Andhra Pradesh Journal of
Agricultural Sciences

Volume 7 **Number 4** **October – December, 2021**

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Andhra Pradesh J Agril. Sci : 7(4): 193-197, 2021

PERFORMANCE OF DIFFERENT PRE-EMERGENCE HERBICIDES ON WEED GROWTH, NUTRIENT UPTAKE AND YIELD OF FOXTAIL MILLET

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Date of Receipt: 22-07-2021 Date of Acceptance: 24-09-2021

ABSTRACT

A field experiment was conducted during *kharif* 2020 at S.V. Agricultural College, Tirupati, Andhra Pradesh to identify the performance of different pre-emergence herbicides on weed growth, nutrient uptake and yield of foxtail millet. The present study has revealed that the lowest weed density and weed dry weight as well as higher WCE including nutrient uptake of foxtail millet were recorded with HW twice (W_{10}) at 20 and 40 DAS followed by PE application of pretilachlor 500 g ha^{-1} *fb* intercultivation at 20 DAS (W_4). Heavy weed infestation in unweeded check drained nutrient uptake by 45.67, 18.03 and 35 kg ha^{-1} of nitrogen, phosphorous and potassium, respectively. Hand weeding twice obtained higher grain yield, but benefit-cost ratio was lag behind the best weed management practice *i.e.,* PE application pretilachlor 500 g ha^{-1} *fb* intercultivation at 20 DAS.

KEYWORDS: Broad-spectrum, Intercultivation, Nutrient uptake, Pre-emergence herbicide, Pretilachlor

INTRODUCTION

Foxtail millet (*Setaria italic* (L.) Beauv) a member of the family Poaceae, is highly drought resistant crop grown under rainfed condition and produces high quality grains than many other cereals under extreme conditions like unfertile soil, intense heat and prolonged drought. In India, the cultivation of foxtail millet is confined to Andhra Pradesh, Karnataka and Tamil Nadu. Generally, small millets are relatively poor competitors for growth resources than weeds, especially during the early stages of the crop. The critical period of crop-weed competition in finger millet was up to four weeks after sowing, to obtain higher grain yield (Nanjappa and Hosmani, 1985). Pre-emergence herbicide improves the weed control and production efficiency in major millets due to their bigger seed size and comparatively deeper depth of sowing than small millets. The yield potential of minor millets including foxtail millet has been very low under rainfed areas because of lack of good management practices (Pandey *et al*., 2018). Keeping the facts in view, the present investigation was undertaken to know the performance of different pre-emergence herbicides on nutrient uptake and yield of foxtail millet.

MATERIAL AND METHODS

A field experiment was conducted during *kharif*, 2020 at wetland farm of S.V. Agricultural College, Acharya N.G. Ranga Agricultural University, Tirupati, Andhra Pradesh in foxtail millet. The experimental field was sandy clay loam in texture which is low in organic carbon (0.35%). The soil is neutral in reaction (pH 6.9), low in available N (176.0 kg ha^{-1}), high in available phosphorus (38 kg ha^{-1}) and potassium (232.0 kg ha^{-1}). The experiment was laid out in a randomized block design with eleven treatments and replicated thrice. Foxtail millet was sown at a spacing of 30 × 10 cm on 14th August, 2020. The weed management practices consisted of pre-emergence (PE) application of pretilachlor, isoproturon and pyrazosulfuron-ethyl 500, 500 and 15 g ha^{-1}, respectively. All the pre-emergence herbicides were supplemented with intercultivation or post-emergence application of penoxsulam 20 g ha^{-1} at 20 DAS. Hand weeding twice and unweeded check were also included as standard checks (Table 1). Pre-emergence herbicides were applied at 1 DAS and intercultivation / post-emergence herbicide, penoxsulam was applied at 20 DAS. All the pre-and post-emergence herbicides were applied with the help of knapsack sprayer fitted with flat fan nozzle and spray volume of 500 L ha^{-1}. Uniform dose of 20 kg N and 20 kg P_2O_5 ha^{-1} was applied in the form of urea and single super phosphate respectively to all the plots. Nitrogen in the form of urea was applied in two splits *viz*., half of the dose as basal and the remaining half of the dose as top dressing at 30 DAS and entire dose of phosphorous in the form of single super phosphate was

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applied as basal at the time of sowing itself. The rest of the packages of practices were adopted as per recommendations of the Acharya N.G. Ranga Agricultural University. Weed density and dry weight were recorded randomly with the help of 0.25 m^2 quadrate. The data on weed density and dry weight were transformed to square root ($\sqrt{X+0.5}$) transformation to normalize their distribution. Weed control efficiency was computed as per the method suggested by Mani *et al.* (1973). The crop was harvested on 5th November, 2020. The nutrient uptake (kg ha^{-1}) by crop and weeds was calculated as per the methods suggested by (Subbiah and Asija, 1956; Olsen *et al*., 1954) respectively at harvest in foxtail millet. Plant height and dry matter production, yield attributes, grain and straw yield were recorded at harvest as per the standard procedure. The net returns were arrived at by deducting the cost of cultivation from gross returns for the corresponding treatments. Benefit-cost ratio was calculated after dividing gross returns with cost of cultivation.

RESULTS AND DISCUSSION

Weed growth

The lowest density and dry weight of all the categories of weeds were noticed with HW twice which was significantly lesser than rest of the weed management practices tried. These results are in agreement with the findings of Patil *et al.* (2013). The next best treatment was the PE application of pretilachlor 500 g ha^{-1} *fb* intercultivation at 20 DAS, which was comparable with the PE application of pyrazosulfuron-ethyl 15 g ha^{-1} *fb* intercultivation at 20 DAS and isoproturon 500 g ha^{-1} *fb* intercultivation at 20 DAS. These results are in conformity with the findings of Yathisha *et al*. (2020). The higher density and dry weight of total weeds was noticed with PE application of isoproturon 500 g ha^{-1} *fb* penoxsulam 20 g ha^{-1} at 20 DAS among the herbicidal treatments. These results are in conformity with findings of Mishra *et al*. (2016). Pre-emergence application of pretilachlor 500 g ha^{-1} *fb* intercultivation at 20 DAS resulted in lesser density and dry weight of total weeds with higher WCE, which was statistically similar to PE application of pryrazosulfuron-ethyl 15 g ha^{-1} *fb* intercultivation at 20 DAS and both of them were significantly less effective in obtaining broad-spectrum weed control than HW twice. Among the herbicidal treatments, significantly higher density and dry weight of weeds as well as lower WCE were obtained with PE application of isoproturon 500 g ha^{-1} *fb* penoxsulam 20 g ha^{-1} applied at 20 DAS.

Nutrient uptake

The lowest nutrient uptake by weeds at harvest was associated with HW twice which was significantly lesser than rest of the treatments. Pre-emergence application of pretilachlor 500 g ha^{-1} *fb* intercultivation was found to be the next best treatment in reducing nutrient drain by weeds. This might be due to control of all weeds and thereby reduced the dry weight of total weeds leading to decreased nutrient uptake in these weed management practices. The nutrient loss due to heavy weed infestation in unweeded check (W_{11}) was 45.67, 18.03 and 35 kg ha^{-1} of nitrogen, phosphorus and potassium, respectively (Table 1). Significantly higher uptake of nitrogen, phosphorus and potassium by foxtail millet at harvest was recorded with HW twice than rest of the weed management practices. Pre-emergence application of pretilachlor 500 g ha^{-1} *fb* intercultivation at 20 DAS resulted in higher nutrients uptake by crop, which was at par with PE application of pyrazosulfuron-ethyl 15 g ha^{-1} *fb* intercultivation (W_6) and isoproturon 500 g ha^{-1} *fb* intercultivation. These three weed management practices offered broad-spectrum weed control during the critical period of crop-weed competition of crop growth that lead to increased plant height, and dry matter production and thereby increased uptake of nutrients by crop. These results are in conformity with findings of Pandey *et al.* (2018). Pre-emergence application of pretilachlor 500 g ha^{-1} *fb* intercultivation resulted in higher uptake of 63.33, 16.93 and 57.00 kg ha^{-1} of nitrogen, phosphorus and potassium respectively (Table 2). The above said weed management practices resulted in higher harvest index of foxtail millet.

