose of NPK (180 kg N – 60 kg P_2O_5 – 50 kg K_2O ha^{-1}) as per the recommendation was applied to all the treatments.

RESULTS AND DISCUSSION

Growth parameters

The results revealed that different levels of zinc in speciality corn significantly influenced the growth parameters such as plant height, LAI and dry matter production. Higher plant height in QPM was observed which was significantly superior over the plant height obtained with Popcorn and Sweet corn. Significant increase in plant height with different levels of 'Zn' along with RDF was probably due to cell and internodal elongation, plant metabolism, there by promoting vegetative growth which is positively correlated to the productive potentiality of plant which corroborates with the results of Masood *et al.* (2011). Soil application of $ZnSO_4$ @ 25 kg ha^{-1} along with two foliar sprays at tasseling and milking stages recorded maximum plant height which was superior over all other zinc treatments. Similarly taller plants in QPM might be due to inherent genetic potential of hybrid which outperformed both Sweet corn and Popcorn (Table 1).

QPM had shown higher LAI which was significantly superior over sweet corn and popcorn. Among the varied zinc levels soil application of 25 kg $ZnSO_4$ ha^{-1} along with two foliar sprays at tasseling and milking stage had significantly produced larger leaf area index. The increase in LAI could be attributed to significant increase in leaf expansion (length and breadth), high rate of cell division and cell enlargement, rapid growth and there by improved quality of vegetative growth due to applied Zn fertilizers along with RDF, which corroborates with the results of Jat *et al.* (2010) and Bisht *et al.* (2012).

Among the three types of corn the dry matter production was significantly higher with sweet corn with higher dose of zinc (Zn_4: 25 kg $ZnSO_4$ ha^{-1} as soil application+ two foliar sprays at tasseling and milking stage) compared to QPM and Popcorn. Higher dry matter production with three different types of speciality corn and zinc could be attributed to enhanced plant height, leaf area index and photosynthates accumulation, thereby improving the plant vigor due to source-sink relationship. These findings are in conformity with those of Tetarwal *et al.* (2011) and Ravi *et al.* (2012).

Flowering was delayed with zinc fertilization. Among the three speciality corns, sweet corn attained tasseling and silking 10-11 days earlier compared to popcorn and QPM. Among zinc levels, days to 50% flowering was found earlier (7-8 days) in no zinc treatment compared to the higher dose of zinc (Zn_4: 25 kg $ZnSO_4$ ha^{-1} as Soil application+ two foliar sprays at tasseling and milking stage).

Yield and Yield attributes

Yield attributes such as number of cobs ha^{-1}, cob length and cob girth obtained with sweet corn was significantly superior over QPM and popcorn. Number of grain rows per cob of popcorn was superior over QPM and sweet corn. Number of grains per row of QPM was significantly superior over popcorn and sweet corn (Table 2). Soil application of 25 kg $ZnSO_4$ ha^{-1} along with two foliar sprays at tasseling and milking stage had significantly produced longer cobs compared to all other zinc treatments. The use of both macro and micro nutrients often results in synergism and improvement of nutrient use efficiency which leads to better cob size. These findings are similar with the findings of Ravi *et al.* (2012).

Green cob yield of sweet corn increased significantly due to increased moisture content. Maximum green cob yield was recorded with sweet corn, while the higher and lower grain yield of was recorded with QPM and popcorn respectively. The higher yield was produced with Zn_4, while lower yield was recorded with Zn_0. Speciality corn and zinc has beneficial effect on physiological process, plant metabolism, growth, there by leading to higher grain or green cob yield. The nutrients also enhance the carbohydrates supply to kernels, increasing yield components such as cob length, cob girth and number of grains row^{-1}, which have direct influence on grain yield and green cob yield. Similar results were reported by Pokharel *et al.* (2009) and Kien *et al.* (2009).

Among three speciality corns sweet corn produced higher green fodder yield and registered higher and lower stover yield with QPM and Popcorn respectively. Application of higher dose of Zinc (Zn_4) produced higher yield, followed by Zn_2 and Zn_0 gave the lower stover yield.

Table 1. Growth parameters of maize as influenced by soil and foliar applied zinc

Treatments	Plant height (cm)	Leaf area index (LAI)	Dry matter production (kg ha^{-1})	Days to 50% tasseling	Days to 50% silking
Speciality corn types					
Popcorn	184.11	1.701	7842	49	55
Sweet corn	181.52	2.028	9372	38	45
QPM	199.43	4.133	8703	54	60
CD (P = 0.05)	11.44	0.151	279	3	4
Zinc levels					
Zn_0 (Control, only recommended dose of fertilizer)	180.44	2.177	8122	44	49
Zn_1 (12.5 kg $ZnSO_4$ ha^{-1} asSoil application)	185.94	2.272	8464	46	52
Zn_2 (25 kg $ZnSO_4$ ha^{-1} as Soil application)	195.86	2.891	9176	50	56
Zn_3 (Zn_1 + 2 Foliar sprays at tasseling and milking stage)	187.42	2.783	8553	47	53
Zn_4 (Zn_2 + 2 Foliar sprays at tasseling and milking stage)	197.24	3.416	9255	51	57
Zn_5 (2 Foliar sprays at tasseling and milking stage)	183.23	2.184	8264	45	51
CD (P = 0.05)	NS	0.214	394	4	6

Table 2. Number of cobs ha^{-1}, cob length (cm) and cob girth (cm) as influenced by different types of corn and zinc levels

Treatments	Number of cobs ('000 ha^{-1})	Cob length (cm)	Cob girth (cm)	Number of grain rows cob^{-1}	Number of grains row^{-1}
Speciality corn types					
Popcorn	39.29	17.36	8.92	14.06	38.45
Sweet corn	45.31	17.75	12.35	12.94	29.59
QPM	42.54	16.66	10.93	13.45	36.21
CD (P = 0.05)	0.44	NS	0.15	NS	0.18
Zinc levels					
Zn_0 (Control, only recommended dose of fertilizer)	39.58	16.10	9.97	12.77	32.44
Zn_1 (12.5 kg $ZnSO_4$ ha^{-1} asSoil application)	41.60	16.86	10.51	13.13	33.84
Zn_2 (25 kg $ZnSO_4$ ha^{-1} as Soil application)	44.42	18.30	11.41	14.26	36.86
Zn_3 (Zn_1 + 2 Foliar sprays at tasseling and milking stage)	42.36	17.30	10.70	13.36	34.49
Zn_4 (Zn_2 + 2 Foliar sprays at tasseling and milking stage)	45.47	18.50	11.56	14.36	37.63
Zn_5 (2 Foliar sprays at tasseling and milking stage)	40.77	16.50	10.26	13.02	33.23
CD (P = 0.05)	0.62	1.69	0.22	NS	0.25

Higher stover yield or green fodder yield among speciality corn and zinc were due to higher plant height, LAI, dry matter accumulation, more nutrient availability and uptake by speciality corn. These results are in conformity with the results of Septa and Kumar (2007) and Singh and Nepalia (2009).

Harvest index of sweet corn increased due to increased moisture content. Maximum harvest index was recorded with sweet corn, while the higher and lower harvest index was recorded with QPM and popcorn respectively. The higher harvest index was produced with Zn_4, while lower harvest index was recorded with Zn_0. Similar results were reported by Arif *et al.* (2010) and Rani *et al*. (2013).

CONCLUSION

Soil application of 25 kg $ZnSO_4$ ha^{-1} along with 2 foliar sprays at tasseling and milking stage (Zn_4) recorded higher growth and yield but it was on par with soil applied 25 kg $ZnSO_4$ ha^{-1} (Zn_2). Among the three types of corn (Popcorn, Sweet corn and QPM) tested, Sweet corn and QPM registered higher growth and yield compared to Popcorn. For southern Telangana zone of Telangana state sweet corn is better with a soil application of 25 kg $ZnSO_4$ along with two foliar sprays.

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EFFECT OF ZINC FERTILIZER DOSAGES ON GROWTH AND YIELD OF SPECIALITY CORN

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ABSTRACT

A field experiment entitled "Biofortification of Speciality corn with zinc" was conducted on sandy loam soils of Maize Research Center, Agricultural Research Institute, Rajendranagar during *kharif*, 2013 to study the effect of zinc nutrition in speciality corn. The experiment comprised of 18 treatments *viz.,* combination of three types of speciality corn [Popcorn, Sweet corn and Quality protein maize (QPM)] and six zinc levels [both soil and foliar application). The results revealed that three different types of corn and zinc levels significantly influenced growth parameters such as plant height, leaf area index(LAI), dry matter production and yield attributes such as cob number, number of grains per cob, cob girth and yield. Better growth and yield was registered with 25 kg $ZnSO_4$ ha^{-1}as soil application along with two foliar sprays i.e. at tasseling and milking stage. Sweet corn registered significantly higher number of cobs, longer cobs and maximum cob girth compared to QPM and popcorn. Number of grain rows per cob of popcorn was superior to QPM and sweet corn. Number of grains per row of QPM was significantly superior over popcorn and sweet corn. Green cob yield of sweet corn was significantly high and higher and lower grain yields were recorded with QPM and popcorn respectively. Likewise, sweet corn produced maximum green fodder yield compared to stover yield of QPM and popcorn.

KEYWORDS: Biofortification, popcorn, speciality corn, sweet corn, QPM, Zinc

INTRODUCTION

Maize (*Zea mays L.*) is emerging as third important cereal crop in the world after wheat and rice. It is called as "Queen of Cereals" due to the high productiveness, ease to process, low cost than other cereals (Jaliya *et al.*, 2008), besides serving as human food and animal feed with wide industrial application.

Speciality corn such as popcorn and sweet corn are popular snack foods whereas Quality Protein Maize (QPM) is important since it is enriched with tryptophan and lysine which provide nutritious food and feed for poultry, cattle. It also forms the basis as food material for poor people particularly for those with maize as staple food, thereby providing food and nutritional security.

Continuous intensive cropping of high yielding crop varieties has further aggravated the depletion of soil zinc leading to low zinc concentration in edible grains. Biofortification is a process in which plants are allowed to take up the minerals (Zn) from the soils and immobilize them in the grains so as to produce nutritionally rich grains that support dietary requirement of humans. Maize is high nutrient demanding crop but sensitive to zinc (Zn) deficiency in soil. Zinc deficiency in crops is the common problem world over; therefore, zinc malnutrition has become a major health burden among the resource poor people (Singh and Sampath, 2011). Application of Zn fertilizers could be a viable option to fulfill the crop demand for Zn and also to increase its content in grains. A field experiment was formulated to study the influence of soil and foliar applied Zn on the growth and yield of the speciality corn.

MATERIAL AND METHODS

A field experiment entitled "Biofortification with zinc in Speciality corn" was conducted during *kharif* 2013 at Maize Research Centre, Acharya N.G Ranga Agricultural University, Rajendranagar, Hyderabad, Andhra Pradesh. The experimental soil was sandy loam in texture with pH (8.2), EC (0.56 dS m^{-1}) and OC (0.42 %). The soil was low in available nitrogen (196 kg ha^{-1}), high in phosphorus (31.21 kg ha^{-1}), high in potassium (201 kg ha^{-1}) and deficient in zinc (0.62 ppm).

The experiment was laid out in a Randomized Block Design and replicated thrice. The treatments comprised of three Speciality corn *viz.,* Popcorn, Sweet corn, QPM and six zinc levels *viz.,* Zn_0: Control (only recommended dose of fertilizer), Zn_1: 12.5 kg $ZnSO_4$ ha^{-1} as Soil

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application, Zn_2: 25 kg $ZnSO_4$ ha^{-1} as Soil application, Zn_3:Zn_1 + 2 Foliar sprays at tasseling and milking stage ($ZnSO_4$ application @ 2g l^{-1} of water), Zn_4:Zn_2 + 2 Foliar sprays at tasseling and milking stage ($ZnSO_4$ application @ 2g l^{-1} of water), Zn_5: 2 Foliar sprays ($ZnSO_4$ application @ 2g l^{-1} of water) at tasseling and milking stage. A uniform dose of NPK (180 kg N – 60 kg P_2O_5 – 50 kg K_2O ha^{-1}) as per the recommendation was applied to all the treatments.

RESULTS AND DISCUSSION

Growth parameters

The results revealed that different levels of zinc in speciality corn significantly influenced the growth parameters such as plant height, LAI and dry matter production. Higher plant height in QPM was observed which was significantly superior over the plant height obtained with Popcorn and Sweet corn. Significant increase in plant height with different levels of 'Zn' along with RDF was probably due to cell and internodal elongation, plant metabolism, there by promoting vegetative growth which is positively correlated to the productive potentiality of plant which corroborates with the results of Masood *et al.* (2011). Soil application of $ZnSO_4$ @ 25 kg ha^{-1} along with two foliar sprays at tasseling and milking stages recorded maximum plant height which was superior over all other zinc treatments. Similarly taller plants in QPM might be due to inherent genetic potential of hybrid which outperformed both Sweet corn and Popcorn (Table 1).

QPM had shown higher LAI which was significantly superior over sweet corn and popcorn. Among the varied zinc levels soil application of 25 kg $ZnSO_4$ ha^{-1} along with two foliar sprays at tasseling and milking stage had significantly produced larger leaf area index. The increase in LAI could be attributed to significant increase in leaf expansion (length and breadth), high rate of cell division and cell enlargement, rapid growth and there by improved quality of vegetative growth due to applied Zn fertilizers along with RDF, which corroborates with the results of Jat *et al.* (2010) and Bisht *et al.* (2012).

Among the three types of corn the dry matter production was significantly higher with sweet corn with higher dose of zinc (Zn_4: 25 kg $ZnSO_4$ ha^{-1} as soil application+ two foliar sprays at tasseling and milking stage) compared to QPM and Popcorn. Higher dry matter production with three different types of speciality corn and zinc could be attributed to enhanced plant height, leaf area index and photosynthates accumulation, thereby improving the plant vigor due to source-sink relationship. These findings are in conformity with those of Tetarwal *et al.* (2011) and Ravi *et al.* (2012).

Flowering was delayed with zinc fertilization. Among the three speciality corns, sweet corn attained tasseling and silking 10-11 days earlier compared to popcorn and QPM. Among zinc levels, days to 50% flowering was found earlier (7-8 days) in no zinc treatment compared to the higher dose of zinc (Zn_4: 25 kg $ZnSO_4$ ha^{-1} as Soil application+ two foliar sprays at tasseling and milking stage).

Yield and Yield attributes

Yield attributes such as number of cobs ha^{-1}, cob length and cob girth obtained with sweet corn was significantly superior over QPM and popcorn. Number of grain rows per cob of popcorn was superior over QPM and sweet corn. Number of grains per row of QPM was significantly superior over popcorn and sweet corn (Table 2). Soil application of 25 kg $ZnSO_4$ ha^{-1} along with two foliar sprays at tasseling and milking stage had significantly produced longer cobs compared to all other zinc treatments. The use of both macro and micro nutrients often results in synergism and improvement of nutrient use efficiency which leads to better cob size. These findings are similar with the findings of Ravi *et al.* (2012).

Green cob yield of sweet corn increased significantly due to increased moisture content. Maximum green cob yield was recorded with sweet corn, while the higher and lower grain yield of was recorded with QPM and popcorn respectively. The higher yield was produced with Zn_4, while lower yield was recorded with Zn_0. Speciality corn and zinc has beneficial effect on physiological process, plant metabolism, growth, there by leading to higher grain or green cob yield. The nutrients also enhance the carbohydrates supply to kernels, increasing yield components such as cob length, cob girth and number of grains row^{-1}, which have direct influence on grain yield and green cob yield. Similar results were reported by Pokharel *et al.* (2009) and Kien *et al.* (2009).