Yield and Economics

Hand weeding twice at 20 and 40 DAS resulted in higher grain and straw yield which was significantly higher than rest of the weed management practices. The next best weed management practice in obtaining higher grain and straw yield was PE application of pretilachlor 500 g ha^{-1} *fb* intercultivation (Table 2). The reduction in grain yield of foxtail millet in unweeded check (W_{11}) and PE application of isoproturon *fb* penoxsulam was 63.41 and 70.63 per cent compared to best weed management practices *i.e*., HW twice.The highest net returns and benefit-cost ratio was obtained with PE application of

Table 1. Weed growth, weed control efficiency (%) and nutrient uptake (kg ha^{-1}) by weeds as influenced by different weed management practices in foxtail millet

Treatments	Dose (g ha^{-1})	Time of application (DAS)	Weed density m^{-2}	Weed dry weight (g m^{-2})	WCE (%)	Nutrient uptake by weeds (kg ha^{-1})		
						Nitrogen	Phosphorus	Potassium
Pretilachlor	500	1	(131.67) 11.49	(94.37) 10.06	27.34	30.00	13.33	22.67
Isoproturon	500	1	(133.33) 11.57	(95.93) 10.14	26.13	32.33	14.00	24.17
Pyrazosulfuron-ethyl	15	1	(132.50) 11.53	(95.60) 10.12	26.39	30.50	13.00	23.67
Pretilachlor *fb* IC	500	1 + 20	(69.33) 8.36	(32.07) 5.70	75.31	11.67	6.00	12.00
Isoproturon *fb* IC	500	1 + 20	(72.00) 8.51	(36.77) 6.07	71.69	14.20	6.67	14.17
Pyrazosulfuron-ethyl *fb* IC	15	1 + 20	(70.00) 8.40	(35.73) 6.01	72.48	13.33	7.00	13.33
Pretilachlor *fb* penoxsulam	500 + 20	1 + 20	(104.33) 10.24	(68.40) 7.39	47.33	24.67	10.33	19.00
Isoproturon *fb* penoxsulam	500 + 20	1 + 20	(161.00) 12.70	(117.27) 11.56	9.70	36.33	16.23	30.67
Pyrazosulfuron-ethyl *fb* penoxsulam	15 + 20	1 + 20	(106.50) 10.34	(69.60) 7.45	46.41	26.33	10.63	19.33
Hand weeding		20 + 40	(21.33) 4.67	(8.50) 2.98	93.45	5.00	2.00	5.67
Unweeded check			(192.33) 13.89	(129.87) 13.20	-	45.67	18.03	35.00
LSD (p = 0.05)			1.06	0.84		2.53	1.07	2.37

Data given in parenthesis are original values. Original data subjected to square root transformation.
WCE : weed control efficiency; IC : Intercultivation; *fb* : followed by

Table 2. Growth, yield and nutrient uptake (kg ha^{-1}) by crops as influenced by different weed management practices in foxtail millet

Treatments	Dose (g ha^{-1})	Time of application (DAS)	Plant height (cm)	Dry matter production (kg ha^{-1})	Nutrient uptake by crop (kg ha^{-1})			Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)	Net returns (₹ ha^{-1})	Benefit-cost ratio
					Nitrogen	Phosphorus	Potassium					
Pretilachlor	500	1	105	4617	41.33	11.17	48.33	1309	3008	30.37	18815	1.86
Isoproturon	500	1	105	4604	36.67	10.33	46.00	1182	2962	28.02	14900	1.68
Pyrazosulfuron-ethyl	15	1	105	4611	40.00	11.00	45.67	1284	2978	30.12	18363	1.85
Pretilachlor *fb* IC	500	1+20	117	5754	63.33	16.93	57.00	1961	3592	35.42	35077	2.37
Isoproturon *fb* IC	500	1+20	116	5298	59.67	15.83	55.00	1660	3348	33.55	25813	2.11
Pyrazosulfuron-ethyl *fb* IC	15	1+20	116	5380	62.00	16.33	55.00	1745	3435	33.75	28834	2.14
Pretilachlor *fb* penoxsulam	500 + 20	1+20	77	3297	25.67	6.00	29.33	779	2438	24.22	2241	1.09
Isoproturon *fb* penoxsulam	500 + 20	1+20	67	3220	21.00	5.33	26.67	690	2250	23.47	472	1.02
Pyrazosulfuron-ethyl *fb* penoxsulam	15 + 20	1+20	76	3256	23.00	5.00	28.33	724	2397	22.92	1483	1.06
Hand weeding		20+40	128	6496	73.00	19.67	64.67	2353	3944	37.47	34867	1.92
Unweeded check			93	3951	25.33	6.17	31.00	861	2881	22.92	7077	1.35
LSD (p = 0.05)			10	4617	4.51	1.27	4.60	315	419	4.11	4634	0.17

pretilachlor 500 g ha^{-1} *fb* intercultivation at 20 DAS. Hand weeding twice was lag behind in obtaining benefit-cost ratio than above weed management practice due to increased cost of weeding.

The present field experiment has revealed that pre-emergence application of pretilachlor 500 g ha^{-1}*fb* intercultivation at 20 DAS resulted in higher grain yield and benefit-cost ratio, apart from obtaining broad-spectrum weed control and nutrient uptake in foxtail millet in sandy clay loam soils of Southern Agroclimatic Zone of Andhra Pradesh. Hand weeding twice obtained higher grain yield, but benefit-cost ratio was lag behind the best weed management practice *i.e.,* PE application pretilachlor 500 g ha^{-1} *fb* intercultivation at 20 DAS (W_4). The present experiment indicated that wherever the labour availability for hand weeding is abundant and cheaper, one can go for hand weeding or opt for the said herbicide recommendation taking into the economical considerations.

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Andhra Pradesh J Agril. Sci : 7(4): 198-203, 2021

EFFECT OF GAMMA IRRADIATION ON THE SURVIVAL AND DEVELOPMENT OF GROUNDNUT BRUCHID, *Caryedon* spp. (COLEOPTERA : BRUCHIDAE)

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Date of Receipt: 26-07-2021 Date of Acceptance: 29-09-2021

ABSTRACT

A study was conducted on the effect of gamma irradiation on survival and progeny development of groundnut bruchid, *Caryedon* spp. (Coleoptera : Bruchidae) 2020-21. Freshly emerged adults were exposed to different doses of gamma irradiation *viz.*, 10, 30, 50, 100, 250 and 500 Gy along with an untreated control. Five days after gamma irradiation, all the adult bruchids were killed at 250 Gy and higher doses compared to 100 per cent survival in the untreated control. All the irradiated adults laid the eggs in the range of 172.33 to 89.67 eggs between 10 Gy to 100 Gy doses compared to 237 eggs/100 pods in untreated control. The sterile eggs were laid by the irradiated adults and there was no embryonic development from the dose of 30 Gy onwards. Bruchid emergence was not recorded from 20 Gy dose onwards. Hence, the groundnut bruchids require 250 Gy for acute mortality within five days of treatment but 30 Gy dose is sufficient to induce sterility in adults and in suppressing the F_1 population build up in groundnut. Gamma irradiation was proved to be an effective alternative measure for the management of *Caryedon* spp. in stored groundnut.

KEYWORDS: Groundnut, Gamma irradiation and Gy.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.), is the major oilseed crop in India which is widely grown for its high-quality edible oil and food use in the tropical and subtropical regions of the world. Globally, India ranks first in groundnut area and the second largest producer with 101 lakh tonnes with a productivity of 1816 kg ha^{-1} in 2020-21 (Anonymous, 2021a) Groundnut outlook report, 2021). In Andhra Pradesh groundnut is cultivated in 6.61 lakh hectares with a production of 8.50 lakh tonnes and productivity of 1285 kg ha^{-1} (Agricultural statistics at a glance - A.P., 2019-20). Indian groundnut has great export potential and exported 6.38 lakh tonnes which earned about 5381 crores during 2020-21 (Anonymous, 2021b).

Groundnut bruchid, *Caryedon* spp. is the most potential and economically important insect pest contributing significant post-harvest losses and deterioration of seed quality in stored groundnut (Redlinger and Davis, 1982). It is the only insect pest that can infest kernels inside the intact pods (Devi and Rao, 2005).

Groundnut has a greater export potential and the groundnut bruchid is an important quarantine pest which was not reported from many countries. Chemical insecticides such as fumigants, disinfectants and grain protectants are powerful components in stored grain pest management. Over the past three decades, with the gradual phase-out of methyl bromide there has been an over reliance on phosphine fumigation. Due to continuous usage of phosphine fumigation in storage godowns, phosphine resistance has been increased in frequency, distribution and strength in many storage pests and that was worsened further by the lack of suitable alternatives (Nayak *et al.,* 2019).

Interest in the use of gamma irradiation as a phytosanitary treatment for agricultural commodities is growing worldwide particularly since the publication of the International plant protection convention standard that endorses and facilitates trade based on this disinfestation method (Follett *et al*., 2007; Gasemzadeh *et al.,* 2010). Gamma irradiation may be an effective and economically feasible alternative method for disinfestation of insects (Tilton and Brower, 1987).

The advantage of gamma irradiation over chemical fumigation has been demonstrated extensively as it is residue free treatment (Tuncbilek, 1995). Most insects can be controlled with doses of less than 0.3 k Gy but some stored product moths may require doses as high as 1 k

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Gy (Follett and Neven, 2006). The information on the effective dosage of gamma irradiation for the control of *Caryedon* spp. in groundnut is very scanty. So, present study of management of groundnut bruchid, *Caryedon* spp. using gamma irradiation technique is proposed and conducted.

MATERIAL AND METHODS

The insect culture of *Caryedon* spp. was collected from groundnut storage godown of Regional Agricultural Research Station, Tirupati, Andhra Pradesh. The obtained insect culture was maintained under laboratory conditions on locally available groundnut variety, Dharani. For mass multiplication of the bruchid adults, about twenty-five pairs of adult beetles were released into plastic containers (30x15 cm) containing 1 Kg of disinfested groundnut pods and the mouth of the container was covered with muslin cloth and tied with rubber bands. The jars were kept undisturbed under laboratory conditions till the emergence of F_1 adults. The bruchids were mass multiplied in the laboratory for about 4-5 generations and the freshly emerged adults were used in the studies. Adult bruchids were exposed to gamma radiation at different dosages *viz*., 10 Gy, 30 Gy, 50 Gy, 100 Gy, 250 Gy and 500 Gy by a Cobalt-60 Gamma irradiator (Gamma Chamber 5000) facility available at ICAR-Indian Institute of Horticultural Research (IIHR), Bengaluru. The irradiated insects were released in to the plastic containers and fed with groundnut kernels. An untreated control without subjecting to irradiation was maintained for comparison. The observations on adult mortality, number of eggs laid per 100 pods, number of F_1 adults emerged were recorded.

RESULTS AND DISCUSSION

The Mortality of *Caryedon* spp. adults was recorded at 1, 3, 5, 7, 10, 15 and 20 days after gamma irradiation treatment (Table 1). One day after treatment, no mortality was recorded up to 50 Gy dose but mortality was recorded as 1.67, 10.00 and 23.33 per cent at 100, 250 and 500 Gy respectively.

Three days after treatment, there was no mortality in adult *Caryedon* spp.in untreated control and the irradiated adults up to 50 Gy, while mortality was recorded as 8.33, 41.67and 68.33 per cent at 100, 250 and 500 Gy, respectively. Five days after treatment, 100 per cent mortality was observed at 250and 500 Gy whereas, mortality was observed to be 31.67per cent at 100 Gy compared to nil mortality in untreated control (Figure 1).

Seven days after treatment, no mortality was recorded in untreated control and at 30 Gy dose. The mortality recorded was 6.67 and 61.67 per cent at50 and 100 Gy, respectively. 100 per cent mortality of *Caryedon* spp. was recorded at 250 Gy.

Ten days after treatment, mortality recorded was 10.00, 23.34, 33.34 and 83.33 per cent in 10, 30, 50 and 100 Gy, respectively. There was 100 per cent mortality at 250 Gy compared to 6.67 per cent mortality in untreated control. Fifteen days after treatment, the mortality per cent recorded was 16.67, 26.67, 53.34 and 70.00 per cent at 0, 10, 30 and 50 Gy, respectively. 100 per cent mortality was observed at 100 250 Gy compared to 16.67 per cent mortality in untreated control.

Twenty days after treatment, 93.34 per cent mortality was recorded at 10 Gy. There was 100 per cent mortality observed in all other irradiation doses compared to 86.67 per cent mortality in untreated control.

Effect of Gamma Irradiation on Oviposition of Irradiated Adults

The number of eggs laid by the irradiated bruchid adults decreased gradually with the increase in irradiation dosage. The highest eggs laid by the irradiated adults were 172.33, 136.00, 118.67 and 89.67 eggs/100 pods at 10, 30, 50 and 100 Gy doses, respectively. No oviposition was observed by the irradiated adults at 250 Gy compared to 237.00 eggs/100 pods in untreated control (Table 1 and Figure 2).

Effect of Gamma Irradiation on F_1 Adult Emergence

The number of emerging F_1 adults decreased with increased irradiation dose and the adult emergence was stopped at 30 Gy. F_1 adult emergence noted was 74.82 and 11.61 per cent at 0 and 10 Gy, respectively. This shows that sterile eggs were laid by the irradiated adults from 30 Gy onwards.

Five days after treatment, 100 per cent mortality was achieved at 250 Gy which was found to be effective in controlling adults of groundnut bruchid *Caryedon*spp. No eggs were laid by the irradiated adults at 250 Gy. Sterile eggs were laid by the irradiated adults at 30 Gy from which the adults were not emerged out. Irradiation dose of 30 Gy was found to cause complete sterility in *Caryedon* spp. (Table 1 and Figure 2).

Table 1. Effect of gamma irradiation on adult mortality and F_1 adult emergence of groundnut bruchid, *Caryedon* spp.

Treatment	Irradiation dose	Per cent mortality of irradiated adults**							Average no. of eggs laid/100 pods*	Average no. of F_1 adults emerged from 100 pods*	Per cent F_1 adult emergence**
		1 DAT	3 DAT	5 DAT	7 DAT	10 DAT	15 DAT	20 DAT			
T_1	Control	0.00 $(0.00)^a$	0.00 $(0.00)^a$	0.00 $(0.00)^a$	0.00 $(0.00)^a$	6.67 $(12.29)^a$	16.67 $(23.86)^a$	86.67 $(68.86)^a$	237.00 $(15.41)^e$	177.33 (13.35)c	74.82 $(60.26)^c$
T_2	10 Gy	0.00 $(0.00)^a$	0.00 $(0.00)^a$	0.00 $(0.00)^a$	0.00 $(0.00)^a$	10.00 $(15.00)^{ab}$	26.67 $(30.00)^a$	93.34 $(77.71)^b$	172.33 $(13.16)^d$	20.00 (4.57)b	11.61 $(19.86)^b$
T_3	30 Gy	0.00 $(0.00)^a$	0.00 $(0.00)^a$	0.00 $(0.00)^a$	0.00 $(0.00)^a$	23.34 $(24.15)^{ab}$	53.34 $(46.92)^b$	100.00 $(90.00)^c$	136.00 $(11.70)^c$	0.00 $(1.00)^a$	0.00 $(0.00)^a$
T_4	50 Gy	0.00 $(0.00)^a$	0.00 $(0.00)^a$	0.00 $(0.00)^a$	6.67 $(12.29)^a$	33.34 $(34.14)^b$	70.00 $(57.29)^b$	100.00 $(90.00)^c$	118.67 $(10.94)^c$	0.00 $(1.00)^a$	0.00 $(0.00)^a$
T_5	100 Gy	1.67 $(4.31)^a$	8.33 $(16.60)^a$	31.67 $(33.55)^b$	61.67 $(52.40)^b$	83.33 $(66.26)^c$	100.00 $(90.00)^c$	100.00 $(90.00)^c$	89.67 $(9.52)^b$	0.00 $(1.00)^a$	0.00 $(0.00)^a$
T_6	250 Gy	10.00 $(18.43)^b$	41.67 $(40.20)^b$	100.00 $(90.00)^c$	100.00 $(90.00)^c$	100.00 $(90.00)^c$	100.00 $(90.00)^c$	100.00 $(90.00)^c$	0.00 $(1.00)^a$	0.00 $(1.00)^a$	0.00 $(0.00)^a$
T_7	500 Gy	23.33 $(28.86)^c$	68.33 $(56.03)^c$	100.00 $(90.00)^c$	100.00 $(90.00)^c$	100.00 $(90.00)^c$	100.00 $(90.00)^c$	100.00 $(90.00)^c$	0.00 $(1.00)^a$	0.00 $(1.00)^a$	0.00 $(0.00)^a$
	SEM	1.63	0.78	2.82	3.64	7.04	3.34	2.54	0.24	0.12	0.91
	SED	2.302	1.110	3.985	5.143	9.957	4.729	3.590	0.334	0.166	1.287
	CD @ 5%	4.94	2.38	8.55	11.03	21.36	9.69	7.70	0.72	0.36	2.76

DAT : Days after treatment; Average : Mean of three replications;
* : Figures in parentheses are square root transformed values;
** : Figures in parentheses are angular transformed values
Means followed by same letters are not significantly different by DMRT