Among three speciality corns sweet corn produced higher green fodder yield and registered higher and lower stover yield with QPM and Popcorn respectively. Application of higher dose of Zinc (Zn_4) produced higher yield, followed by Zn_2 and Zn_0 gave the lower stover yield.

Table 1. Growth parameters of maize as influenced by soil and foliar applied zinc

Treatments	Plant height (cm)	Leaf area index (LAI)	Dry matter production (kg ha^{-1})	Days to 50% tasseling	Days to 50% silking
Speciality corn types					
Popcorn	184.11	1.701	7842	49	55
Sweet corn	181.52	2.028	9372	38	45
QPM	199.43	4.133	8703	54	60
CD (P = 0.05)	11.44	0.151	279	3	4
Zinc levels					
Zn_0 (Control, only recommended dose of fertilizer)	180.44	2.177	8122	44	49
Zn_1 (12.5 kg $ZnSO_4$ ha^{-1} asSoil application)	185.94	2.272	8464	46	52
Zn_2 (25 kg $ZnSO_4$ ha^{-1} as Soil application)	195.86	2.891	9176	50	56
Zn_3 (Zn_1 + 2 Foliar sprays at tasseling and milking stage)	187.42	2.783	8553	47	53
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Zn_5 (2 Foliar sprays at tasseling and milking stage)	183.23	2.184	8264	45	51
CD (P = 0.05)	NS	0.214	394	4	6

Table 2. **Number of cobs ha^{-1}, cob length (cm) and cob girth (cm) as influenced by different types of corn and zinc levels**

Treatments	Number of cobs ('000 ha^{-1})	Cob length (cm)	Cob girth (cm)	Number of grain rows cob^{-1}	Number of grains row^{-1}
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Popcorn	39.29	17.36	8.92	14.06	38.45
Sweet corn	45.31	17.75	12.35	12.94	29.59
QPM	42.54	16.66	10.93	13.45	36.21
CD (P = 0.05)	0.44	NS	0.15	NS	0.18
Zinc levels					
Zn_0 (Control, only recommended dose of fertilizer)	39.58	16.10	9.97	12.77	32.44
Zn_1 (12.5 kg $ZnSO_4$ ha^{-1} asSoil application)	41.60	16.86	10.51	13.13	33.84
Zn_2 (25 kg $ZnSO_4$ ha^{-1} as Soil application)	44.42	18.30	11.41	14.26	36.86
Zn_3 (Zn_1 + 2 Foliar sprays at tasseling and milking stage)	42.36	17.30	10.70	13.36	34.49
Zn_4 (Zn_2 + 2 Foliar sprays at tasseling and milking stage)	45.47	18.50	11.56	14.36	37.63
Zn_5 (2 Foliar sprays at tasseling and milking stage)	40.77	16.50	10.26	13.02	33.23
CD (P = 0.05)	0.62	1.69	0.22	NS	0.25

Higher stover yield or green fodder yield among speciality corn and zinc were due to higher plant height, LAI, dry matter accumulation, more nutrient availability and uptake by speciality corn. These results are in conformity with the results of Septa and Kumar (2007) and Singh and Nepalia (2009).

Harvest index of sweet corn increased due to increased moisture content. Maximum harvest index was recorded with sweet corn, while the higher and lower harvest index was recorded with QPM and popcorn respectively. The higher harvest index was produced with Zn_4, while lower harvest index was recorded with Zn_0. Similar results were reported by Arif *et al.* (2010) and Rani *et al*. (2013).

CONCLUSION

Soil application of 25 kg $ZnSO_4$ ha^{-1} along with 2 foliar sprays at tasseling and milking stage (Zn_4) recorded higher growth and yield but it was on par with soil applied 25 kg $ZnSO_4$ ha^{-1} (Zn_2). Among the three types of corn (Popcorn, Sweet corn and QPM) tested, Sweet corn and QPM registered higher growth and yield compared to Popcorn. For southern Telangana zone of Telangana state sweet corn is better with a soil application of 25 kg $ZnSO_4$ along with two foliar sprays.

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EVALUATION OF CERTAIN INSECTICIDES FOR THE MANAGEMENT OF SAFFLOWER INSECT PESTS UNDER FIELD CONDITIONS

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ABSTRACT

A field experiment on bioefficacy of newer insecticides against the important insect pests was conducted using three systemic and three contact insecticides along with untreated check (UTC). The results revealed that the treatment with thiamethoxam 25 WG @ 0.2 g/l recorded 10.48 aphids/5 cm top shoot length (83.85% reduction over UTC). Management with respect to capsule borer and the safflower caterpillar chlorantraniliprole 20 SC @ 0.15 ml/l was superior with mean larval population of 0.84 larvae/plant and 0.77 larvae/plant (82.90 and 82.53% reduction over UTC, respectively). Highest benefit cost ratio was obtained in chlorantraniliprole 20 SC @ 0.15 ml/lit (2.85) followed by thiamethoxam 25 WG @ 0.2 g/l (2.81), buprofezin 50 SC @ 0.2 ml/l (2.51) and emamectin benzoate 5 SG @ 0.2 g/l (2.47).

KEYWORDS: Bioefficacy, safflower, pest

Safflower (*Carthamus tinctorius* Linn.) is a multipurpose oil seed crop with unexploited potential and world adaptability. Traditionally, the crop was grown for its seeds and flower petals used for colouring and flavouring foods. For the last fifty years, the safflower crop has been cultivated mainly for the vegetable oil extracted from its seeds. All the parts of the plant find useful applications in herbal medicine specifically in preparations to treat physical disorders. Safflower produces oil rich in polyunsaturated fatty acids which play an important role in reducing blood cholesterol level and is considered as a healthy cooking medium.

Although the crop is known for its tolerance to moisture stress conditions, the area is being drastically reduced over the years. Among the several factors that are responsible for reduction in area and production insect pests contribute a major share. A total of 101 insects have been recorded on safflower throughout the world. However, in India as many as 75 insect species have been reported by Basavangoud (1979) while Parlekar (1987) has enlisted 36 insect species in Maharastra state. In Karnataka, 20 insect pests have been recorded on safflower along with nine species of natural enemies. Narayanan (1961) has recorded few caterpillar pests and aphids as serious pests among many insects that infest safflower crop. Twenty three insect pests in safflower ecosystem have been recorded in Vijayapur and Dharwad district among which aphid, capsule borer and the safflower caterpillar were the major insect pests.

MATERIAL AND METHODS

To know the bio efficacy of new insecticide molecules to aphids, capsule borer and the safflower caterpillar a field experiment was conducted at Regional Agricultural Research Station (RARS), Vijayapur during *rabi* 2015-2016. The experiment was laid out in Randomized Complete Block Design (RCBD) in three replications with six treatments and a control. The size of each plot was 17.64 m^2 (4.2 m x 4.2 m). The crop was raised using A-1 variety of safflower with a spacing of 60cm x 30cm by adopting recommended agronomical practices except for insect pest control. Three systemic and three safer contact insecticides were selected along with one untreated check. After spraying the systemic insecticides, the crop was sprayed with recommended contact insecticides for lepidopteran insect as blanket spray, similarly after spraying three contact insecticides; recommended systemic insecticide was sprayed for aphid control (Table 1).

The aphid count was recorded by counting the number of aphids per five cm top shoot length. The capsule borer and leaf eating caterpillar count was recorded by counting the number of larvae per plant and later the data was subjected to $\sqrt{X + 0.5}$ transformation

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before statistical analysis. Per cent larval reduction was subjected to arc sine transformation before statistical analysis. Further, yield data was computed to quintals per hectare.

RESULTS AND DISCUSSION

The efficacy of the insecticides to important insect pests *i.e.* aphids, leaf eating caterpillars and capsule borer was studied and the results are elucidated here under.

Safflower aphid *Uroleucon compositae* (Theobald)

No statistically significant difference between the treatments with respect to mean number of aphids per five cm shoot length were observed in pre counts that were taken a day before spraying (Table 1).

At three Days After Spray (3DAS), there was a significant difference among the treatments where the population ranged between 5.43 to 72.83 aphids per five cm shoot length. The plots sprayed with thiamethoxam 25 WG @ 0.2 g/l recorded least number of aphids (5.43 aphid/five cm shoot length) which was on par with buprofezin 50 SC @ 0.25 ml/l (10.43 aphids/five cm shoot length) and spinetoram 12 SC @ 0.2 ml/l (11.50 aphids/ five cm shoot length). The plots sprayed with emamectin benzoate 5 SG @ 0.2 g/l recorded highest number of aphids per plant (39.67 aphids/five cm shoot length). While, plots sprayed with spinosad 45 SC @ 0.15 ml/l recorded (33.17 aphids/ five cm shoot length) which was statistically on par with chlorantraniliprole 20 SC @ 0.15 ml/l (29.83 aphids/five cm shoot length). With respect to per cent aphid population reduction, at three days after spraying (3DAS) the highest reduction of aphid population (92.56 %) was recorded in plots treated with thiamethoxam 25 WG @ 0.2 ml/l followed by buprofezin 50 SC@ 0.2 ml/l (85.71%) and spinetoram 12 SC @ 0.2 ml/l (84.18%). Similar trend was also observed for the remaining observations

At seven DAS, a similar trend in the efficacy of insecticides was observed where the aphid population ranged from 7.83 to 75.83 per five cm top shoot length. Least number of aphids was recorded in plots treated with thiamethoxam 25 WG @ 0.2 g/l (7.83 aphids / five cm shoot length) and buprofezin 50 SC @ 0.25 ml/l (15.70 aphids / five cm shoot length) which were on par with each other. Next best treatment was spinetoram 12 SC @ 0.2 ml/l (14.93 aphids / five cm shoot length). Similarly, highest aphid population was recorded in plots treated with emamectin benzoate 5 SG @ 0.2 g/ l (48.73 aphids/ five cm top shoot length) followed by spinosad 45 SC @ 0.15 ml/l (36.17 aphids/ five cm top shoot length) and chlorantraniliprole 20 SC @ 0.15 ml/l (34.23 aphids/ five cm top shoot length). The highest per cent reduction in aphid population (89.69%) was recorded in the plots sprayed with thiamethoxam 25 WG @ 0.2 ml/l followed by spinetoram 12 SC @ 0.2 ml/l (80.26%) and buprofezin 50 SC @ 0.25 ml/l (79.48%). Least per cent reduction (35.59%) in aphid population were recorded in plots sprayed with emamectin benzoate 5 SG @ 0.2 g/l.

At 10 and 15 DAS, a similar trend in efficacy of insecticides was observed where, thiamethoxam 25 WG @ 0.2 ml/l, buprofezin 50 SC @ 0.25 ml/l and spinetoram 12 SC @ 0.2 ml/l sprayed plots recorded least population of aphids. Whereas, highest aphid population was recorded in plots sprayed with emamectin benzoate 5 SG @ 0.2 g/l, spinosad 45 SC @ 0.15 ml/l and chlorantraniliprole 20 SC @ 0.15 ml/l.

Similar results were also observed by Hanumantharaya *et al.* (2007), who reported that thiamethoxam was the most effective (97% kill) and economic insecticide against safflower aphids.

Safflower capsule borer, *Helicoverpa armigera* (Hub)

No statistically significant difference between the treatments with respect to mean number of of larvae per plant were observed in pre counts that were taken a day before spraying (Table 2). The larval population in different treatments were uniform and ranged from 3.43 to 3.91 per plant (Table 2).

At three DAS, there was a significant difference among the treatments where the population of larvae ranged from 1.53 to 5.30 larvae per plant. The plots sprayed with chlorantraniliprole 20 SC @ 0.15 ml/l recorded least larval population (1.53 larvae/ plant) which was on par with emamectin benzoate 5 SG 0.2 g/l (1.92 larvae/plant) and spinosad 45 SC @ 0.15 ml/l (3.01 larvae/ plant) sprayed plots. With respect to per cent larval reduction, highest reduction of larval population (71.41%) was also recorded in plots sprayed with chlorantraniliprole 20 SC @ 0.15 ml/l followed by emamectin benzoate 5 SG @ 0.2 g/l (61.99%) and spinosad 45 SC @ 0.15 ml/l (43.20%) which were on par with each other.

At seven DAS, the larval population ranged from 0.85 to 4.97 per plant. Least number of larvae were

Table 1. Bio-efficacy of certain new insecticides against safflower aphid, *Uroleucon compositae* (Theobald) under field condition

T. No.	Treatments	Dose ml/gm/l	Number aphids/5 cm top shoot length*						Per cent reduction over UTC**				
			1 DBS	3 DAS	7 DAS	10 DAS	15 DAS	Mean	3 DAS	7 DAS	10 DAS	15 DAS	Mean
1	Buprofezin 50SC	0.25	49.33 (7.06)	10.43 $(3.27)^a$	15.70 $(3.25)^a$	17.83 $(4.23)^a$	28.33 $(5.32)^a$	18.08 $(4.02)^a$	85.71 (67.78)	79.48 (63.01)	74.36 (59.54)	45.04 (42.10)	71.15 (57.56)
2	Thiamethoxam 25WG	0.2	47.67 (6.93)	5.43 $(2.43)^a$	7.83 $(3.57)^a$	9.00 $(3.06)^a$	19.67 $(4.47)^a$	10.48 $(3.38)^a$	92.56 (74.15)	89.69 (71.19)	87.16 (68.95)	65.99 (54.27)	83.85 (66.28)
3	Spinetoram 12 SC	0.2	52.33 (7.27)	11.50 $(3.46)^a$	14.93 $(3.93)^b$	20.03 $(4.51)^a$	29.67 $(5.38)^a$	19.03 $(4.32)^a$	84.18 (9.20)	80.26 (63.58)	71.63 (57.80)	47.26 (43.39)	70.83 (57.29)
4	Emamectin benzoate 5SG	0.2	53.00 (7.31)	39.67 $(6.34)^c$	48.73 $(7.02)^c$	37.33 $(6.11)^b$	45.33 $(6.77)^c$	42.77 $(6.56)^b$	45.53 (42.42)	35.59 (36.57)	47.58 (6.91)	27.72 (31.76)	39.10 (38.69)
5	Spinosad 45 SC	0.15	47.67 (6.94)	33.17 $(5.79)^b$	36.17 $(4.89)^c$	27.33 $(5.21)^b$	34.33 $(5.89)^b$	32.75 $(5.45)^c$	54.25 (47.41)	52.24 (46.26)	61.13 (51.41)	43.68 (41.32)	52.83 (46.61)
6	Chlorantraniliprole 20 SC	0.15	44.33 (6.66)	29.83 $(5.51)^c$	34.23 $(4.92)^c$	25.27 $(5.07)^b$	31.56 $(5.66)^b$	30.00 $(5.29)^c$	59.07 (50.18)	55.02 (47.87)	64.04 (53.13)	54.82 (47.75)	58.24 (43.72)
7	Un treated check	-	48.33 (6.97)	72.83 $(8.57)^d$	75.83 $(6.40)^d$	70.67 $(8.43)^c$	63.33 $(7.99)^d$	70.67 $(7.85)^d$	-	-	-	-	-
	S.Em ±		-	0.46	0.45	0.42	0.39	0.51	4.78	4.79	4.78	4.17	4.21
	CD @ 5 %		NS	1.36	1.30	1.23	1.13	1.48	13.95	13.98	13.95	12.16	12.28
	CV (%)		-	15.92	16.65	13.47	11.38	16.03	16.61	17.66	16.61	19.38	16.45

Note:

NS – Non Significant. DBS – Day Before Spray, DAS – Days After Spray. UTC : Un treated Check

In a column, means followed by a same letter are not significantly different at p = 0.05 by Duncan's Multiple Range Test (DMRT)

* Figures in the parentheses are subjected to $(\sqrt{X + 0.5})$ transformed values. ** Figures in parentheses are arc sin transformed values.

Table 2. Bio-efficacy of certain new insecticides against safflower capsule borer, *Helicoverpa armigera* (Hub) under field condition

T. No.	Treatments	Dose (ml or g/l)	Number of larvae/plant*						Per cent reduction over UTC**				
			1 DBS	3 DAS	7 DAS	10 DAS	15 DAS	Mean	3 DAS	7 DAS	10 DAS	15 DAS	Mean
1	Buprofezin 50SC	0.25	3.91 (2.10)	3.67 (2.04)^{b}	2.20 (1.64)^{b}	3.40 (1.97)^{b}	3.80 (2.07)^{b}	3.26 (1.94)^{b}	35.81 (36.74)	55.73 (48.27)	20.40 (25.02)	24.00 (29.33)	33.98 (35.64)
2	Thiamethoxam 25WG	0.2	3.60 (2.02)	3.53 (2.00)^{b}	3.47 (1.99)^{b}	3.27 (1.94)^{b}	3.20 (1.92)^{b}	3.37 (1.96)^{b}	33.62 (35.37)	30.24 (33.34)	23.95 (28.78)	36.00 (36.87)	30.95 (33.78)
3	Spinetoram 12 SC	0.2	3.89 (2.10)	3.83 (2.08)^{b}	3.73 (2.06)^{b}	3.57 (2.02)^{b}	3.67 (2.04)^{b}	3.70 (2.05)^{b}	26.90 (30.31)	24.72 (29.76)	19.27 (25.05)	26.67 (31.05)	24.39 (29.31)
4	Emamectin benzoate 5SG	0.2	3.43 (1.95)	1.92 (1.56)^{a}	0.85 (1.16)^{a}	0.13 (0.79)^{a}	1.05 (1.24)^{a}	0.98 (1.22)^{a}	61.99 (51.92)	80.54 (63.80)	97.07 (80.11)	79.00 (62.72)	79.65 (63.16)
5	Spinosad 45 SC	0.1	3.77 (2.07)	3.01 (1.87)^{a}	1.92 (1.56)^{a}	0.94 (1.20)^{a}	1.23 (1.32)^{a}	1.77 (1.51)^{a}	43.20 (41.08)	61.36 (51.55)	78.48 (62.34)	72.23 (58.18)	63.81 (53.00)
6	Chlorantraniliprole 20 SC	0.15	3.50 (2.00)	1.53 (1.41)^{a}	0.93 (1.20)^{a}	0.70 (1.09)^{a}	0.20 (0.84)^{a}	0.84 (1.16)^{a}	71.41 (58.10)	81.11 (64.28)	83.10 (66.06)	96.00 (78.46)	82.90 (65.56
7	Untreated check	-	3.87 (2.09)	5.30 (2.41)^{c}	4.97 (2.34)^{c}	4.37 (2.20)^{c}	4.43 (2.22)^{c}	5.05 (2.36)^{c}	-	-	-	-	-
	S.Em ±		-	0.14	0.15	0.19	0.17	0.19	3.76	3.28	3.23	2.65	3.82
	CD @ 5 %		NS	0.41	0.43	0.55	0.49	0.54	10.99	9.59	9.44	7.73	11.16
	CV (%)		-	14.11	14.33	17.40	15.14	17.49	17.94	15.60	16.45	10.89	17.81

Note:

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In a column, means followed by a same letter are not significantly different at p = 0.05 by Duncan's Multiple Range Test (DMRT)

* Figures in the parentheses are subjected to $(\sqrt{X + 0.5})$ transformed values. ** Figures in parentheses are arc sin transformed values.

Table 3. Bio-efficacy of newer insecticides against safflower leaf eating caterpillar, *Perigia capensis* (Guen) under field condition

T. No.	Treatments	Dose (ml or gm/l)	Number of larvae/plant*						Per cent reduction over UTC**				
			1 DBS	3 DAS	7 DAS	10 DAS	15 DAS	Mean	3 DAS	7 DAS	10 DAS	15 DAS	Mean
1	Buprofezin 50 SC	0.25	3.00 (1.87)	1.93 $(1.56)^b$	2.37 $(1.69)^b$	2.57 $(1.75)^b$	2.99 $(1.87)^b$	2.46 $(1.72)^b$	50.22 (45.10)	61.02 (51.35)	59.47 (50.42)	24.11 (29.40)	48.70 (44.24)
2	Thiamethoxam 25 WG	0.20	3.20 (1.92)	2.47 $(1.72)^b$	2.80 $(1.81)^b$	3.13 $(1.91)^b$	3.36 $(1.96)^b$	2.94 $(1.85)^b$	36.47 (37.11)	53.91 (47.24)	50.63 (45.34)	14.72 (22.55)	38.93 (38.59)
3	Spinetoram 12 SC	0.20	3.23 (1.93)	2.33 $(1.68)^b$	2.53 $(1.74)^b$	2.73 $(1.80)^b$	3.04 $(1.88)^b$	2.65 $(1.77)^b$	39.75 (39.06)	58.14 (49.66)	57.01 (49.02)	22.84 (28.54)	44.43 (41.79)
4	Emamectin benzoate 5 SG	0.20	3.27 (1.94)	0.77 $(1.12)^a$	0.91 $(1.19)^a$	1.60 $(1.45)^a$	1.91 $(1.55)^a$	1.29 $(1.34)^a$	80.63 (63.87)	85.00 (67.21)	74.84 (59.87)	51.52 (45.85)	72.99 (58.66)
5	Spinosad 45 SC	0.15	3.00 (1.87)	1.03 $(1.24)^a$	1.31 $(1.35)^a$	1.53 $(1.42)^a$	1.80 $(1.52)^a$	1.41 $(1.38)^a$	81.27 (64.33)	78.41 (62.29)	75.98 (60.63)	54.31 (47.45)	72.49 (58.34)
6	Chlorantraniliprole 20 SC	0.15	3.23 (1.93)	0.07 $(0.75)^a$	0.90 $(1.24)^a$	1.03 $(1.24)^a$	1.10 $(1.26)^a$	0.77 $(1.13)^a$	98.72 (83.47)	85.17 (66.31)	74.28 (59.50)	72.81 (58.55)	82.53 (65.27)
7	Untreated check	-	3.30 (1.95)	5.50 $(2.45)^c$	6.07 $(2.56)^c$	6.37 $(2.62)^c$	3.94 $(2.11)^c$	5.47 $(2.44)^c$	-	-	-	-	-
	S.Em ±		-	0.13	0.15	0.15	0.12.	0.15	4.19	4.01	3.49	3.22	3.43
	CD at 5 %		NS	0.38	0.38	0.44	0.35	0.44	12.23	11.71	10.20	9.39	10.01
	CV (%)		-	14.54	15.20	15.20	12.23	15.37	16.92	16.20	13.01	17.44	13.84

Note:

NS – Non Significant. DBS – Day Before Spray, DAS – Days After Spray. UTC : Un treated Check

In a column, means followed by a same letter are not significantly different at p = 0.05 by Duncan's Multiple Range Test (DMRT)

* Figures in the parentheses are subjected to $(\sqrt{X + 0.5})$ transformed values. ** Figures in parentheses are arc sin transformed values.

recorded in emamectin benzoate 5 SG @ 0.2 g/l (0.85 larvae/plant) sprayed plot which was on par with chlorantraniliprole 20 SC @ 0.15 ml/l (0.93 larvae /plant) and spinosad 45 SC @ 0.15 ml/l (1.92 larvae/plant) sprayed plots. Similarly, in these treatments highest per cent larval reduction was also recorded (Table 2).

At 10 and 15 DAS, similar trend in efficacy of insecticides was observed, where least larval population was recorded in plots sprayed with chlorantraniliprole 20 SC @ 0.15 ml/l followed by spinosad 45 SC @ 0.15 ml/l and emamectin benzoate 5 SG @ 0.2 g/l sprayed plots. Similarly, in these treatments highest per cent larval reduction was also recorded.

The efficacy of new insecticides molecules against lepodopteran insect pests has been well documented in various crops. Spinosad 45 SC and was found more effective against greengram leaf eating caterpillar, *Agrius convolvuli* (Jayaram, 2006). Similarly, emamectin benzoate 5 SG was found to be most effective against *Spodoptera litura* in soybean (Harish *et al.,* 2009), *Helicoverpa armigera* in groundnut (Gadhiya *et al.,* 2014) and chickpea (Kambrekar *et al.,* 2012). These findings confirm the efficacy of new molecules used in the present investigation.

Safflower leaf eating caterpillar, *Perigia capensis* (Guen)

Before the imposition of treatment, there was no statistically significant difference between the treatments with respect to mean number of larvae per plant. The larval population in different treatments was uniform and ranged from 3.00 to 3.30 per plant (Table 3).

At three DAS, there was a significant difference among the treatments where the population of larvae ranged from 0.07 to 5.50 larvae per plant. The plots sprayed with chlorantraniliprole 20 SC @ 0.15 ml/l recorded least larval population (0.07 larvae/ plant) which was on par with emamectin benzoate 5 SG @ 0.2 g/l (0.77 larvae /plant) and spinosad 45 SC @ 0.15 ml/l (1.03 larvae/plant)sprayed plots. With respect to per cent larval reduction, highest reduction of larval population (98.72%) was recorded in plots sprayed with chlorantraniliprole 20 SC @ 0.15 ml/l followed by spinosad 45 SC @ 0.15 ml/l (81.27%) and emamectin benzoate 5 SG @ 0.2 g/l (80.63%) sprayed plots which were on par with each other.

At seven days after spray the larval population ranged from 0.90 to 6.07 per plant. The least number of larvae was recorded in chlorantraniliprole 20 SC @ 0.15 ml/l (0.90 larvae/plant) sprayed plots which was on par with emamectin benzoate 5 SG @ 0.2 g/l (0.91 larvae/ plant) and spinosad 45 SC @ 0.15 ml/l (1.31 larvae/plant) sprayed plots. Similarly the highest per cent larval reduction (85.17%) was recorded in the plots sprayed with chlorantraniliprole 20 SC @ 0.15 ml/l (85.17%) followed by emamectin benzoate 5 SG @ 0.2 g/l (85.00%) and spinosad 45 SC @ 0.15 ml/l (78.98%) sprayed plota. At 10 and 15 DAS, similar trend in efficacy of insecticides was observed where, least larval population was registered in plots sprayed with chlorantraniliprole 20 SC @ 0.15 ml/l followed by spinosad 45 SC @ 0.15 ml/l and emamectin benzoate 5 SG @ 0.2 g/l sprayed plots. Similarly, in these treatments highest per cent larval reduction was also recorded.

The present results are in accordance with Mohan (2015) who reported that chlorantraniliprole 20 SC recorded highest per cent reduction (68.19%) of larvae *Perigia capensis* followed by emamectin benzoate 5SG (65.16%), flubendiamide 480 SC (55.70%) and spinosad 45 SC (55.08%).

Seed yield and cost economics

The data pertaining to seed yield of safflower and economics of different treatments are presented in Table 4. The seed yield obtained from different insecticides sprayed plots was significantly higher compared to unsprayed control. Among the different treatments, chlorantraniliprole 20 SC @ 0.15 ml/lit sprayed plots registered higher seed yield (12.65 q/ha) followed by thiamethoxam 25 WG @ 0.2 g/l (11.51 q/ha) and emamectin benzoate 5 SG @ 0.2 g/l (10.63 q/ha) sprayed plots which were statistically on par with each other. Whereas, least seed yield was observed in plots sprayed with spinetoram 12 SC @ 0.2 ml/l (8.19 q/ha) followed by spinosad 45 SC @ 0.15 ml/l (8.94 q/ha) and buprofezin 50 SC @ 0.2 ml/l (10.00 q/ha) sprayed plots.

The economics of different treatments revealed that, among different chemicals highest net return was realized in the treatment with chlorantraniliprole 20 SC @ 0.15 ml/lit (₹ 29577 ha^{-1}) followed by thiamethoxam 25 WG @ 0.2 g/l (₹ 26702 ha^{-1}) and emamectin benzoate 5 SG @ 0.2 g/l (₹ 22775 ha^{-1}). Whereas, least net returns of

Table 4. Seed yield and economics of safflower crop as influenced by different insecticides

T. No.	Treatments	Dosage (ml/g/ha)	Yield (q/ha)	Gross income (₹/ha)	Cost of cultivation (₹/ha)	Net income (₹/ha)	B: C ratio
1	Buprofezin 50 SC	0.25 ml	10.00	36,000.00	14,318.42	21,681.58	2.51
2	Thiamethoxam 25 WG	0.2 g	11.51	41,448.98	14,747.30	26,701.68	2.81
3	Spinetoram 12 SC	0.2 ml	8.19	29,469.39	15,640.00	13,829.39	1.88
4	Emamectin benzoate 5 SG	0.2 ml	10.63	38,265.31	15,490.30	22,775.01	2.47
5	Spinosad 45 SC	0.15 ml	8.94	32,183.67	15,940.30	16,243.37	2.01
6	Chlorantraniliprole 20 SC	0.15 ml	12.65	45,557.82	15,981.25	29,576.57	2.85
7	Untreated check	-	4.13	14,863.95	14,140.30	723.65	1.05
	S.Em ±		0.75	27,17.49	-	-	-
	CV (%)		13.86	13.86	-	-	-
	CD @ 5%		2.20	8373.84	-	-	-

₹ 13830 per hectare was realized in spinetoram 12 SC @ 0.2 ml/l followed by spinosad 45 SC @ 0.15 ml/l (₹ 16243 ha^{-1}) and buprofezin 50 SC @ 0.2 ml/l (₹ 22775 ha^{-1}).

The results on the benefit cost ratio revealed that, among the chemical treatments, highest benefit cost ratio was obtained in chlorantraniliprole 20 SC @ 0.15 ml/lit (2.85) followed by thiamethoxam 25 WG @ 0.2 g/l (2.81), buprofezin 50 SC @ 0.2 ml/l (2.51) and emamectin benzoate 5 SG @ 0.2 g/l (2.47). While, least benefit cost ratio was recorded in spinetoram 12 SC @ 0.2 ml/l (1.88) followed by spinosad 45 SC @ 0.15 ml/l (2.01) (Table 4)

In general in minimizing the population of safflower aphids, systemic insecticides were found to be effective among the tested insecticides *i.e.* thiamethoxam 25 WG @ 0.2 g/l, buprofezin 50 SC @ 0.25 ml/l and spinetoram 12 SC @ 0.2 ml/l. However, contact insecticides *i.e.* chlorantraniliprole 20 SC @ 0.15 ml/l, emamectin benzoate 5 SG @ 0.2 g/l and sad 45 SC @ 0.15 ml/l were effective against safflower capsule borer and leaf eating caterpillar.