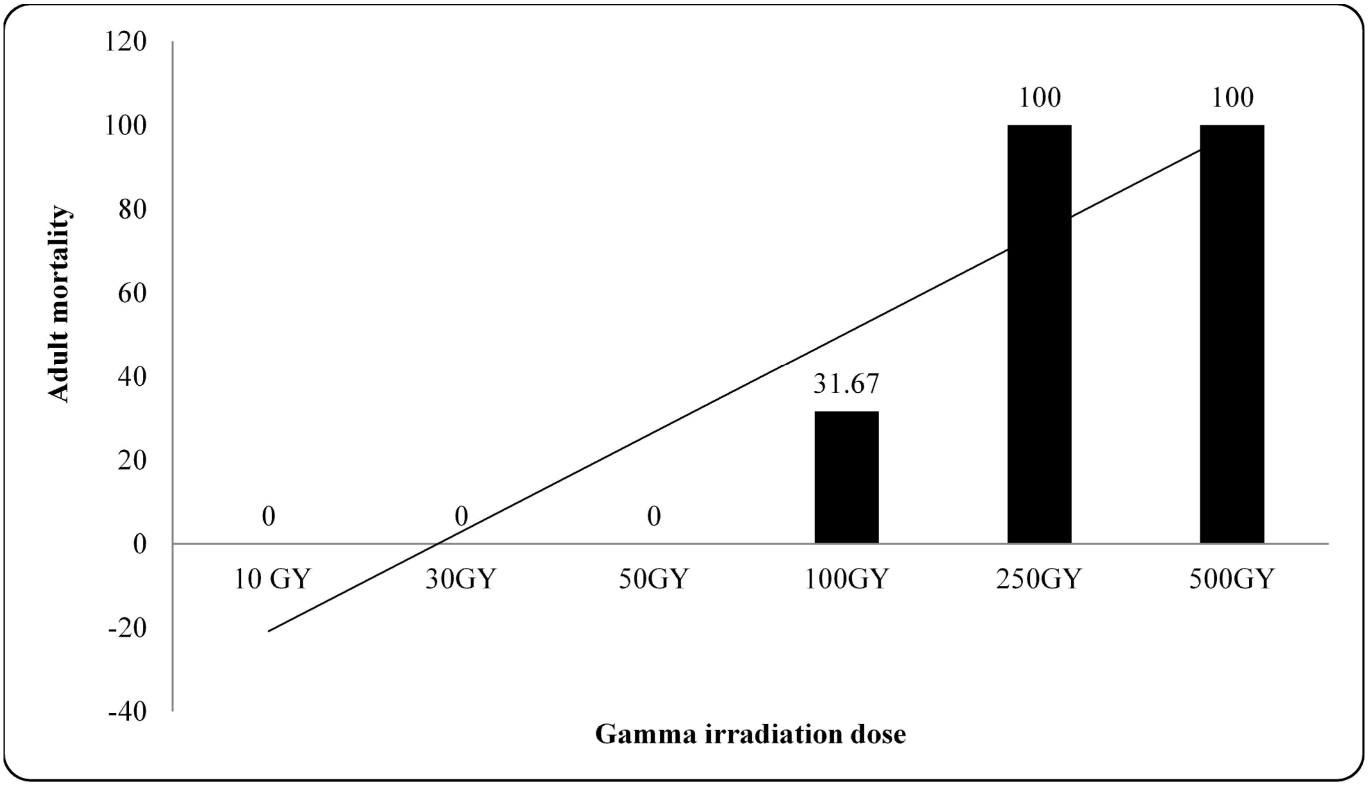

Figure 1. Effect of Gamma irradiation on groundnut bruchid mortality at 5 days after treatment.

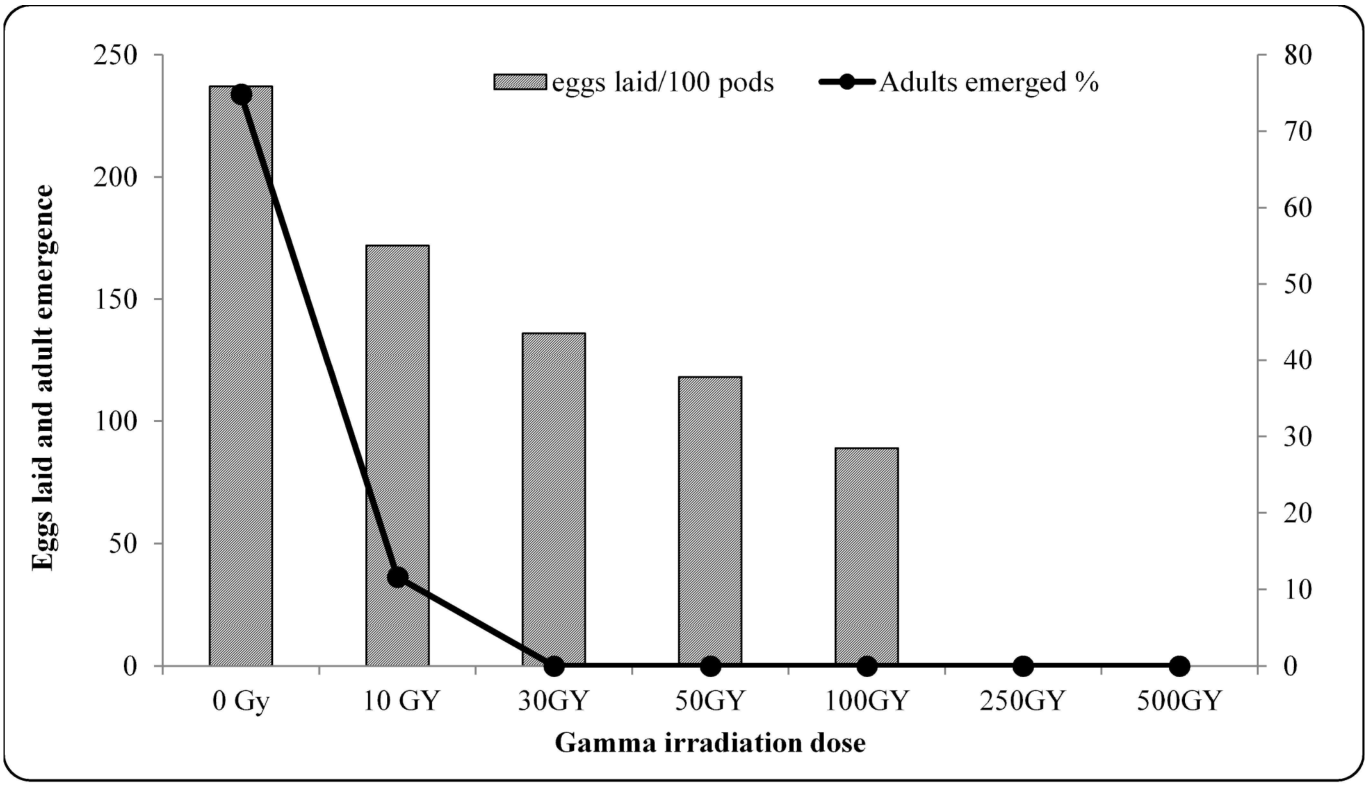

Figure 2. Effect of gamma irradiation on oviposition and F_1 adult emergence of *Caryedon* spp.

According to Tilton and Brower (1987), a dosage of 500 Gy would effectively control all stored product pests by inhibiting reproduction or adult emergence rather than causing acute death, which would need considerably larger doses. Higher doses of radiation were necessary to cause insect mortality but low doses of radiation can cause insect sterilisation or genetically damaged gametes (Molin, 2001). According to Tilton (1974), the dosages necessary to sterilise stored product insects might vary greatly, with the *Callosobruchuschinensis* requiring 70 Gy. Similar results were reported by Hussain and Imura (1989) that a dose of 640 Gy caused instant kill of the mature pupae and one day old adults but complete sterility was obtained at 80 Gy in the 1-day old adults of *C. chinensis*.

According to Boshra (1994), gamma radiation dose required to sterilize *C. chinensis* adults was 120 Gy. According to the International Atomic Energy Agency (IAEA 2002), 100 Gy is the minimum dosage necessary to sterilise *C. maculatus* adults. Soumya *et al*. (2017) suggested that 50 Gy was the optimal dosage for inducing sterility in *C. chinensis*. According to Hammad *et al.* (2020), at a dose of 1250 Gy no emerging adults were seen but 650 Gy is sufficient for suppression of F_1 population.

Gamma irradiation was found to be an effective technique to control the groundnut bruchid, *Caryedon* spp. in stored groundnut. A dose of 250 Gy effectively controlled the bruchid insects with 100 per cent adult mortality after five days of exposure to gamma radiation. The egg laying of irradiated adults was totally stopped at 250 Gy dose. But the low dose of 30 Gy was optimal dose to induce sterility in bruchid female insects to lay sterile eggs and complete inhibition of reproduction and F1 adult emergence. Gamma irradiation of ground nut pods is the viable alternative to phosphine fumigation which can be explored for exporting bruchid free groundnut consignments to other countries.