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IMPACT OF SYSTEM OF RICE INTENSIFICATION (SRI) TECHNOLOGY AMONG PRACTICING RICE FARMERS OF NAGAPATTINAM DISTRICT OF TAMIL NADU

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ABSTRACT

Rice is the most important staple food crop for about two thirds of the population. The recent break through in rice cultivation known as System of Rice Intensification (SRI) method is the one which can be considered as a new system of rice cultivation for increasing productivity with a comprehensive package of practices involving less seed, less water , less chemical fertilizers and pesticides. The present study was conducted in Nagapattinam district of Tamil Nadu. This district was purposively selected for the study because it is one of the leading rice producing districts of Tamil Nadu and also it ranked first in SRI paddy coverage for the period of 2011-12. Out of eleven blocks from the Nagapattinam district four blocks and three villages from each selected block were purposively selected according to the highest area under SRI. From each village ten SRI farmers were selected by following simple random sampling procedure, thus making a total of 120 respondents. The study revealed that education, training undergone, social participation, extension contact, economic motivation, scientific orientation, management orientation, achievement motivation, innovativeness, mass media exposure and risk orientation were found to be positively significant with their extent of adoption of SRI technology. Age and farming experience were found negatively and significantly related whereas land holding had non-significant relationship with their extent of adoption of SRI technology. Further the association between various attributes with production level of paddy among SRI practicing farmers revealed that education, farming experience, training undergone, extension contact, scientific orientation, innovativeness, mass media exposure and risk orientation were found to be significant with production level of paddy whereas age, land holding, social participation, economic motivation, management orientation and achievement motivation had showed non-significant association with production level of paddy among SRI practicing farmers.

KEYWORDS: Extent of adoption, production levels, SRI technology, rice

INTRODUCTION

Tamil Nadu is considered as one of the leading rice producing and consuming states of India. Out of the total geographical area of 130 lakh hectares, around 51 lakh hectares are the net cultivated area. About 28.63 lakh hectares constituted the net irrigated area and the balance area of 22.37 lakh hectares is rainfed. So it was felt necessary to adopt a low water consuming rice production technology to attain the targets of National Food Security Mission. Thus System of Rice Intensification was introduced by the State Government. SRI method is the one which can be considered as a new system of rice cultivation for increasing productivity with a comprehensive package of practices involving less seed, less water , less chemical fertilizers and pesticides. So it was felt important to study the impact of SRI technology among the practicing rice farmers.

MATERIALS AND METHODS

The study was conducted with an expost- facto research design to study the the impact of SRI technology among the practicing rice farmers. The study was conducted in Nagapattinam district of Tamil Nadu. Nagapattinam district was purposively selected for the study because it is one of the leading rice producing districts of Tamil Nadu as it lies in the Cauvery Delta zone and also it ranked first in SRI paddy coverage for the period of 2011-12 in the Tamil Nadu. Out of eleven blocks from the Nagapattinam district four blocks were purposively selected to represent the north and southern parts of the districts according to the highest area under SRI. Three villages from each selected block were purposively selected according to the highest area under SRI. From each village 10 farmers were selected by following simple random sampling procedure, thus making a total of 120 respondents. Extent of adoption and production levels of SRI technology by the

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respondents was studied by a well-structured and pre-tested schedule developed for the study.

RESULTS AND DISCUSSION

Extent of Adoption by the respondents

Extent of adoption refers to measure how far a particular technology was adopted by the individual correctly without any distortion of message. Hence an attempt was made to assess the extent of adoption of SRI cultivation. Eight major areas were listed with 26 sub items. The overall adoption and practice-wise adoption were studied and presented. The values of adoption indices obtained from the survey are classified and presented in the Table 1.

Table 1. Distribution of respondents according to their Adoption Level (n=120)

S. No.	Category	Number	Per cent
1	Low	19	15.83
2	Medium	78	65.00
3	High	23	19.17
	Total	120	100.00
	Mean	45.98	
	Standard Deviation	2.72	

From the Table 1 it could be observed that more than half of the respondents (65.00 %) had medium level of adoption in the cultivation of paddy under SRI method and 19.17 per cent and 15.83 per cent of the respondents had come under high and low level of adoption respectively. It could be understood that majority of the respondents possessed medium to higher level of adoption. This might be due to their higher knowledge level on the recommended practices, better social participation, medium levels of scientific and risk orientation. This finding was in agreement with results of Alagesan and Budhar (2009).

Item wise analysis of extent of adoption of recommended package of practices in SRI cultivaiton

The data in Table 2 showed that some variation existed in the extent of adoption of the recommended practices under SRI method of cultivation. Some of the recommended practices like soaking the seeds in water for 24 hours before transplanting, transplanting the seedlings at the field saturation level, using field markers for spacing in the main field and transplanting only one plant / hill were fully adopted by the farmers.

However, considerable gap was observed in adopting the other recommended practices *viz.,* broadcasting seeds uniformly on the raised beds in a thin layer, pulling the seedlings along with soil without causing any damage, and not applying any weedicides (97 % each) followed by seed treatment (94 %), using only 2 kg seed for nursery, soaking and incubation (91 % each), applying well decomposed manure to nursery (89 %), transplanting 8 to 12 day old nursery and using conoweeder for weeding in the main field (87 %), maintaining field at saturation level (80 %), adopting a spacing at 25 X 25 cm in the main field (75 %), providing drainage channels and maintaining correct plant density of 16 plants / m2 (74 % each), preparing raised beds for growing nursery (67 %) and nutrient management only through organic sources (65 % only).

From the above results, it could be inferred that the gaps that existed in the adoption were mainly in the nutrient management of the main field, preparing raised beds for nursery, maintaining correct plant population etc. It was also observed in the field that farmers expressed difficulty in maintaining the field at the saturation levels (mud condition without water stagnation) throughout the crop growing period. This clearly indicated that there were some knowledge gaps with respect to nutrient management in SRI, hence application of higher doses of fertilizers was observed. This needs a focused attention to improve the availability of the manures and educate the farmers how the organic manures coupled with saturated field conditions and turning the weeds in the field with cono weeder will help in exploiting the rice genome capacity to yield on par with conventional cultivation. The improvement in the availability of manures will in turn be dependent on the livestock availability in the villages.

The results in the Table 3 exhibit that out of fourteen variables studied Education (X_2), Training undergone (X_5), Social participation (X_6), Extension contact (X_7), Economic motivation (X_8), Scientific orientation (X_9), Management orientation (X_{10}), Innovativeness (X_{11}), Achievement motivation (X_{12}), Mass Media exposure (X_{13}) and Risk orientation (X_{14}) showed a positive and significant association with Extent of Adoption of the SRI technology by SRI farmers at one per cent level of significance.

Table 2. Extent of adoption of recommended practices of SRI method of cultivation

(n=120)

S. No.	Recommendations	Extent of Adoption					
		FA (2)		PA (1)		NA(0)	
		F	%	F	%	F	%
I	**Seed selection**						
1.	Recommended Hybrids / High yielding varieties	2	1.67	95	79.17	23	19.16
II	**Nursery Management**						
2.	Mat nursery	7	5.83	16	13.33	97	80.83
3.	100 m^2ha^{-1} area	6	5.00	15	12.50	99	82.50
4.	Use of recommended soil mixture.	6	5.00	16	13.33	98	81.67
5.	Use of wooden frames.	6	5.00	18	15.00	96	80.00
6.	Sowing of sprouted seeds.	112	93.33	5	4.17	3	2.50
7.	Sprinkling of water.	7	5.83	17	14.17	98	81.67
8.	Spraying fertilizer solution (optional)	5	4.17	63	52.50	52	43.33
III	**Seed rate**						
9.	7-8 kg/ha	7	5.83	16	13.33	97	80.34
IV	**Main field preparation**						
10.	Perfect puddling	31	25.83	84	70.00	5	4.17
11.	Perfect leveling	24	20.00	90	75.00	6	5.00
V	**Transplanting**						
12.	Using spacing markers	81	67.50	39	32.50	-	-
13.	Transplanting within 30 minutes after pulling out.	57	47.50	43	35.83	20	16.67
14.	Single seedling	120	100.00	-	-	-	-
15.	Seedling of 15 days old.	108	90.00	10	8.33	2	1.67
16.	Square planting of 25 x 25 cm.	120	100.00	-	-	-	-
VI	**Irrigation Management**						
17.	Irrigation only to moist the soil in the early period of 10 days (alternate wetting and drying).	21	17.50	66	55.00	33	27.50
18.	Restoring irrigation to a maximum depth of 2.5 cm after development of hairline cracks in the soil until panicle initiation.	18	15.00	59	49.17	43	35.83
19.	Increasing irrigation depth to 5.0 cm after PI one day after disappearance of ponded water.	23	19.17	58	48.33	39	32.50
VII	**Weed Management**						
20.	Using Rotary weeder / Cono weeder	120	100.00	-	-	-	-
21.	Moving the weeder with forward and backward motion to bury the weeds and as well to aerate the soil.	113	94.17	7	5.83	-	-
22.	Usage at 7-10 days interval from 10-15 days after planting.	34	28.33	81	67.50	5	4.17
23.	Usage on either direction of the rows and columns.	101	84.17	-	-	19	15.83
24.	Manual weeding after cono weeding.	118	98.33	-	-	2	1.67
VIII	**Nutrient Management**						
25.	Recommended green manure and farm yard manure application.	32	26.67	62	51.67	26	21.66
26.	Periodical observation of boot leaf and comparison with LCC	28	23.33	58	48.33	34	28.34

Table 3. Relationship between independent variables of SRI farmers with their extent of adoption

Variable No.	Variables	Correlation co-efficient 'r' value
X_1	Age	-0.5077**
X_2	Education	0.6343**
X_3	Experience	-0.5224**
X_4	Land Holding	0.1542 NS
X_5	Training Undergone	0.5464**
X_6	Social Participation	0.3831**
X_7	Extension Contact	0.3331**
X_8	Economic Motivation	0.5613**
X_9	Scientific Orientation	0.6149**
X_{10}	Management Orientation	0.3367**
X_{11}	Innovativeness	0.6074**
X_{12}	Achievement Motivation	0.3056 **
X_{13}	Mass Media Exposure	0.5790**
X_{14}	Risk Orientation	0.2102*

** - Significant at 1% level
* - Significant at 5% level
NS - Non- Significant

It is quite natural that as the education enhances the knowledge level of the farmers and helps to acquire latest technical know-how about SRI cultivation. Education helps them to find out the cause and effect of the specific constraints and enable them to address the constraints efficiently. Further the farmers who have undergone more number of trainings related to specific subjects will have more knowledge and exposure related to that particular aspect. And the training offered by the state department of agriculture was short in duration i.e. half day or one day. It was followed by the demonstration by the departmental personnel. So acquiring technical knowledge through the training could be easy for the respondents. After gaining familiarity with this technology the individual may develop a favourable attitude towards this innovation and eventually decides to adopt this technology.

Increased social participation of farmers provides more chances of getting exposed to different sources and ideas related to agriculture also provide better opportunity to have interpersonal interactions which will help in easy adoption of technologies and also to tackle the constraints. So interpersonal and cosmopolite channels would pave a way for more adoption. Extension contact always increases the adoption rate as it is positively related to adoption.

Farmers having more scientific orientation will always search for new and advanced production technologies and have keen observation power to find out the cause effect relationship in any constraint situation. Person who believes in science always looks for innovation. Most of the innovations will be adopted by the persons with more scientific orientation who prefer new technology. So a portion of respondents adopted SRI technology. Thus scientific orientation had positive relationship with the extent of adoption of SRI technology. Innovativeness is associated with the individuals' earliness in the use of new practices. Innovative farmers will always be experimenters. During any constraint situation farmers with high levels of innovativeness will experiment the new ways of doing things to change the existing situation. Generally person with more Innovativeness would be looking for new ideas. Thus innovativeness was found positively related with adoption of SRI technology.

Risk taking is the ability to take the right decision during uncertainties; these uncertainties are nothing but the constraints. The farmer who is willing to take calculated risks during constraint situation will gain better results. Same time it was seen that many farmers were taking risks due to peer pressure or demanding situation. There is a generalization that "Early adopters are better able to cope with uncertainty and risk than are later adopters"-Rogers (1971).

These findings were in agreement with results of Kumar (2004), Gopinath (2005) and Thiyagarajan (2011).

The correlation values of the variables such as Age (X_1), and Farming experience (X_3) had showed a negative relationship with the Extent of Adoption of SRI technology. The variable Land holding (X_4) had showed a non-significant association with the extent of adoption of the SRI technology by SRI farmers. The data further revealed that, better participation of extension officials had positive response towards adoption which was reinforced by risk and scientific orientations, experience in SRI method and attending more number of trainings.

Table 4. Distribution of SRI practicing farmers according to their Production levels

(n=120)

S. No	Category	Frequency	Percentage
1	Low (40-45q)	37	30.83
2	Medium (46-50q)	60	50.00
3	High (51-55q)	23	19.17
	Total	120	100.00

Table 4 indicates the distribution of respondents according to their production level of paddy crop. It was found that half of the (50.00 %) practicing farmers who were adopting SRI method of paddy cultivation technology had obtained medium production level ranging from 46 quintal to 50 quintals per hectare followed by low production level ranging from 40 quintal to 45 quintals per hectare (30.83 %) and high production level ranging from 51 quintal to 55 quintals per hectare.

The results from the Table 5 indicated that the association between various attributes of SRI farmers like education, farming experience, training undergone, extension contact, scientific orientation, innovativeness, mass media exposure and risk orientation were found to be significant with production level of paddy among SRI practicing farmers, whereas age, land holding, social participation, economic motivation, management orientation and achievement motivation had showed non-significant association with production level of paddy among SRI practicing farmers. These findings were in agreement with results of Santhi (2006).

Table 5. Association of independent variables of SRI farmers with their production levels

Variable No.	Variables	Chi sqare value	Degrees of freedom
X_1	Age	4.56^{NS}	4
X_2	Education	16.51^{S}	3
X_3	Farming Experience	11.94^{S}	2
X_4	Land Holding	13.54^{NS}	2
X_5	Training Undergone	4.14^{S}	2
X_6	Social Participation	7.90^{NS}	2
X_7	Extension Contact	27.91^{S}	2
X_8	Economic Motivation	13.83^{NS}	2
X_9	Scientific Orientation	12.06^{S}	4
X_{10}	Management Orientation	25.14^{NS}	1
X_{11}	Innovativeness	12.94^{S}	2
X_{12}	Achievement Motivation	11.75^{NS}	2
X_{13}	Mass Media Exposure	12.68^{S}	4
X_{14}	Risk Orientation	12.97^{S}	2

CONCLUSION

The results showed that, education, training undergone, social participation, extension contact, economic motivation, scientific orientation, management orientation, achievement motivation, innovativeness, mass media exposure and risk orientation were found to be positively significant with their extent of adoption of SRI technology. Age and farming experience were found negatively and significantly related whereas land holding had non-significant relationship with their extent of adoption of SRI technology. Hence, there is every need to promote SRI method of cultivation focusing more on imparting the principles of SRI during the training programmes and demonstrations, skill development among rural youth and farmers. Further the association between various attributes of SRI farmers like education, farming experience, training undergone, extension contact, scientific orientation, innovativeness, mass media exposure and risk orientation were found to be significant with production level of paddy among SRI practicing farmers, whereas age, land holding, social participation, economic motivation, management orientation and achievement motivation had showed non-significant association with production level of paddy among SRI practicing farmers.