ACKNOWLEDGEMENTS

The authors would like to thank the ICAR-Indian Institute of Horticultural Research (IIHR), Bengaluru for providing Cobalt-60 Gamma irradiator (Gamma Chamber 5000) facility and thanks are also to Acharya N.G. Ranga Agricultural University, Guntur for all the facilities extended during the period of my study.

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Andhra Pradesh J Agril. Sci : 7(4): 204-209, 2021

SEQUENTIAL APPLICATION OF HERBICIDES AND THEIR IMPACT ON PRODUCTIVITY OF RABI GROUNDNUT (*Arachis hypogaea* L.)

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Date of Receipt: 28-07-2021 Date of Acceptance: 29-09-2021

ABSTRACT

Field experiment entitled "Sequential application of herbicides and their impact on productivity of *rabi* groundnut (*Arachis hypogaea* L.)" was conducted during *rabi*, 2020-2021 on sandy loam soils of wetland farm of S.V. Agricultural college, Tirupati, Andhra Pradesh. Among all the weed management practices, higher dry matter production, weed control efficiency, yield attributes and yield with lower weed index of groundnut was recorded with hand weeding twice at 20 and 40 DAS (T_9), which was comparable with pre-emergence (PE) application of diclosulam 20 g ha^{-1} *fb* quizalofop-p-ethyl 50 g ha^{-1} + bentazone 960 g ha^{-1} at 20 DAS (T_8) and PE application of alachlor 1250 g ha^{-1} *fb* quizalofop-p-ethyl 50 g ha^{-1} + bentazone 960 g ha^{-1} at 20 DAS (T_5). The latter two chemical weed management practices can be effectively utilized to control weeds in place of unprofitable and burdensome hand weeding in groundnut.

KEYWORDS: *rabi* groundnut, weed index and yield.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is renowned as king of oilseed crop. In India during *rabi* season it is cultivated over total area of 6.65 lakh ha with a production of 1.6 million tonnes and with an average yield of 2352 kg ha^{-1} (Anonymous, 2019). The productivity of groundnut crop depends on several biotic and abiotic factors. One of the severe biotic factor is weed infestation. According to Priya *et al*. (2013) pod yield losses due to severe weeds in bunch type groundnut ranges between 15-75 per cent. Further, Poonia *et al*. (2016) reported that luxurious weed growth in groundnut led to 45.5 per cent less pod yield over the weed free situation in medium clay soils. Weeds can be controlled by different methods, of which chemical method of weed management is of prime importance.

There is still a need to provide more optional pre-emergence herbicide followed by post-emergence herbicide for better management of weeds to achieve most sustainable and economical production of groundnut. Therefore the present investigation was tried to find out the best sequential application of herbicides in *rabi* groundnut for realizing higher pod yield with minimum weed index.

MATERIAL AND METHODS

A field experiment was conducted during *rabi,* 2020-21 on sandy loam soils of Wetland Farm of S.V. Agricultural College, Tirupati, Acharya N.G. Ranga Agricultural University which is geographically situated at 13.5°N latitude and 79.5°E longitude and at an altitude of 182.9 m above the mean sea level in the Southern Agro-Climatic Zone of Andhra Pradesh. The soil of experimental field was neutral in reaction, low in organic carbon (0.21 %) and available nitrogen (244 kg ha^{-1}), medium in available phosphorus (26 kg ha^{-1}) and available potassium (289 kg ha^{-1}). The experiment was laid out in randomized block design with three replications and ten treatments *viz.,* Pre-emergence (PE) application of pendimethalin+imazethapyr (pre-mix) 1000 g ha^{-1} (T_1), PE application of diclosulam 20 g ha^{-1} (T_2), PE application of alachlor 1250 g ha^{-1} *fb* imazethapyr 75 g ha^{-1} at 20 DAS (T_3), PE application of alachlor 1250 g ha^{-1} *fb* bentazone 960 g ha^{-1} at 20 DAS (T_4), PE application of alachlor 1250 g ha^{-1} *fb* quizalofop-p-ethyl 50 g ha^{--1} + bentazone 960 g ha^{-1} at 20 DAS (T_5), PE application of diclosulam 20 g ha^{-1} *fb* imazethapyr 75 g ha^{-1} at 20 DAS (T_6), PE application of diclosulam 20 g ha^{-1} *fb* bentazone 960 g ha^{-1} at 20 DAS (T_7), PE application of diclosulam 20 g ha^{-1} *fb* quizalofop-p-ethyl 50 g ha^{--1} + bentazone 960 g ha^{-1} at 20 DAS (T_8), Hand weeding at 20 and 40 DAS (T_9) and weedy check (T_{10}). The test variety of Dharani

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was sown at a spacing of 22.5 cm x 10 cm spacing with a seed rate of 175 kg ha^{-1}. The recommended dose of the nutrients applied was 30-40-50 kg N, P_2O_5 and K_2O ha^{-1}. All the other recommended practices were also adopted as per the crop requirement. The collected data was statistically analyzed following the analysis of variance for RBD (Panse and Sukhatme, 1985). Weed index was calculated by employing formula as given by Tripathi *et al.* (1971).

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

WI = Weed index (%)

X = Yield obtained from minimum weed competition plot

Y = Yield obtained from treated plot

Weed control efficiency was calculated by employing formula given by Mani *et al.* (1973).

$$WCE = \frac{DM_c - DM_t}{DM_c} \times 100$$

WCE = Weed Control Efficiency (%)

DM_c = Dry matter of weeds in unweeded check (Control)

DM_t = Dry matter of weeds in treatment plot

RESULTS AND DISCUSSION

Weed flora

The predominant weed flora in the weedy check plot was *Digitaria sanguinalis, Dactyloctenium aegyptium, Boerhavia erecta* L., *Borreria hispida* (L.) K. Schum, *Celosia argentea* L., *Commelina benghalensis* L. *Digera arvensis* Forsk. *Euphorbia hirta* L., *Phyllanthus niruri* L., *Trichodesma indicum* L., *Tridax procumbens* and *Cyperus rotundus* L.

Effect of weed management practices on groundnut

The results revealed that different weed control measures significantly improved the dry matter accumulation, total number of pods plant ^{1}, number of filled pods $plant^{-1}$, shelling percentage, hundred pod weight, hundred kernel weight, haulm yield and pod yield over weedy check (Table 1 and 2).

Dry matter production

Dry matter production of groundnut was highest with hand weeding twice at 20 and 40 DAS (T_9), which was on par with PE application of diclosulam 20 g ha^{-1} *fb* quizalofop-p-ethyl 50 g ha^{-1} + bentazone 960 g ha^{-1} at 20 DAS (T_8) and PE application of alachlor 1250 g ha^{-1} *fb* quizalofop-p-ethyl 50 g ha^{-1} + bentazone 960 g ha^{-1} at 20 DAS (T_5). These results were in corroborate with findings of Balyan *et al.* (2016) and Kokonu *et al.* (2020). The next best treatment in recording higher dry matter production of groundnut was PE application of pre mix herbicide pendimethalin + imazethapyr 1000 g ha^{-1} (T_1) which was on par with PE application of alachlor 1250 g ha^{-1} *fb* imazethapyr 75 g ha^{-1} at 20 DAS (T_3) and PE application of diclosulam 20 g ha^{-1} *fb* imazethapyr 75 g ha^{-1} at 20 DAS (T_6). Post emergence application of imazethapyr 75 g ha^{-1} at 20 DAS (T_3 and T_6) caused phytotoxicity effect on plants and caused reduced plant height, LAI and dry matter accumulation at 40 to 60 DAS of plant growth but in later days the toxic effect was mitigated and was able to put forth its growth. Significantly lowest drymatter production was recorded with weedy check (T_{10}) due to heavy weed infestation which lead to shorter plants with less foliage and dry matter production.