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WEED MANAGEMENT IN TRANSPLANTED FINGERMILLET IN SOUTHERN AGRO-CLIMATIC ZONE OF ANDHRA PRADESH

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ABSTRACT

Field experiment to study the efficiency of different herbicides to control the weeds in fingermillet was conducted during two seasons of *kharif* 2014 and 2015 in sandy loam soils at Agricultural Research Station Perumallapalle. Results from two consecutive seasons revealed that among different weed management practices,pre- emergence application of oxyfluorfen 0.2 kg a.i /ha + one hand weeding at 20 DAP (1.56) followed by pendimethalin 0.5 kg a.i/ha+ one hand weeding at 20 DAP realized higher benefit cost ratio (1.52) compared to hand weeding. Post emergence application of 2, 4-D Sodium salt @ 0.8 kg a.i /ha at 20 days after planting realized higher cost benefit ratio (1.91). Post-emergence application of bispyribac sodium @ 20 g a.i/ha showed phototoxicity on crop growth.

KEYWORDS: Fingermillet, Weed management, Oxyflurofen, Pendimethalin and Hand weeding

Fingermillet is the most important small millet grown in Andhra Pradesh in an area of 0.29 lakh ha with a production of 0.03 lakh tonnes and a productivity of 951 kg/ha (Annual Report AICRIP on Small Millets 2016). The production and productivity of fingermillet is low because of insufficient irrigation, poor nutrient management, heavy weed infestation and incidence of blast disease. Among these, weed infestation is a serious threat to its production, particularly during the critical period of the crop. Reduction in yield due to weed competition to an extent of 55-61 per cent was reported earlier by Ramachandra Prasad *et al.* (1991) up to 43 per cent by Kumar, 2004 and Nanjappa (1980). Eventhough manual weeding is effective, it is time consuming and labour intensive and uneconomical. In view of the escalation of cost of labour, manual weeding is not worthy. Post-emergence herbicides for weed control in fingermillet become cheaper when compared to manual weeding. Hence, the present study was taken up with the objective to find out the best pre and post-emergence herbicides and best weed management practice in transplanted fingermillet during *kharif* 2014 and 2015 for two consecutive seasons in sandy loam soils of Southern Agro-climatic Zone of Andhra Pradesh.

MATERIALS AND METHODS

The field experiments were conducted at Agricultural Research Station, Perumallapalle, Andhra Pradesh, during *kharif* 2014 and 2015. The experiment was laid out in a Randomized block design with three replications. The variety used for the experiment was Vakula (PPR2700). The treatmental details are : T_1 : Control (no weeding), T_2: Hand weeding at 20, 40 days after planting, T_3: Pre-emergence application of oxyfluorfen 0.2 kg a.i /ha + one hand weeding at 20 DAP, T_4: Pre-emergence application o of pendimethalin 0.5 kg a.i/ha+ one hand weeding at 20 DAPT_5: Bispyribac sodium @ 20 g a.i/ha 20 days after planting, T_6: 2,4-D sodium salt @ 0.8 kg a.i /ha at 20 days after planting, T_7 : Oxyfluorfen 0.2 kg a.i /ha at 20 DAP. Seedlings were raised in nursery and 21 days old seedlings were transplanted with a spacing of 22.5 x 7.5 cm at one seedling per hill. The recommended dose of 60 kg N, 40 kg P_2O_5, 30 kg K_2O/ha was applied. P_2O_5 and K_2O were applied as basal dose in the form of single super phosphate and muriate of potash. Nitrogen was applied as urea in two equal splits half at the time of transplanting remaining half at 20-25 days after transplanting (after weeding). Need based irrigations were given when there were long dry spells. Major weed flora observed in the experimental field were *Cynodon dactylon, Cyperus rotundus, Dactyloctenium aegyptium , Panicum repens, Digitar*ia sps among grasses and *Trianthemma portulacastrum, Commelina benghalensis, phyllathus niruri, Parthenium hysterphorus* among broad leaved weeds. The data on weed density and weed dry matter were recorded at the time of harvest besides yield and yield components by adopting standard procedures.

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RESULTS AND DISCUSSION

Effect on weeds

During both the seasons, weed management treatments significantly reduced the weed density and weed dry matter over un-weeded control plots at harvest (Table 1). Among the different weed management practices tried hand weeding at 20 and 40 days after planting recorded significantly lower weed density and weed dry matter. These results are in accordance with Basavaraj Patil *et al.,* 2013. Among herbicidal treatments, pre-emergence application of pendimethalin 0.5 kg a.i/ ha+ one hand weeding at 20 DAP gave lower weed density and weed dry matter followed by pre-emergence application of oxyfluorfen 0.2 kg a.i /ha + one hand weeding at 20 DAP. Post-emergence application of bispyribac sodium @ 20 g a.i/ at 20 days after planting was effective only against broad leaved weeds. Post-emergence application of 2,4-D Sodium salt @ 0.8 kg a.i /ha at 20 days after planting suppressed only broad leaved weeds and could not control grassy weeds and sedges and thereby weed infestation was severe which affected the grain yield of fingermillet during both seasons of study. Post-emergence application of oxyfluorfen 0.2 kg *a.i* /ha at 20 DAP effectively controlled both grassy and broad leaved weeds.

Effect on Crop Growth and yield:

Oxyfluorfen 0.2 kg a.i /ha at 20 DAP (T_7) and bispyribac sodium @ 20 g a.i/ha 20 days after planting (T_5) applied as post-emergence affect the crop growth, intensity of reduced tillering, phytotoxicity symptoms like leaf scorching and yellowing immediately after herbicide application crop was recovered subsequently within 10 days after treatment imposition. Severe crop damage was observed with application of bispyribac sodium @ 20 g a.i/ha. compared to oxyfluorfen 0.2 kg ai /ha. at 20 days after planting.

Yield and yield attributes were significantly influenced by different weed management practices. Among the different weed management practices hand weeding at 20,40 days after transplanting recorded the highest grain yield with pre-emergence application of oxyfluorfen 0.2 kg ai /ha + one hand weeding at 20 DAP which was on a par with pre emergence application of pendimethalin 0.5 kg a.i/ha+ one hand weeding at 20 DAP(33.6 q/ha). The increase in yield can be attributed due to better weed control in initial stages by pre-emergence application of herbicides and subsequently by manual weeding that resulted in better translocation of photosynthetates sufficient to the sink needs. The similar results were also reported by Basavaraj patil *et al.,* (2013), Ashok *et al.,* (2003), Kumar (2004), Rama moorthy *et al.*, (2009) and Channa Naik (2000). The lowest number of productive tillers and grain yield were recorded with post- emergence application of bispyribac sodium @ 20 g a.i/ha at 20 days after planting followed by post emergence application of oxyfluorfen 0.2 kg a.i /ha at 20 DAP which initial set back in crop growth was due to phytotoxic effect which affected initial plant growth.

Among weed management treatments, the highest net returns were realized with pre- emergence application of oxyfluorfen 0.2 kg a.i /ha + one hand weeding at 20 DAP followed by pre-emergence application of pendimethalin 0.5 kg a.i/ha. + one hand weeding at 20 DAP. Among the post-emergence herbicides application of 2,4-D Sodium salt @ 0.8 kg a.i /ha. at 20 days after planting realized higher benefit cost ratio. The results are in accordance with Krishna Prithvi *et al*.,(2015).

CONCLUSION

Among the different pre-emergence herbicides, oxyfluorfen 0.2 kg *a.i* /ha. or Pendimethalin 0.5 kg *a.i/*ha recorded significantly lesser weed density and dry weight, besides producing higher grain yield in fingermillet. Among the post-emergence herbicides, 2,4-D Sodium salt @ 0.8 kg/ha effectively controlled the weeds compared to bispyribac sodium and oxyfluorfen in Fingermillet as these post-emergence herbicides showed phytotoxicity to the crop.

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Table 1: Weed parameters, yield components and yield of Fingermillet as influenced by different Weed management practices

Treatments	Weed density (No./m²)			Weed dry matter (g/m²)			Grain yield (q)			Productive tillers/m²	Fingers /ear	Grain yield (q/ha)	Gross returns (₹/ha.)	Net returns (₹/ha)	B:C
	2014 *kharif*	2015 *kharif*	Mean	2014 *kharif*	2015 *kharif*	Mean	2014 *kharif*	2015 *kharif*	Mean						
T_1 : Control (no weeding)	31.8	39.6	35.7	216	41.9	128.9	24.4	22.7	23.5	78.6	8.6	23.5	58750	19250	1.48
T_2 : Hand weeding at 20, 40 days after planting	8.3	9.2	8.75	152	25.8	88.9	34.8	36.6	35.7	124.0	9.0	35.7	89425	19925	1.28
T_3 : Pre emergence application of oxyfluorofen 0.2 kg *a.i* /ha + one hand weeding at 20 DAP	17.2	18.6	17.9	96.3	37.2	66.7	34.6	35.4	35.0	98.0	9.2	35.0	87500	31440	1.56
T_4 : Pre emergence application of Pendimethalin 0.5 kg *a.i* /ha + one hand weeding at 20 DAP	18.3	16.0	17.1	79.6	40.4	60.0	32.4	34.9	33.6	114.0	9.0	33.6	84000	28770	1.52
T_5 : Bispyribac sodium @ 20 g *a.i* /ha 20 days after planting	22.3	29.5	25.9	141.0	43.9	92.4	12.8	13.2	13.0	64.0	8.8	13.0	32500	-9030	0.78
T_6 : 2, 4 D Sodium salt @ 0.8 kg *a.i* /ha at 20 days after planting	24.3	19.7	22.0	121.0	53.2	87.1	27.7	33.3	30.5	106.6	8.6	30.5	76250	36452	1.91
T_7 : Oxyfluorofen 0.2 kg *a.i* /ha at 20 DAP	17.4	22.8	20.1	146.6	37.5	92.0	16.2	15.3	15.7	65.3	8.7	15.7	39250	-2310	0.94
S Em ±	3.63	0.59	-	30.2	0.61	-	4.38	1.72	-	2.86	0.36	0.35	-	-	-
CD (0.05)	11.3	1.84	-	NS	1.92	-	13.5	0.35	-	8.9	NS	1.72	-	-	-

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EFFECT OF PLANT GROWTH REGULATORS ON DORMANCY AND FLOWERING IN GLADIOLUS *(Gladiolus grandiflorus* L.)

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ABSTRACT

Studies were conducted on the effect of plant growth regulators on dormancy and flowering in gladiolus cvs. American Beauty and White Prosperity during *rabi* 2009. The plant growth regulators, Gibberellic acid (GA_3) at 75, 100 and 125 ppm, Benzyl Adenine (BA) at 25, 50 and 100 ppm, Naphthalene Acetic Acid (NAA) at 50, 100 and 150 ppm were used for this study. Gladiolus corms were dipped in the plant growth regulator solutions for a period of 10 hours before planting. Cultivar American Beauty with GA_3 at 125 ppm recorded less number of days to sprout (17.00) and 50 per cent sprouting (29.00) of gladiolus corms. All the plant growth regulator treatments at higher concentrations recorded less number of days to sprouting and 50 per cent sprouting of gladiolus corms. GA_3 at 125 ppm recorded highest percentage of sprouting (100.00) in both the cultivars. Among the plant growth regulator treatments, cv. American beauty in combination with NAA at 150 ppm recorded less number of days to first floret appearance (70.00), 50 per cent flowering (80.67) and number of days to first flower spike harvest (75.33). BA at 100 ppm recorded maximum number of spikes per corm in cv. American beauty (1.67). Cultivar White Prosperity in combination with GA_3 at 125 ppm recorded significantly higher mean spike length (65.00 cm) as well as maximum number of florets per spike (11.33).

KEYWORDS: Gladiolus, Gibberellic acid, Naphthalene Acetic Acid, Benzyl Adenine, dormancy, flowering

INTRODUCTION

Gladiolus (*Gladiolus grandifloras* L.) is a bulbous cut flower of beauty and perfection. It is popularly known as 'Queen of the bulbous flowers' because of attractive spikes, having florets of different colours and longer keeping quality. Gladiolus is very popular for its wide open, good texture and impressive colored spikes which are of great demand in both domestic and international market. Gladiolus is commercially propagated by corms. Poor multiplication rate and presence of dormancy for 3-4 months in corms restricts their immediate use in the following season resulting in high cost of corms and is often higher than the sale price of flower spike produced by the corm. Dormancy of corm and cormel is one of the major hindrance in the commercial cultivation of Gladiolus. The physiological basis of corm and cormel dormancy has been ascribed to the accumulation of growth inhibiting substances, especially Abcissic acid (ABA) in the tissue as well as in the scales encapsulating them. In many of the cultivars, it is possible to regulate morphogenic processes successfully with physiologically active compounds to shorten natural dormancy and control flowering dates (Ganyushkin, 1991). The plant growth regulators play an important role in production of quality corms and cormels in gladiolus (Bhattacharjee, 1984). The present investigation is aimed to reduce the dormancy period of freshly harvested corms and improve their flowering, quality corm and cormel production by treating the corms with various plant growth regulators at different concentrations.

MATERIAL AND METHODS

Effect of plant growth regulators on dormancy and flowering in gladiolus cvs. American Beauty and White Prosperity were studied during *rabi* 2009. The plant growth regulator treatments, Gibberellic acid (GA_3) at 75, 100 and 125 ppm, Benzyl Adenine (BA) at 25, 50 and 100 ppm and Naphthalene Acetic Acid (NAA) at 50, 100 and 150 ppm were used for this experiment. The corms were soaked in the solutions for a period of 10 hours before planting after removal of corm scales. There were 20 treatments each replicated thrice in Randomized Block Design with factorial concept. The data was analyzed using computer software programmed by the method of variance outlined by Panse and Sukhatme (1985).

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RESULTS AND DISCUSSION

In the present study, cultivar American Beauty has taken significantly minimum number of days for sprouting of corms and days taken to 50 per cent sprouting of corms over cv. White Prosperity (Table 1), which indicated that number of days taken to sprouting is a genetic character of cultivar. Cultivar American Beauty recorded significantly minimum number of days to earlier sprouting (22.08 days) and 50 per cent sprouting of corms (33.85 days) than cv. White Prosperity (23.60 days and 35.53 days respectively). Highest percentage of sprouting (82.30) of corms was recorded in cv. White Prosperity followed by cv. American Beauty (80.40). Genotypic variation in respect of days to sprouting and per cent sprouting was reported earlier by Seenivasan (2001) in gladiolus.

In general, the study indicated that the plant growth regulator treatments (GA_3, NAA and BA) at higher concentrations recorded less number of days for sprouting over the lower concentrations (Table- 1). The treatment GA_3 at 125 ppm recorded less number of days both for early sprouting (17.66 days) and 50 per cent sprouting of corms (29.50days).However, control recorded maximum number of days to early sprout (26.66days) and 50 per cent sprouting of corms (39.08days). GA_3 at 125 ppm recorded significantly maximum percentage of sprouting (100.00) over other treatments.

Though, GA_3 effect is not exactly determined, early sprouting of corms in treatment with GA_3 might be through alteration of hormonal balance in favour of promoters or through promotion of alternate respiration. Another hypothesis is that, free GA_3 is active in breaking down the reserve food material by hydrolytic enzymes which might have resulted in quick sprouting. These results are in conformity with the earlier reports of promotion effects of GA_3 on the sprouting of corms and cormels (Kumar *et al.,* 2008). In breaking the dormancy of gladiolus corms, Gibberellic acid and Benzyl adenine were more effective. Breaking of dormancy in gladiolus has been linked to ethylene production. Ginzburg (1973) reported that ethepon promoted the growth of dormant corms, and application of BA induced ethylene production. Promotional effect of BA was reported by Ram *et al.* (2002) in gladiolus cv. Friendship. Among the plant growth regulators, NAA with all the concentrations recorded maximum number of days for corm sprouting. Similar results were reported by Kirad *et al.* (2001) in gladiolus cv. Friendship.