Yield attributes and Yield

Pod yield and yield attributes *viz.,* total number of pods $plant^{-1}$, number of filled pods $plant^{-1}$, hundred pod weight, hundred kernel weight, shelling percentage and yield were significantly affected by different weed control methods (Table 1 and 2). Among the different weed management practices hand weeding twice at 20 and 40 DAS (T_9) resulted in higher values of yield attributes and yield which was on par with PE application of diclosulam 20 g ha^{-1} *fb* quizalofop-p-ethyl 50 g ha^{-1} + bentazone 960 g ha^{-1} at 20 DAS (T_8) and PE application of alachlor 1250 g ha^{-1} *fb* quizalofop-p-ethyl 50 g ha^{-1} + bentazone 960 g ha^{-1} at 20 DAS (T_5). In the latter two chemical weed management practices post emergence application of tank mix herbicides were found effective because quizalofop-p-ethyl controls grassy weeds effectively by inhibiting Acetyl CO-A Carboxylase (ACCase) enzyme (Vora *et al.,* 2019) where as another component, bentazone controls broadleaf weeds by inhibiting photosystem II. Thus efficient control of both grasses and broadleaf weeds were possible by tankmix. Marchioretto and Magro (2017) reported that herbicides which control broadleaf weeds

Table 1. Dry matter production, total no. of pods plant^{-1}, no. of filled pods plant^{-1}, hundred pod weight, hundred kernel weight and shelling percentage at harvest of *rabi* groundnut as influenced by weed management practices

Treatments	Drymatter production at harvest (kg ha^{-1})	Total no. of pods plant^{-1}	No. of filled pods plant^{-1}	Hundred pod weight (g)	Hundred kernel weight (g)	Shelling percentage (%)
T_1 : Pre-emergence (PE) application of pendimethalin + imazethapyr (pre-mix) 1000 g ha^{-1}	8796	15.00	11.33	105.87	42.77	69.09
T_2 : PE application of diclosulam 20 g ha^{-1}	7426	13.27	8.17	95.33	39.00	64.67
T_3 : PE application of alachlor 1250 g ha^{-1} *fb* imazethapyr 75 g ha^{-1} at 20 DAS	8534	14.94	10.60	102.33	41.30	67.93
T_4 : PE application of alachlor 1250 g ha^{-1} *fb* bentazone 960 g ha^{-1} at 20 DAS	7740	13.40	8.30	101.00	40.33	65.47
T_5 : PE application of alachlor 1250 g ha^{-1} *fb* quizalofop-p-ethyl 50 g ha^{-1} + bentazone 960 g ha^{-1} at 20 DAS	9564	16.55	15.12	108.33	43.83	71.67
T_6 : PE application diclosulam 20 g ha^{-1} *fb* imazethapyr 75 g ha^{-1} at 20 DAS	8566	14.96	10.90	103.67	41.66	68.68
T_7 : PE application diclosulam 20 g ha^{-1} *fb* bentazone 960 g ha^{-1} at 20 DAS	7578	13.30	8.20	97.33	39.64	65.07
T_8 : PE application diclosulam 20 g ha^{-1} *fb* quizalofop-p-ethyl 50 g ha^{-1} + bentazone 960 g ha^{-1} at 20 DAS	9737	16.60	15.33	110.93	44.03	72.83
T_9 : Hand weeding at 20 and 40 DAS	9765	16.67	15.50	111.67	45.46	73.80
T_{10} : Weedy check	6642	11.70	6.60	90.60	38.00	62.33
SEm ±	255.5	0.517	0.497	1.945	0.571	0.728
CD (P = 0.05)	759	1.53	1.48	5.78	1.70	2.16

Table 2. Pod yield, haulm yield, weed index and weed control efficiency at harvest of *rabi* groundnut as influenced by weed management practices

Treatments	Pod yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Weed index (%)	Weed control efficiency (%)
T_1 : Pre-emergence (PE) application of pendimethalin + imazethapyr (pre-mix) 1000 g ha^{-1}	8796	15.00	11.33	105.87
T_2 : PE application of diclosulam 20 g ha^{-1}	7426	13.27	8.17	95.33
T_3 : PE application of alachlor 1250 g ha^{-1} *fb* imazethapyr 75 g ha^{-1} at 20 DAS	8534	14.94	10.60	102.33
T_4 : PE application of alachlor 1250 g ha^{-1} *fb* bentazone 960 g ha^{-1} at 20 DAS	7740	13.40	8.30	101.00
T_5 : PE application of alachlor 1250 g ha^{-1} *fb* quizalofop-p-ethyl 50 g ha^{-1} + bentazone 960 g ha^{-1} at 20 DAS	9564	16.55	15.12	108.33
T_6 : PE application diclosulam 20 g ha^{-1} *fb* imazethapyr 75 g ha^{-1} at 20 DAS	8566	14.96	10.90	103.67
T_7 : PE application diclosulam 20 g ha^{-1} *fb* bentazone 960 g ha^{-1} at 20 DAS	7578	13.30	8.20	97.33
T_8 : PE application diclosulam 20 g ha^{-1} *fb* quizalofop-p-ethyl 50 g ha^{-1} + bentazone 960 g ha^{-1} at 20 DAS	9737	16.60	15.33	110.93
T_9 : Hand weeding at 20 and 40 DAS	9765	16.67	15.50	111.67
T_{10} : Weedy check	6642	11.70	6.60	90.60
SEm ±	255.5	0.517	0.497	1.945
CD (P = 0.05)	759	1.53	1.48	5.78

in combination with ACCase inhibitor herbicides increases the weed control spectrum. The next best weed management practice in recording higher yield attributes and yield was Pre-emergence (PE) application of pendimethalin + imazethapyr (pre-mix) 1000 g ha^{-1} (T_1) followed by PE application of diclosulam 20 g ha^{-1} *fb* imazethapyr 75 g ha^{-1} at 20 DAS (T_6) and PE application of alachlor 1250 g ha^{-1} *fb* imazethapyr 75 g ha^{-1} at 20 DAS (T_3) in the order of descent with no significant disparity between any two of them. These results were in line with Reddy *et al*. (2021) in blackgram and Mohanty *et al*. (2020) in groundnut. Increase in yield attributes and yield in the above weed management practices were due to reduced weed density and dry weight thus decreasing the competition for growth resources aiding in the better photosynthesis and dry matter production.

Lower yield attributes and yield were recorded with PE application of alachlor 1250 g ha^{-1} *fb* bentazone 960 g ha^{-1} at 20 DAS (T_4), PE application of diclosulam 20 g ha^{-1} *fb* bentazone 960 g ha^{-1} at 20 DAS (T_7) and PE application of diclosulam 20 g ha^{-1} (T_2) the above treatments were found to be significantly superior over weedy check (T_{10}).

Weed index

Weed index refers to reduction in yield due to presence of weeds in comparison to the best weed management practice. So lower the weed index higher the control of weeds by that weed management practice. Hand weeding at 20 and 40 DAS (T_9) was considered as the best treatment for calculating weed index which recorded higher pod yield. The minimum weed index of groundnut was recorded with sequential application of diclosulam 20 g ha^{-1} as pre-emergence *fb* quizalofop-p-ethyl 50 g ha^{-1} + bentazone 960 g ha^{-1} at 20 DAS as post-emergence (T_8) which was followed by PE application of alachlor 1250 g ha^{-1} *fb* quizalofop-p-ethyl 50 g ha^{--1} + bentazone 960 g ha^{-1} at 20 DAS (T_5) (Table 2) indicating the effective control of weeds aiding in increased pod yield.

Weed control efficiency

At harvest, the higher weed control efficiency was recorded with hand weeding at 20 and 40 DAS (T_9), which was closely followed by PE application of diclosulam 20 g ha^{-1} *fb* quizalofop-p-ethyl 50 g ha^{-1} + bentazone 960 g ha^{-1} at 20 DAS (T_8) and PE application of alachlor 1250 g ha^{-1} *fb* quizalofop-p-ethyl 50 g ha^{-1} + bentazone 960 g ha^{-1} at 20 DAS (T_5). This might be due to better weed control during early stages of crop growth by sequential application of pre emergence and in the later stages with tank-mix post-emergence herbicides, which maintained weed free congenial conditions for plant growth and recorded lesser weed biomass, finally leading to higher WCE. These results were in conformity with Song *et al.* (2020) and Gunri *et al.* (2014). The lower weed control efficiency was recorded with PE application of diclosulam 20 g ha^{-1} *fb* bentazone 960 g ha^{-1} at 20 DAS (T_7), PE application of alachlor 1250 g ha^{-1} *fb* bentazone 960 g ha^{-1} at 20 DAS (T_4) and PE application of diclosulam 20 g ha^{-1} (T_2) in decreasing order of efficiency. With increase in the age of crop the drymatter associated with crop also increased leading to lower weed control efficiency.

In recent times herbicides are becoming increasingly popular because of the awareness among the farmers about the losses caused by weeds in crops. Thus, effective management of weeds gained a wider importance. Although hand weeding at 20 and 40 DAS is most effective in controlling weeds but being more costly and labour intensive operation it is not economical to the farmers. Hence, from the present study, it can be concluded that Sequential application of diclosulam 20 g ha^{-1} *fb* quizalofop-p-ethyl 50 g ha^{-1} + bentazone 960 g ha^{-1} at 20 DAS as post-emergence (T_8) or PE application of alachlor 1250 g ha^{-1} *fb* quizalofop-p-ethyl 50 g ha^{-1} + bentazone 960 g ha^{-1} at 20 DAS (T_5), were found to be equivalent to hand weeding twice in recording higher weed control efficiency, yield attributes and yield with minimum weed index in *rabi* groundnut on sandy loam soils of Tirupati.