A perusal of the data presented, significant influence of cultivars, plant growth regulators, and their interaction on number of days taken for first floret opening, 50% flowering, number of spikes, spike length, number of florets per spike and days to first harvest (Table 2 and 3).

Earliest first floret appearance (79.56 days), minimum number of days to 50 percent flowering (91.40days) and days to first harvest (83.16days) was observed in cv. American beauty. Among the plant growth regulator treatments, minimum number of days for first floret appearance (80.00days), 50 percent flowering (91.33days), and days to first harvest (85.16days) was recorded with NAA at 150 ppm where as control recorded maximum number of days for first floret appearance, 50 per cent flowering and days to first harvest (97.00 days, 108.33 days and 101.67 days respectively)(Table2 and 3). In gladiolus the differentiation of the inflorescence from the apex occurs after the full number of leaves has been initiated. In the present experiment, all the treatments, which recorded higher leaf area during early stages of growth flowered earlier. Among the plant growth regulators, NAA promoted earliness in flowering however GA_3 treatments delayed the flowering. Activity of GA_3 to delay flowering correlates with effectiveness for promoting stem elongation (King *et al.,* 1993). Among different levels of GA_3, the higher dose (125ppm) resulted in the earliest spike emergence in gladiolus cv. Congo song (Vijai Kumar and Singh 2005).

There was no significant difference in cultivars on number of spikes per corm. The cultivar American beauty produced more number of spikes per corm (1.33) over cv. White prosperity (1.30). Among the plant growth regulator treatments BA at 100 ppm recorded maximum number of spikes per corm (1.64) where as control recorded minimum number of spikes per corm (1.07)(Table 2). The increased number of flower spikes with BA treatments might be due to sprouting of more buds per corm and their capacity to produce spike. Cultivar White prosperity recorded maximum spike length (56.25 cm) over cv. American beauty (53.48 cm). GA_3 at 125 ppm recorded significantly higher mean spike length (63.83 cm), followed by GA_3 at 100 ppm (62.35 cm). Minimum spike length was observed with BA at 25 ppm (47.91 cm). GA_3 at different concentrations significantly increased mean spike length. The increased spike length with GA_3 might be due to rapid internodal elongation as a result of increased cell division and cell elongation in the intercalary meristem. Plant growth regulators such as

Table 1. Effect of pre planting plant growth regulator treatments of Gladiolus corms on number of days taken to sprouting, 50 per cent sprouting and per cent sprouting in cultivars American Beauty and White Prosperity

Treatments	Number of days taken to sprouting			Number of days taken to 50 per cent sprouting			Per cent sprouting		
	A.B	W. P	Mean	A.B	W. P	Mean	A.B	W. P	Mean
Gibberellic acid (75 ppm)	22.66	24.00	23.33	34.50	35.00	34.75	80.00	82.00	81.00
Gibberellic acid (100 ppm)	18.33	20.33	19.33	29.66	32.16	30.91	88.00	90.00	89.00
Gibberellic acid (125 ppm)	17.00	18.33	17.66	29.00	30.00	29.50	100.00	100.00	100.00
Benzyl Adenine (25 ppm)	22.16	25.33	23.75	33.50	37.33	35.41	69.00	72.00	70.50
Benzyl Adenine (50 ppm)	20.66	22.33	21.50	32.00	34.16	33.08	72.00	74.00	73.00
Benzyl Adenine (100 ppm)	20.00	22.00	21.00	31.66	33.83	32.75	86.00	88.00	87.00
Naphthalene Acetic Acid (50 ppm)	26.00	27.00	26.50	37.66	39.00	38.33	70.00	72.00	71.00
Naphthalene Acetic Acid (100 ppm)	25.00	25.66	25.33	37.33	38.50	37.91	74.00	77.00	75.50
Naphthalene Acetic Acid (150 ppm)	23.00	23.66	23.33	35.00	35.33	35.16	80.00	82.00	81.00
Control	26.00	27.33	26.66	38.16	40.00	39.08	85.00	86.00	85.50
MEAN	22.08	23.60		33.85	35.53		80.40	82.30	
C.D at 5%									
Cultivars (C)		0.31			0.30			1.50	
Treatments (G)		0.69			0.68			3.37	
Interaction (C × G)		0.98			0.96			4.77	

A.B- American Beauty
W.P- White Prosperity

Table 2. Effect of pre planting plant growth regulator treatment of Gladiolus corms on number of days taken to first floret appearance, days taken to 50% flowering and number of spikes per plant in cultivars American Beauty and White Prosperity

Treatments	Number of days taken to first floret appearance			Number of days taken to 50% flowering			Number of spikes per plant		
	A.B	W. P	Mean	A.B	W. P	Mean	A.B	W. P	Mean
Gibberellic acid (75 ppm)	86.00	106.00	96.33	96.67	118.33	107.50	1.05	1.16	1.10
Gibberellic acid (100 ppm)	81.00	102.00	91.50	92.00	114.00	103.00	1.25	1.21	1.23
Gibberellic acid (125 ppm)	77.66	99.33	88.50	90.33	110.00	100.16	1.41	1.22	1.32
Benzyl Adenine (25 ppm)	82.33	102.33	92.33	95.00	111.00	103.00	1.40	1.33	1.36
Benzyl Adenine (50 ppm)	80.33	97.00	88.66	90.00	107.33	98.66	1.46	1.37	1.42
Benzyl Adenine (100 ppm)	77.66	95.00	86.33	89.33	105.00	97.16	1.67	1.62	1.64
Naphthalene Acetic Acid (50 ppm)	80.00	105.00	92.50	92.67	118.00	105.33	1.15	1.09	1.12
Naphthalene Acetic Acid (100 ppm)	75.00	95.00	85.00	86.33	104.67	95.50	1.36	1.31	1.33
Naphthalene Acetic Acid (150 ppm)	70.00	90.00	80.00	80.67	102.00	91.33	1.48	1.59	1.54
Control	85.66	108.33	97.00	101.0	116.67	108.83	1.09	1.05	1.07
MEAN	79.56	100.00		91.40	110.70		1.33	1.30	
			C.D at 5%						
Cultivars (C)		3.35			2.84			N.S.	
Treatments (G)		7.51			6.35			0.14	
Interaction(C × G)		N.S.			N.S.			N.S.	

A.B- American Beauty
W.P- White Prosperity

Table 3. Effect of pre planting plant growth regulator treatments of Gladiolus corms on spike length (cm), number of florets per spike and days taken to first harvest in cultivars American Beauty and White Prosperity

Treatments	Spike length (cm)			Number of florets per spike			Days taken to first harvest		
	A.B	W. P	Mean	A.B	W. P	Mean	A.B	W. P	Mean
Gibberellic acid (75 ppm)	56.00	56.66	56.33	9.86	10.40	10.13	89.66	111.66	100.33
Gibberellic acid (100 ppm)	61.00	63.50	62.35	10.47	11.00	10.73	84.66	107.33	96.00
Gibberellic acid (125 ppm)	62.66	65.00	63.83	10.63	11.33	11.00	82.66	102.33	92.50
Benzyl Adenine (25 ppm)	47.33	48.50	47.91	9.00	8.93	8.96	85.66	106.00	95.83
Benzyl Adenine (50 ppm)	50.13	52.06	51.10	9.30	10.16	9.73	84.66	103.66	94.33
Benzyl Adenine (100 ppm)	55.50	57.16	56.33	9.50	10.00	9.75	82.00	99.95	90.97
Naphthalene Acetic Acid (50 ppm)	47.66	50.00	48.83	8.88	9.200	9.04	85.33	108.00	96.66
Naphthalene Acetic Acid (100 ppm)	51.00	52.66	51.83	9.20	10.00	9.60	80.33	98.33	89.33
Naphthalene Acetic Acid (150 ppm)	51.66	54.33	53.00	9.40	10.10	9.75	75.33	95.00	85.16
Control	51.83	52.66	52.25	9.00	9.400	9.20	90.33	113.00	101.67
MEAN	53.48	56.25		9.53	10.05		83.16	104.30	
			C.D at 5%						
Cultivars (C)		0.055			0.36			3.71	
Treatments (G)		0.124			0.80			8.31	
Interaction(C × G)		N.S.			N.S.			11.7	

A.B- American Beauty
W.P- White Prosperity

GA_3 promotes vegetative growth and increases the photosynthetic and metabolic activities resulting in more transport and utilization of photosynthetic products which might have resulted in increased spike length. Similar results were also reported by Vijai Kumar and Singh (2005) in cv. Congo Song and Rajesh bhalla and Ajay Kumar (2007) in cv. White prosperity. Flower inducing ability of Benzyl adenine was reported by several workers under in vitro as well as in vivo conditions. Induction of flowering may be due to its ability to alter the assimilate distribution i.e. the theory of nutrient diversion (Sachs *et al.,* 1979).

Number of florets were maximum (10.05) in gladiolus cv. White prosperity (Table 3). All the plant growth regulators improved the number of florets with increased concentrations. Among the plant growth regulator treatments, GA_3 at 125 ppm increased the number of florets per spike (11.00) followed by GA_3 at 100 ppm (10.73), however minimum number of florets per spike was observed with BA at 25 ppm (8.96) (Table 3). Increase in number of florets per spike with treatments in gladiolus have been reported by Rajesh bhalla and Ajay Kumar (2007) in cv. White prosperity. Reduced number of florets with NAA might be due to reduced number of nodes which resulted in reduced plant height and spike length. Similar results were reported by Sharga (1979) and Bhattacharjee (1984) in gladiolus cv. Friendship.

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COMPARATIVE STUDY OF DIFFERENT FILLING MATERIALS OF MECHANISED SYSTEM OF RICE INTENSIFICATION (MSRI) IN A SEMI ARID REGION OF ANDHRA PRADESH

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ABSTRACT

The Mechanized System of Rice Intensification (MSRI) reportedly enhances the yields of rice (*Oriyza sativa* L.) through synergy among several agronomical management and engineering practices. This study was conducted to investigate on alternative tray filling materials to replace the soil media on crop growth, yield characteristics and yield attributes in The Mechanized System of Rice Intensification (MSRI). Focusing on the different alternative filling materials suitable to replace the soil media with 100% seed germination, Ten treatments with different combinations were experimented and a fine thin layer of well decomposed farm yard manure was spread over all ten treatments o bed filling material (i.e., T1 - 10% Groundnut Shell (GS) + 90% Soil; T2 - 10% Vermin-Compost (VC) + 90% Soil; T3 - 10% Rice Husk (RH) + 90% Soil; T4 - 25% Vermin-Compost (VC) + 75% Soil; T5 - 25% Rice Straw (RW) + 75% Soil;T6 - 25% Rice Husk (RH) + 75% Soil; T7 - 10% Rice Straw (RS) + 90% Soil; T8 - 25% Groundnut Shell (GS) + 75% Soil; T9 - Field Soil (100%) (MT); T10 - Manual Planting (MP)). Above all the filling material pH value was evaluated and was FYM-7.10, rice husk-7.9: rice straw powder -7.6: vermin- compost -6.4 and groundnut shell powder-7.8. The performance with respect to individual treatment of bed material significant difference was observed. The observation of transplanted hills was also noted in root growth and leaf number, Leaf Area Index and number of tillers and panicle number, panicle length and grain number per panicle, grain filling and 1000-grain weight and straw weight. The raising nursery with different bedding materials transplanted with machine significantly influenced grain yield per hectare. Among tested treatments highest grain yield per hectare was observed with T8 (25% GS) as 4858.5 kg/ha and followed by T4 (25% VC) as 4685 kg/ha. However, the lowest grain yield was recorded at 2212.6 kg ha^{-1} was observed in T6 (25% RH), due to lowest N, P, K contents in rice husk bed material. Finally it has been concluded that there is significant effect of bedding materials on crop growth and yield parameters.

KEYWORDS: MSRI, SRI, Yield and Crop Parameters.

INTRODUCTION

Rice (*Oryza Sativa* L.) is a member of Gramaine family and is relished as staple food. It is most important crop in India, covering an area of about 44 million hectares with an annual production of 90 million tonnes and productivity of 2086 kg/ha. Across South Asia, labour scarcity is a major problem and there is a need to explore establishment methods for rice that require less labour but still allow the crop to be transplanted on time. Mechanical transplanting of rice is the process of transplanting young rice seedlings, which have been grown in a tray nursery, using a self-propelled rice transplanter. In conventional manual transplanting practice, 8-12 laborers' are required to transplant one acre. However, if a self propelled rice transplanter is used, three people can transplant up to four acres in a day. The nursery was prepared in trays. Trays are filled with good soil and each tray is filled by approximately 5 kg soil required. The seed rate in nursery trays was 110-120 grams. The number of required nursery trays was 160 trays per hectare of the field. The seed rate was about 30 kg seed and 90 kg of soil for filling the trays is soil required for transplanting of 1 ha area. To fill the tray, dry soil need to be procured, pulverized and screened soil. The availability of dry soil during sowing season is very limited due to rains, hence the farmer need to procure dry soil in advance and stored in roofed structure. This is not only cost involving process but also time consuming process. To reduce the difficulty and reduce the cost of raising nursery the experiment was conducted to suggest suitable readily available (farm waste) alternative material for seed bed preparation in the trays for MSRI.

MATERIALS AND METHODS

The experiment was conducted at agricultural farm, Agricultural Research Station, Acharya N.G. Ranga

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Agricultural University, Perumalapalli, Tirupati, and Andhra Pradesh. Perumallapalli was geographically situated at 13.61°N latitude, 79.33°E longitude and at an altitude of 150 m above the mean sea level. The experimental plots were planted at a general spacing of 30 x 14 cm by using mechanical transplanter by running length wise of the field on the puddled and levelled. The seedlings were transplanted within 30 minutes after uprooting and 3-7 seedlings were placed in each hill. The water level in the field was kept at 2 cm only to avoid floating of seedlings. Four and five seedling per hill and young seedlings of 12 to 14 days old, quality seeds ensure vigorous seedling growth, absolute establishment in the field, uniform plant population and accelerated growth rate, resistance against pest and diseases and uniform maturity at harvest. Most importantly a quality seed was selected to have above 90 per cent germination rate.

For the experiment a fine thin layer of well decomposed farm yard manure (FYM) was spread over all the soil and different bed filling material (i.e., 10% Rise straw + 90 % soil, 25% rice straw +75% soi1, 10% vermi-compost, 25% vermi- compost+75 soi1,10% ground nut shell+ 90% soil, 25% ground nut shell+ 75% soil, 10% rice husk + 90% soil, 25% rice husk+ 75% soil and 100% soil) were used for rising nursery. Rice straw was used as a covering material over the trays for retention of soil moisture. The nursery was raised up to 15 days and the seedlings are transplanted on 17th day of sowing. Soil is an important resource exhausting day by day due to different reasons. The conservation of soil is important aspect to be considered. In MSRI, the basic material for filling tray is soil. It requires 6 kg of soil in one tray. For growing nursery for one acre 75 trays are required. It means it require 450 kg of soil. The requirement of soil for one hectare is 1125 kg which is more than one tonne per hectare. For excavation and transportation requires lot of labour and money. The excavation of soil also leads to imbalance of eco system. If this soil is replaced by any filling material which costs less than this cost of soil leads to compensate all the above problems.