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Andhra Pradesh J Agril. Sci : 7(4): 210-216, 2021

VERTICAL DISTRIBUTION OF NUTRIENTS IN GROUNDNUT GROWING SOILS IN NARAYANAVANAM MANDAL OF CHITTOOR DISTRICT, ANDHRA PRADESH

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ABSTRACT

Soil survey was undertaken to study the vertical distribution of plant nutrients in the soil profiles / pedons in groundnut growing areas of Narayanavanam mandal of Chittoor district, Andhra Pradesh to understand nutrient supply capacity of soils. The soils were slightly acidic to strongly alkaline (6.10 to 8.95), non saline (0.13 to 1.43 dSm^{-1}), low to medium in organic carbon (0.03 to 0.74%) and texture varied from loamy sand to clay loam. The available P and K, exchangeable Ca and Mg and available S were sufficient in surface and sub-surface soils of all the pedons. DTPA extractable Zn was found to be deficient in both surface and sub-surface soils of all the pedons. DTPA extractable Cu was sufficient in surface horizons of all the pedons except in pedons 2 and 4 whereas most of the sub-surface horizons all the pedons were deficient in Cu. The DTPA extractable Mn was sufficient in both surface and sub-surface horizons of pedons 1 and 5 whereas in the remaining pedons, it was sufficient in surface horizons and sufficient to deficient in sub-surface horizons. However, the DTPA extractable Fe was sufficient in surface and subsurface horizons of pedon 1 and sufficient in surface horizons and sufficient to deficient in sub-surface horizons of all the reaming pedons.

KEYWORDS: Groundnut, Macro and Micronutrients, Organic carbon, pH, Surface and Sub -surface soil.

INTRODUCTION

The vertical distributions of plant nutrients in soils is important for efficient nutrient management and for achieving sustainable yields (Leelavathy *et al.,* 2021) as roots of most of the crops go beyond the surface layer and draw part of their nutrient requirement from the sub-surface layers of the soil. Most of the earlier researchers have limited their studies on nutrient status of surface soils only, but nutrient status of sub surface soils plays a key role for effective nutrient management. Hence, an attempt was made to study the nutrient status of sub surface soils. However, the detailed information regarding the vertical distribution of macro and micronutrient status in groundnut growing soils of Chittoor district in particular and Andhra Pradesh in general is very much lacking. Hence, present survey was conducted to study the depth wise distribution of nutrients in groundnut growing soils of Narayanavanam mandal of Chittoor district, Andhra Pradesh, as the groundnut is major crop in the area.

MATERIAL AND METHODS

Location and Agro-climate

Narayanavanam mandal of Chittoor district, Andhra Pradesh was spread over an area of 11,389 ha and lies in between 13° 25'to 13° 42' of North latitude and 79° 35' to 79° 58' of East longitudes. The climate of the area is semi-arid monsoonic with distinct summer, winter and rainy seasons with a mean annual rainfall of 1170.86 mm, of which 92.05 per cent is received during May to December. The mean annual temperature is 28.37°C with mean summer temperature of 28.00°C and the mean winter temperature of 27.82°C. The maximum temperature was recorded in May that rises to 36.35°C and the minimum temperature is 26.19°C in December. The soil moisture regime is ustic and soil temperature regime is isohyperthermic.

Field survey and Taxonomic classification

Reconnaissance soil survey was conducted and s even typical pedons were arranged in the groundnut growing areas of Narayanavanam mandal of Chittoor district, Andhra Pradesh during 2020-21.The taxonomy

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of these seven pedons *viz.,* Kalyanapuram, pedon 1 (P1- Fine -loamy, mixed, isohyperthermic, Typic Rhodustalfs), Thiruvatyam, pedon 2 (P2- Fine-loamy, smectitic, iso-hyperthermic, Dystric Haplustepts), Kasimmitta, pedon 3 (P3- Fine - loamy, smectitic, isohyperthermic, Typic Haplustalfs), Aranyamkandriga, pedon 4 (P4- Fine- loamy, mixed, isohyperthermic, Typic Haplustalfs), Erikambatt, pedon 5 (P5 – Fine-loamy, smectitic, isohyperthermic, Vertic Haplustepts),Vethalathaduku, pedon 6 (P6- Fine-loamy, smectitic, isohyperthermic, Fluventic Haplustepts) and Palamangalam,7 pedon 7 (P7- Fine, smectitic, isohyperthermic, Vertic Haplustepts). The horizon wise soil samples were collected for detailed analysis. The pedons P2, P5, P6 and P7 belongs to Inceptisols, P1, P3 and P4 were classified under Alfisols. The soil samples were processed and analyzed for pH, EC, organic carbon, texture available macro and micronutrients using standard methods as described by Jackson (1973).

The critical limits proposed by Patel and Savani (1987) for available P (13 kg P ha^{-1}), Aulakh *et al.* (1988) for available K (150 kg K ha^{-1}), Tandon (1991) for exchangeable Ca (1.5 cmol (p+) kg^{-1}), Mg (1.0 cmol (p+) kg^{-1}) and available S (10 mg kg^{-1}), Anon (1977) for Zn (0.75 mg kg^{-1}) and Tandon (1993) for Fe (4 mg kg^{-1}), Cu (0.5 mg kg^{-1}) and Mn (2 mg kg^{-1}) were followed for classifying profile soil samples into sufficient or deficient for groundnut.

RESULTS AND DISCUSSION

pH, EC, OC and texture

The groundnut growing soils were slightly acidic to strongly alkaline in their reactivity (6.10 to 8.95) (Table 1) and this wide variation in pH was attributed to the nature of the parent material, leaching, presence of calcium carbonate, exchangeable sodium and the release of organic acids during decomposition of organic matter. Similar findings were reported by Leelavathy and Naidu (2020). The texture of the groundnut growing soils varied from loamy sand to clay loam and this textural variation was caused by topographic position, nature of parent material, *in situ* weathering and translocation of clay (Leelavathi *et al*., 2010). The EC in groundnut growing soils was ranged from 0.13 to1.19 dSm^{-1} indicating their non-saline nature (Table 1). The low EC of groundnut growing soils can be attributed to free drainage conditions which favoured the removal of released bases by percolation and drainage (Sashikala *et al*., 2019). The organic carbon content of the groundnut growing soils was low to medium (0.03 to 0.74 per cent), which can be attributed to the prevalence of tropical condition, where the degradation of organic matter occurs at a faster rate coupled with low vegetative cover, thereby leaving less organic carbon in the soils (Supriya *et al.,* 2019).

Macronutrients

The available N varied from 69.0 to 351.9 kg N ha^{-1} with a mean of 255.4 kg N ha^{-1} in all the pedons in groundnut growing areas indicating low to medium in nature (Table 2). The low available nitrogen in the soils may be due to semi arid climate of the area which might have favoured rapid oxidation and lesser accumulation of organic matter, releasing more NO_3-N which could have been lost by leaching (Devi *et al.,* 2015).

The available P varied from 17.7 to 73.4 kg P kg ha^{-1} in all horizons of the pedons of groundnut growing areas with a mean of 44 P kg ha^{-1} (Table 2). Considering 13 kg P ha^{-1} as critical level, the available P status was sufficient in the surface and sub-surface horizons of all the pedons except Bw4 horizon of pedons 2 and 3 and decreased with depth in all the pedons of groundnut growing areas, which might be due to the confinement of crop cultivation to the rhizosphere and supplementing the depleted P by external sources *i.e.,* application of fertilizers to the surface soil (Purandhar and Naidu, 2020).

The available K of groundnut growing soils was varied from 140.2 to to 616.5 kg ha^{-1} with a mean value 327.4 kg ha^{-1} (Table 2). Taking 150 kg K ha^{-1} as a critical limit, both surface and sub-surface horizons of all the pedons were sufficient in available and showed a decreasing trend with depth. The higher available potassium could be attributed for greater weathering of the K bearing minerals, application of K fertilizers and upward translocation of K from lower depths along with capillary movement of ground water (Vedadri and Naidu, 2018).