RESULTS AND DISCUSSIONS

The following data were collected from the day of sowing of the crop for assessing the effect of soil media on growth parameters of the crop. For periodical observations 10 plants per each in experiment was selected randomly from each treatment and was tagged. Plant height, no of tillers and yield parameters. Plant height was measured at 15 DAT from date of transplanting. Numbers of tillers were measured at 30, 60 and 90 days after transplanting and the numbers of tillers were summed up to the previous number.

Number of tillers

Numbers of tillers at 15 DAT were numerically higher with treatment 10 (manual planting) as 6.75, whereas lowest number of tillers was at 15 DAT, 5.00 were observed in treatment 2 (10% WC). However number of tillers at 30 DAT showed significant variability among the treatments and highest tiller number was recorded with treatment 8 (25% GS) as 14.50 followed by treatment 10 (manual planting) as 13.25, whereas lowest number of tillers was at 30 DAT. 9.50 was observed in treatment 2. Number of tillers per plant was also varied significantly at 60 DAT and superiority of MSR1 method of transplanting was clearly evidenced compared to manual planting, which recorded lowest number of tillers per plant (24.00). Among the different nursery bedding materials, treatment 3 (10% RH) recorded highest number of tillers per plant (36.75) and other treatments T4 (36.50), T5 (34.50) T6 (35.00) and T8 (34.50) recorded at par values, whereas lowest number of tillers (23.7) were recorded in treatment 9 (field soil) as shown in Table 1 to was significantly influenced by different bedding material used for nursery rising.

The results were in accordance with the reports of Aime Severin Kima *et al.* (2014). This advantage of SRI method in enhancing tiller numbers has been reported by Gani *et al.* (2002).

Yield and Grain Yield Parameters

Grain Yield parameters i.e. panicle length, number of productive tillers, unproductive tillers, filled grains, unfilled grains and total grains are taken the data was analyzed with procedure of randomized block design. ANOVA test was performed at 5 per cent level of significance and the results are presented in table. The results revels that grain yield parameters i.e. the panicle length, number of productive tillers, unproductive tillers, filled grains, unfilled grains and total grains as shown in Table 2 was significantly influenced by different bedding material used for nursery rising .

Panicle length

Panicle length was height with treatment 9 (Field soil) as 20.90 cm, followed by T4 (25% VC) as 20.36 cm, T10 (manual planting) as 20.31 cm, T2 (10% VC) as

Table 1. Mean number of tillers per plant in different treatments at different days after transplantation

Treatments	Number of tillers at 15 days	Number of tillers at 30 days	Number of tillers at 60 days
T1	6.00	10.75[bc]	24.25[b]
T2	5.00	9.50[c]	25.25[b]
T3	6.00	10.25[bc]	36.75[a]
T4	6.00	11.50[abc]	36.50[a]
T5	6.25	12.75[ab]	34.50[a]
T6	5.25	13.00[ab]	35.00[a]
T7	6.00	11.75[abc]	25.00[b]
T8	6.50	14.50[a]	34.50[b]
T9	6.50	12.50[ab]	23.75[b]
T10	6.75	13.25[ab]	24.00[b]
Mean	6.02	11.97	28.95
CD (P = 0.05)	NS	1.86*	2.32*
CV (%)	22.07	15.21	7.83

* Significant at 5 % level of significant; NS-non significant

20.25 cm, T7 (10% RS) and T5 (25% RS) as 20.12 cm and 20.02 cm, T6 (25% RH), T8(25% GS) as 19.63, 19.38, whereas lowest panicle length was observed with T1 (10% GS)and T3 (10% RH)as 19.37 cm. This was in accordance with results of Srinivasulu *et al.* (2014)

Number of productive tillers

Number of productive tillers was highest with T2 (10% VC) as 39.45 followed by T4 (25% VC) as 31.37, T1 (10% GS) as 26.57, T8 (25% GS) as 26.15, T3 (10% RH) as 25.10, T5 (25% RS) as 24.50, T9 (Field soil) as 23.60, T7(10% RS) as 22.40 and T6(25% RH) as 21.77, whereas lowest number of productive tillers was observed as 20.80 with T10(manual planting).

Number of unproductive tillers

Number of unproductive tillers was highest in T6 (25% RH) as 3.62 followed by T2 (10% VC), T4 (25% VC) as 3.20, 3.05, T5 (25% RS) as 2.87, T8 (25% GS) as 2.77, T10 (manual planting) as 2.47, T3 (10%RH) as 2.40, whereas lowest number of unproductive tillers was observed as 2.37 with T1 (10% GS) and T7.

Number of filled grains

Number of filled grains was height T2 (10% VC) as 186.58 followed by T4 (25% VC) as 185.05, T10 (manual planting) as 177.70, T5 (25% RS) as 175.65, T3 (10% RH) as 173.33, T9 (field soil) as 172.65, whereas lowest number of filled grains was observed as 144.53 with T6 (25% RH), T1 as 159.33 with (10% GS) followed by T8 (25%GS) as 160.00 and T7 (10% RS) as 160.55.

Number of unfilled grains

Unfilled grains was height T5 (25% RS) as 24.32 followed by T10 (manual planting), T3 (10% RH), T4 (25% VC), T9 (field soil), T6 (25% RH), T2 (10% VC), T1 (10% GS) and T7 (10% RS) as 18.12, 15.40, 15.30, 13.75, 13.65, 13.55 and 12.80. Whereas lowest number of unfilled grains was observed as 10.90 with T8 (25% GS).

Total Grains

Total Grains was height T4 (25% VC) followed by T2 (10% VC), 5 (25% RS), 10 (manual planting), 3 (10% RH), 9 (Field soil), T1 (10% GS), T7 (10% RS) and T8 (25% GS) as 200.45, 200.22, 199.97, 195.90, 191.45, 187.95, 173.47, 173.35 and 170.90, whereas lowest total grains was observed as 158.27 with T6 (25% RH).

The DMRT test result of the treatment means at different treatment means are presented In Grain yield parameters i.e. panicle length, number of productive tillers, unproductive tillers, filled grains, unfilled grains

Table 2. Mean Plants heights, panicle length, Number of productive tillers, unproductive tillers, filled grains, unfilled grains and total grains in different treatments at different days after transplantation

Treatments	Panicle length (cm)	Number of productive tillers	Number of unproductive tillers	Filled grains	Unfilled grains	Total grains
T1	19.37^{c}	26.57^{c}	2.37^{bc}	159.93^{bc}	13.55	173.47^{bc}
T2	20.25^{ab}	39.45^{a}	3.20^{ab}	186.58^{a}	13.65	200.22^{a}
T3	19.37^{c}	25.10^{cd}	2.40^{bc}	173.33^{ab}	18.12	191.45^{ab}
T4	20.36^{ab}	31.37^{b}	3.05^{ab}	185.05^{a}	15.40	200.45^{a}
T5	20.02^{bc}	24.50^{cd}	2.87^{ab}	175.65^{ab}	24.32	199.97^{a}
T6	19.63^{bc}	21.77^{cd}	3.62^{a}	144.53^{c}	13.75	158.27^{c}
T7	20.12^{bc}	22.40^{cd}	2.37^{bc}	160.55^{bc}	12.80	173.35^{bc}
T8	19.38^{c}	26.15^{c}	2.77^{abc}	160.00^{bc}	10.90	170.90^{bc}
T9	20.90^{a}	23.60^{cd}	1.62^{c}	172.65^{ab}	15.30	187.95^{ab}
T10	20.31^{ab}	20.80^{d}	2.47^{abc}	177.70^{ab}	18.20	195.9^{0a}
Mean	19.97	26.17	2.67	169.59	15.60	185.19
CD (P = 0.05)	0.49*	3.14*	0.74*	15.01*	NS	13.40*
CV (%)	2.41	11.71	27.03	8.62	33.37	7.05

*Significant at 5% level of significant; NS - non significant

and total grains are taken. The DMRT test reveals that yield parameters. There is significant difference between treatment means with respect to yield parameters i.e. panicle length, number of productive tillers, unproductive tillers, filled grains, unfilled grains and total grains. Further treatments grouping was done based on DMRT for significant parameters. The result reveals that at panicle length, there is significant difference between T9 is on par with T4, T7 and T10. There is significant difference between T4 is on par with T10, T2, T7, T5 and T6. T7 is on par with T5, T8, T3 and T7.

DMRT test of number of productive tillers, there is significant difference between T6 with other groups. T1 is on par with T8, T3, T5, T9, T7 and T6. T3 is on par with T5, T9, T7, T6 and T10. The DMRT test reveals that, the number of unproductive tillers, there is no significant difference between T6 which is on par with T2, T4, T5, T8 and T10. There is no significance difference between T2, T4, T5, T8, T10, T3 and T1. There is significant difference between T8, T10, T3, T1 and T7. The DMRT test reveals that the filled grains, there is no significant difference between and T4, T10, T5, T3 and T9. There is no significant difference between T10, T7, T5, T3, T9, T7, T8 and T1. There is no significant difference between treatment means T7, T8, T1 and T6. The DMRT test reveals that the unfilled grains, there is no significant difference between treatment means. The DMRT test on total grains, T4 is on par with T2, T5, T10, T3 and T9. There is no significant difference between T3 and T9, T1, T7 and T8. There is no significant difference between T1 and T7, T8 and T6.

Yield parameters

Grain and straw yield and thousand grain weight of rice was significantly influenced by bedding materials used for rising nursery. The data was analyzed with standard procedure of randomized block design. Various Treatments (Bedding materials) are differing significantly

Table 3. Mean Grain yield, Straw yield and thousand grain weight in different treatments at different days after transplantation

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Thousand grain weight(g)
T1	4524.80[a]	5081.00[a]	13.77[a]
T2	4628.30[a]	4862.00[ab]	12.80[b]
T3	2765.80[c]	3600.00[c]	11.37[cde]
T4	4685.00[a]	4975.00[ab]	13.19[ab]
T5	2628.00[d]	2700.00[de]	10.94[cde]
T6	2212.60[e]	2300.00[e]	10.58[e]
T7	2765.80[d]	2853.50[d]	10.64[de]
T8	4858.50[a]	4903.80[ab]	13.96[a]
T9	4501.50[a]	4563.00[b]	11.53[cd]
T10	3565.50[b]	3674.50[c]	11.76[c]
Mean	3752.78	3944.52	12.05
CD (P = 0.05)	263.23*	284.41*	0.60*
CV (%)	6.83	7.02	4.85

* Significant at 5% level of significant; NS-non significant

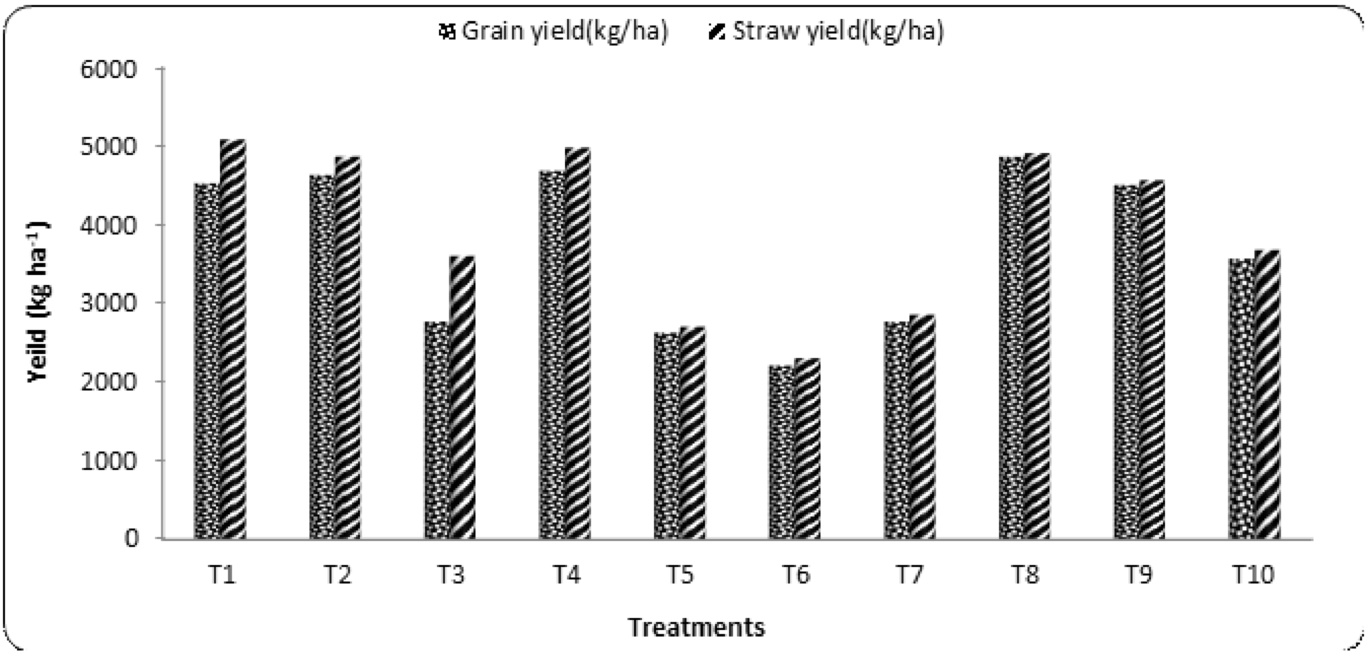

Fig. 1. Mean grain yield characteristics in different treatments at different days after transplantation

in respect of grain yield and straw yield and thousand grain weight at 5% level of significance as resulted in ANOVA test as shown in Table 3 was significantly influenced by different bedding material used for nursery rising.

Grain yield

The results revealed that raising nursery with field soil alone and mixed with different bedding material and transplanted with MSRI method significantly influenced by Grain yield per hectare was significantly higher with treatment 8 (25% GS) as 4858.5 kg/ha and other treatments 4 (4685.0 kg/ha), treatment 2 (4628.3 kg ha^{-1}) and treatment 1 (4524.8 kg ha^{-1}) recorded at par values. These treatments also showed significantly higher grain yield over manually transplanted treatment. Superiority of these treatments compared to field soil alone can be explained due higher N, P, K contents and higher seedling growth and early establishment in the field. Lowest grain yield of 2212.6 kg/ha was observed in treatment 6 (25% RH), due to lowest N, P, K contents in Rice husk.

Straw yield

Straw yield was also superior with the seedling transplanted by MSRI method compared to manually transplanted method (3674.5 kg ha^{-1}). Straw yield was also significantly higher with treatment T1 (5081.0 kg ha^{-1}) compared to other treatments followed by treatment 4 (4975.00 kg ha^{-1}), treatment 8(4903.8 kg ha^{-1}) and T2 (4862 kg ha^{-1}). Similar to grain yield lowest straw yield of 2300 kg ha^{-1} was also recorded in treatment 6 (25% RH). Kakamanu *et al.* (2011).

Thousand grain weight

Thousand grain weight is an important yield component which also influence grain yield. Thousand grain weight was also highest with treatment 8 (25% GS) as 13.86 g followed by treatment 1 (10% GS) as 13.77 g. Treatment 8, 3 and treatments are comparable to each other, where as lowest thousand grain weight, 10.58 g was observed in treatment 6 i.e. 25 per cent rice husk as observed in grain and straw yield.

The DMRT test result of the treatment means at different treatment means are presented in Grain, Straw yield and thousand grain weights, there is significant difference between treatment mean 6 with other groups. The DMRT test reveals that at grain yield (kg/ha), there is significant difference between treatment means with respect to grain yield (kg/ha), Straw yield and thousand grain weight. Further treatments grouping was done based on DMRT for significant parameters. The results revels that at grain yield (kg/ha), there is no significant difference between T8 and T4, T2, T1 and T9 was grouped ‘a’. There is significant difference between T10 and other means and was grouped with ‘b’. There is significant difference between T3 and other means and was grouped ‘c’. T7 is on par with T5. Treatment means of straw yield shown significant difference between T10 and T3 and other groups and was grouped ’c’. T1 is on par with T4, T8 and T2 was grouped. T4 is on par with T8, T2 and T9. T7 is on par with T5; T5 is on par with T6. Thousand grain weights means shown significant difference between all treatments with each other. T8 is on par with T1 and T2. T4 is on par with T2. T10 is on par with T9, T3 and T5. T9 is on par with T3, T5 and T7. T3 is on par with T5, T7 and T6. Comparatively highest grain yield with T8 (25%GS) because more nutrient value in groundnut shell useful for plant growth.Finally it has been concluded that there is significant effect of bedding materials used for rising nursery on Grain yield, Straw yield and thousand grain weights.

CONCLUSION

1. Among the ten different media viz; 10% RH, 10% RS, 10% VC, 10% GS, 25% RS, 25% RH, 25% GS, 25% VC and field soil. The picking performance of transplanting was good in the case of vermin compost and ground nutshell media. Higher yields were realised when bedding material was prepared in trays with groundnut shell and vermin compost media.

2. Higher yields were realised when groundnut shell and vermin compost was used as nursery tray bedding material in certain proportion, it may be due to better initial establishment in the main field.

3. By replacing soil with different bedding material of N, P and K values were 1.7, 0.72 and 1.9 percent; farmer not only benefitted by displacement soil but also improves the soil health by adding humus in to the soil strata.

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FACTORS AFFECTING THE UTILIZATION OF INTER-PERSONAL LOCALITE SOURCES BY THE RICE FARMERS

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ABSTRACT

With a view to know the utilization and credibility of various inter-personal localite sources as perceived by the rice growers, the study was conducted with Ex-post facto research design in SPSR Nellore district of Andhra Pradesh over a randomly drawn sample of 120 rice growing farmers as respondents. The results of the study revealed that educational status, social participation, mass media exposure, innovativeness, and scientific orientation were positively correlated with frequency of use of information sources and association was found significant at 1 per cent level. The r-values of farm size, annual income, extension contact showed positive correlation with frequency of use and association was found significant at 5% level of probability. Multiple Linear Regression (Step wise) of selected profile characteristics with the extent of use of information sources revealed that the the last model revealed only educational status i.e., intermediate; degree/post-graduation, secondary education and risk orientation had contributed significantly towards the extent of use of information sources. Further the Multiple Linear Regression (Step wise) of selected profile characteristics with the extent of use of information sources revealed that the last model revealed only educational status i.e., intermediate; degree/post-graduation, secondary education and risk orientation had contributed significantly towards the extent of use of information sources.

KEYWORDS: Inter-Personal Localite Sources, Correlation, MLR, Rice Farmers

INTRODUCTION

Information is considered as a vital resource, along with land, labour, capital and skills. People need information for their day-to-day activities and for the development of their environment and their selves. Information serves as the cornerstone of successful socio-economic development because it plays a key role in decision making. Access to reliable, timely and relevant information can help significantly and in many ways to reduce farmers' risk and uncertainty, empowering them to make good decisions. Information is vital for increasing production and improving marketing and distribution strategies. Hence timely, relevant, and accurate information collection is crucial to farmers. Information also opens windows of sharing experiences, best practices, sources of financial aids and new markets. Present Extension system is already under pressure due to wide ratio between the extension worker and farmers. In this situation, it is very difficult to provide latest information and farm technologies to the farmers in short time. To solve such problems, cost effective and efficient information support systems like Inter-personal localite, Inter-personal cosmopolite and Mass media sources/ Impersonal cosmopolite sources are very much required. Keeping in view the factual position, it was felt necessary to investigate the information source utilization pattern by the rice farmers.

MATERIAL AND METHODS

The study was conducted with expost-facto research design to study the information source utilization pattern of rice farmers. The SPSR Nellore district of Andhra Pradesh was purposively selected for the study because maximum number of rice farmers were involved in rice farming and having agriculture as main occupation. SPSR Nellore district comprises of 46 mandals out of which four mandals namely Nellore, Venkatachalam, Allur and Vidavalur mandals were purposively selected for the study. From each of the selected mandals, two villages were selected based on random sampling procedure. Thus, totally eight villages were selected for the study. A total sample of 120 rice farmers were selected by selecting 15 farmers from each village through simple random sampling procedure. Keeping in view the objectives of the study, a well structured interview schedule was developed and pretested. This was administered to sample respondents through personal investigation.

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RESULTS AND DISCUSSION

Correlation between the selected profile characteristics and frequency of use of information sources

In order to study the nature of relationship between the selected profile characteristics and the frequency of use of information sources by the rice farmers, correlation coefficients ('r' values) were computed and the values were presented in Table 2.

The r-values in Table 1 indicated that educational status (0.9429**), social participation (0.9042**), mass media exposure (0.4109**), innovativeness (0.3664**), and scientific orientation (0.3083**) were positively correlated with frequency of use of information sources and association was found significant at 1 per cent level. The r-values of farm size (0.1816*), annual income (0.2043*), extension contact (0.1864*) showed positive correlation with frequency of use and association was found significant at 5% level of probability. These results are in line with the findings of Arathy (2011) and Sriharinarayana (2013)

The r-values of age (-0.3623**) and farming experience (-0.3473**) were negatively correlated with frequency of use and association was found significant at 1% level of probability. These findings are in consonance with the findings of Meena and Sharma (2012) and Kumar *et al.* (2012)

The r- values of occupational status (-0.2283*) was negatively correlated with frequency of use and association was found significant at 5% level of probability.

The r-values of cosmopoliteness (0.1517) and risk orientation (0.0896) showed non-significant relation with frequency of use of information sources. These findings are in line with the findings of Meena and Aishwarya (2011), Ashok(2012) and Sahu *et al.*(2012).

From the above findings it could be inferred that, higher the educational status, social participation, mass media exposure, innovativeness and scientific orientation, higher would be the frequency of use information sources by the rice farmers. The variables age, farming experience and occupational status were negatively correlated with frequency of use of information sources. This could be explained as, younger the respondents, higher would be the frequency of use of information sources and vice versa. Similarly, lower the farming experience of the respondents, higher would be the frequency of use of information sources. The same trend was revealed in case of occupational status which could be explained as, the respondents with agriculture alone as main occupation lower would be their frequency of use of information sources.

As the cosmopoliteness increased, the frequency of use is increased but the relationship was non-significant. As the risk orientation increased, the frequency of use increased but the relationship was non-significant. It could be concluded that the frequency of use was independent of cosmopoliteness and risk orientation.

Correlation between the selected profile characteristics and extent of use of information sources

The r-values in Table 1 indicated that educational status (0.9729**), social participation (0.9325**), mass media exposure (0.3605**), innovativeness (0.3416**) and scientific orientation (0.2726**) were positively correlated with extent of use of information sources and association was found significant at 1 per cent level of probability. These findings are in consonance with the findings of Arathy (2011) Sahu *et al.* (2012).

The r-value of age (-0.3574**), farming experience (-0.3492**) and occupational status (-0.2558**) were negatively correlated with extent of use of information sources and association was found significant at 1 per cent level of probability.

The r-values of farm size (0.1165), annual income (0.1509), extension contact (0.1217), cosmopoliteness (0.1594) and risk orientation (0.0689) showed non-significant relation with extent of use of information sources. These findings are in line with the findings of Meena and Aishwarya (2011) and Sahu *et al.* (2012)

The above findings could be explained as, the higher the educational status, social participation, mass media exposure, innovativeness and scientific orientation, higher would be the extent of use information sources by the rice farmers.

The variables age, farming experience and occupational status were negatively correlated with the extent of use of information sources. This could be explained as, younger the respondents higher would be the extent of use of information sources and vice versa. Similarly, lower the farming experience of the respondents higher would be the extent of use of information sources. The same trend was revealed in case of occupational status

Table 1. Correlation between selected profile characteristics and the information source utilization patter (frequency of use and extent of use) by the rice farmers

(n= 120)

S. No.	Variable No	Independent variables	Correlation coefficients	
			Frequency of use ('r' value)	Extent of use ('r' value)
1	X_1	Age	-0.3623**	-0.3574**
2	X_2	Educational status	0.9429**	0.9729**
3	X_3	Farming experience	-0.3473**	-0.3492**
4	X_4	Farm size	0.1816*	0.1165NS
5	X_5	Occupational status	-0.2283*	-0.2558**
6	X_6	Annual income	0.2043*	0.1509NS
7	X_7	Social participation	0.9042**	0.9325**
8	X_8	Extension contact	0.1864*	0.1217NS
9	X_9	Mass media exposure	0.4109**	0.3605**
10	X_{10}	Cosmopoliteness	0.1517NS	0.1594NS
11	X_{11}	Innovativeness	0.3664**	0.3416**
12	X_{12}	Risk orientation	0.0896NS	0.0689NS
13	X_{13}	Scientific orientation	0.3083**	0.2726**

** : Correlation is significant at the 0.01 level
* : Correlation is significant at the 0.05 level
NS : Non significant

which could be explained as, the respondents with agriculture alone as main occupation lower would be their extent of use of information sources.

As the farm size increased, the extent of use is increased but the relationship was non-significant. As the annual income increased, the extent of use increased but the relationship was non- significant. As the extension contact increased the extent of use is increased but the relationship was non-significant. As cosmopoliteness increased, the extent of use is increased but the relationship was non-significant. As the risk orientation increased, the extent of use increased but the relationship was non-significant.

Multiple Linear Regression (Step wise) of selected profile characteristics with the information source utilization pattern

Step wise multiple linear regression has been carried out on 'frequency of use' and 'extent of use' separately by means of independent variables viz. age, educational status, farming experience, farm size, occupational status, annual income, social participation, extension contact, mass media exposure, cosmopoliteness, innovativeness, risk orientation and scientific orientation and results are summarized.

Table 2. Multiple Linear Regression –Coefficient table (Frequency of use)

Model		Unstandardized Coefficients		Standardized Coefficients	t-value	p-value
		B	Std. Error	Beta		
1	(Constant)	131.719	3.968		33.193	0.000
	Social participation	4.875	0.212	0.904	22.995	0.000
2	(Constant)	116.478	6.780		17.180	0.000
	Social participation	4.824	0.207	0.895	23.272	0.000
	Extension contact	0.562	0.206	0.105	2.736	0.007
3	(Constant)	123.777	7.284		16.992	0.000
	Social participation	4.361	0.278	0.809	15.690	0.000
	Extension contact	0.539	0.202	0.101	2.675	0.009
	Degree/PG	10.794	4.426	0.126	2.439	0.016
4	(Constant)	141.822	7.757		18.283	0.000
	Social participation	3.004	0.389	0.557	7.731	0.000
	Extension contact	0.485	0.186	0.091	2.604	0.010
	Degree/PG	31.172	5.991	0.363	5.203	0.000
	Inter	17.480	3.764	0.252	4.644	0.000
5	(Constant)	165.611	7.553		21.925	0.000
	Social participation	-0.197	0.589	-0.037	-0.334	0.739
	Extension contact	0.540	0.159	0.101	3.390	0.001
	Degree/PG	92.488	10.632	1.078	8.699	0.000
	Inter	59.887	7.203	0.864	8.314	0.000
	Secondary	29.182	4.434	0.463	6.581	0.000
6	(Constant)	163.721	4.988		32.826	0.000
	Extension contact	0.539	0.159	0.101	3.395	0.001
	Degree/PG	89.088	3.088	1.038	28.849	0.000
	Inter	57.652	2.669	0.832	21.601	0.000
	Secondary	27.958	2.491	0.444	11.222	0.000
7	(Constant)	161.839	4.925		32.862	0.000
	Extension contact	0.504	0.156	0.094	3.238	0.002
	Degree/PG	87.896	3.051	1.024	28.811	0.000
	Inter	57.304	2.610	0.827	21.959	0.000
	Secondary	27.374	2.443	0.434	11.204	0.000
	Farm Size	4.954	1.926	0.075	2.572	0.011

Table 3. Multiple Linear Regression –Coefficient table (Extent of use)

Model		Unstandardized Coefficients		Standardized Coefficients	t-value	p-value
		B	Std. Error	Beta		
1	(Constant)	67.526	2.845		23.737	0.000
	Social participation	4.262	0.152	0.932	28.043	0.000
2	(Constant)	70.002	2.541		27.554	0.000
	Social participation	3.960	0.143	0.866	27.643	0.000
	Inter	10.904	1.841	0.186	5.922	0.000
3	(Constant)	89.996	3.233		27.836	0.000
	Social participation	2.416	0.225	0.529	10.735	0.000
	Inter	23.626	2.177	0.402	10.855	0.000
	Degree/PG	27.668	3.461	0.380	7.994	0.000
4	(Constant)	105.277	3.505		30.038	0.000
	Social participation	0.489	0.336	0.107	1.453	0.149
	Inter	49.179	4.115	0.837	11.950	0.000
	Degree/PG	64.638	6.076	0.888	10.639	0.000
	Secondary	17.555	2.530	0.329	6.938	0.000
5	(Constant)	110.083	1.163		94.683	0.000
	Inter	54.729	1.538	0.932	35.584	0.000
	Degree/PG	73.083	1.776	1.005	41.151	0.000
	Secondary	20.591	1.434	0.385	14.356	0.000
6	**(Constant)**	**119.644**	**4.522**		**26.458**	**0.000**
	Inter	**55.184**	**1.528**	**0.939**	**36.119**	**0.000**
	Degree/PG	**73.277**	**1.750**	**1.007**	**41.872**	**0.000**
	Secondary	**20.683**	**1.412**	**0.387**	**14.647**	**0.000**
	Risk orientation	**-0.929**	**0.425**	**-0.044**	**-2.185**	**0.031**

Multiple Linear Regression (Step wise) of selected profile characteristics with the frequency of use of information sources

A close view of the Table 3 revealed that the last model revealed only three variables *viz.,* extension contact, educational status i.e. degree/Post-graduation; intermediate; secondary education and farm size had contributed significantly towards frequency of use of information sources.

Extension contact, educational status i.e. degree/ Post-graduation; intermediate; secondary education levels and farm size were the major variables to explain the frequency of use of information sources by the rice farmers. The combined effect of these three variables might had contributed to the behavior pattern of the rice farmers towards achieving the high frequency of use information sources.

Multiple Linear Regression (Step wise) of selected profile characteristics with the extent of use of information sources

The table 3 revealed that the the last model revealed only educational status i.e., intermediate; degree/post-graduation, secondary education and risk orientation had contributed significantly towards the extent of use of information sources.

Educational status i.e. intermediate; degree/Post-graduation, secondary education levels and risk orientation were the major variables to explain the extent of use of information sources by the rice farmers. The combined effect of these two variables might had contributed to the behavior pattern of the rice farmers towards achieving the high extent of use of information sources.

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