The exchangeable Ca in groundnut growing soils was ranged from 31.3 to 69.5 cmol (p+) kg^{-1} soil with a mean of 51.2 cmol (p+) kg^{-1} soil. Similarly, the exchangeable Mg in groundnut growing areas was found to vary from 7.70 to 24.6 cmol (p+) kg^{-1} of soil with a mean of 16.0 cmol(p+) kg^{-1} of soil (Table 2). Taking 1.5 cmol (p+) kg^{-1} of soil for Ca and Mg as critical limit, the exchangeable Ca and Mg were well above their critical limits and found sufficient for crop growth. The exchangeable Ca was

Table 1. Physico–chemical properties of soils of Narayanavanam village of Chittor district

Pedon No. & Horizon	Depth (m)	Texture	pH (1:2.5)	OC (%)	EC (dSm^{-1})
Pedon 1 Kalyanapuram					
Ap	0.00 – 0.18	scl	6.93	0.52	0.41
Bt1	0.18 – 0.31	scl	6.30	0.47	0.33
Bt2	0.31 – 0.46	scl	6.18	0.33	0.44
Bt3	0.46 – 0.60	scl	6.24	0.18	0.53
Pedon 2 Thiruvatiam					
Ap	0.00 – 0.18	scl	6.24	0.68	0.78
Bw1	0.18 – 0.32	scl	6.56	0.59	0.61
Bw2	0.32 – 0.58	scl	6.89	0.44	0.57
Bw3	0.58 – 0.82	scl	6.10	0.30	0.68
Bw4	0.82 – 1.20+	scl	8.48	0.08	1.19
Pedon 3 Kasimmitta					
Ap	0.00 – 0.16	scl	8.06	0.74	0.30
Bw1	0.16 – 0.34	scl	8.07	0.68	1.43
Bw2	0.34 – 0.58	scl	8.12	0.65	0.79
Bw3	0.58 – 0.79	scl	8.03	0.32	0.77
Bw4	0.79 – 1.10+	scl	7.89	0.14	1.12
Pedon 4 Aranyam kandriga					
Ap	0.00 – 0.26	sil	6.50	0.47	0.25
Bt1	0.26 – 0.65	cl	6.44	0.44	0.22
Bt2	0.65 – 1.03	sicl	7.04	0.36	0.59
Bt3	1.03 – 1.28	cl	7.31	0.11	0.63
Bt4	1.28 – 1.62+	cl	7.44	0.03	0.49
Pedon 5 Erikambattu					
Ap	0.00 – 0.15	sicl	6.81	0.65	0.47
Bw1	0.15 – 0.44	sicl	7.02	0.26	0.23
Bw2	0.44 – 0.75	sicl	7.07	0.12	0.27
Bw3	0.75 – 0.99	cl	7.16	0.12	0.36
Bw4	0.99 – 1.30+	cl	7.44	0.05	0.40
Pedon 6 Vethalathuduku					
Ap	0.00 – 0.20	scl	8.13	0.38	0.36
Bw1	0.20 – 0.35	sicl	8.45	0.18	0.16
1C1	0.35 – 0.60	ls	8.87	0.15	0.13
Bw2	0.60 – 1.00+	sicl	8.95	0.09	0.18
Pedon 7 Palamangalam					
Ap	0.00 – 0.24	cl	7.63	0.74	1.02
Bw1	0.24 – 0.62	sicl	7.64	0.62	0.62
Bw2	0.62 – 0.92	sicl	7.71	0.41	0.47
Bw3	0.92 – 1.12	sicl	7.75	0.33	0.42
Bw4	1.12 – 1.50+	sicl	8.10	0.10	0.51
Range			**6.1 – 8.95**	**0.03 – 0.74**	**0.13 – 1.43**
Mean			**7.38**	**0.36**	**0.54**

found to be the dominant cation followed by Mg because of its higher mobility, earlier removal than the Mg and also Ca dominates in the prevailing semi-arid weathering environment and consequently occupied the major portion on the exchange complex in the groundnut growing soils (Reddy and Naidu, 2016).

The available S in groundnut growing soils varied from 13.54 to 56.92 mg kg^{-1} with a mean of 25.2 mg kg^{-1} (Table 2). Taking 10 mg S kg^{-1} soil as critical value, the available S was sufficient in surface and subsurface horizons of all the pedons of groundnut growing areas. The higher available sulphur may be due to higher amount of organic matter in surface layers than in sub-surface layers. Similar findings were reported by Devi *et al*. (2015).

Micronutrients

The available Zn content in the soil profiles of groundnut growing areas varied from 0.07 mg kg^{-1} to 0.83 mg kg^{-1} with a mean of 0.22 mg kg^{-1} (Table 3). Further, by taking 0.75 mg Zn kg^{-1} soil as critical limit, the available Zn found to be deficient in both surface and sub-surface soils of all the pedons. The deficiency of Zn was ascribed to low amount of organic carbon in these soils, which was confirmed by significant and positively correlation (r =+0.340) of Zn with organic carbon. Similar findings were reported by Sireesha and Naidu (2013).

The available Fe status in all the pedons of groundnut growing areas was found to be varied from 1.46 and 14.00 mg kg^{-1} soil with a mean of 4.69 mg kg^{-1} soil (Table 3). As per the critical limit of 4.0 mg kg^{-1} soil, the DTPA extractable Fe in groundnut growing areas was sufficient in surface and subsurface horizons of pedon 1 and sufficient in surface horizons of remaining pedons and sufficient to deficient in sub-surface horizons of most of the pedons. The sufficiency of Fe in surface horizons might be due to accumulation of organic carbon and prevalence of reduced conditions in the surface horizons. The organic carbon influence the solubility and availability of Fe by chelation effect might have protected the Fe from oxidation and precipitation, which consequently increased the availability of iron (Prasad and Sakal, 1991). These results were significant and positive correlation of available iron with organic carbon (r = + 0.659**) and significant negative correlation with pH (r= -0.345*). These findings were in good agreement with those of Sarkar *et al*. (2000).

Available Cu in the pedons of groundnut growing areas was ranged from 0.21 to 1.06 mg kg^{-1} with an average of 0.42 mg kg^{-1} (Table 3). Considering on 0.50 mg Cu kg^{-1} soil as a critical limit, the available Cu in groundnut growing areas was sufficient in surface horizons of all the pedons except in surface horizons of pedon 2. Whereas, the sub-surface of horizons of all the pedons was mostly were deficient. Available Cu was positively correlated (r = + 0.439) with organic carbon indicating the low organic carbon was responsible for the deficiency of Cu in the groundnut growing soils. Similar findings were also reported by Venkatesu *et al*. (2002).

The available Mn in groundnut growing soils was varied from 0.85 to 12.86 mg kg^{-1} with a mean of 3.83 mg kg^{-1} (Table 3). As per the critical limit of 2 mg kg^{-1} Mn for groundnut growing soil, the availble Mn was sufficient in both surface and sub-surface soils of pedons 1 and 5 whereas in the remaining pedons, it was sufficient in surface horizons and sufficient to deficient in sub-surface horizons . In general the higher Mn in pedons 1 and 5 might be due to comparatively higher biological activity and the chelating of organic compounds released during the decomposition of organic matter left after harvest of crop. Similar findings were made by Reddy and Naidu (2016).

Groundnut growing soils of Narayanavanam village of Chittoor district, were were slightly acidic to strongly alkaline, non-saline and low in organic carbon. The pedons P2, P5, P6 and P7 belongs to Inceptisols, P1 and P4 were classified into Alfisols. They were sufficient in available P, K and S and exchangeable Ca and Mg in surface and subsurface soils. The DTPA extractable Zn was found to be deficient in both surface and sub-surface soils of all the pedons. The DTPA extractable Cu was sufficient in surface horizons of all the pedons except in pedons 2 and 4 whereas most of the sub-surface horizons all the pedons were deficient in Cu. The DTPA extractable Mn was sufficient in both surface and sub-surface horizons of pedons 1 and 5 whereas in the remaining pedons, it was sufficient in surface horizons and sufficient to deficient to sufficient in sub-surface horizons. However, the DTPA extractable Fe was sufficient in surface and subsurface horizons of pedon 1 and sufficient in surface horizons and sufficient to deficient in sub-surface horizons of all the reaming pedons.

Table 2. Macronutrient status of groundnut growing soils of Narayanavanam village of Chittoor district

Pedon No. & Horizons	Depth (m)	Available macronutrients (kg ha^{-1})			Exchangeable bases (cmol (p+) kg^{-1})		S (mg kg^{-1})
		N	P	K	Ca^{+2}	Mg^{+2}	
Pedon 1 Kalyanapuram							
Ap	0.00 – 0.18	351.9	64.1	416.7	57.38	24.59	56.92
Bt1	0.18 – 0.31	345.0	53.0	301.6	57.08	24.35	43.26
Bt2	0.31 – 0.46	317.4	46.4	162.6	56.30	23.70	26.18
Bt3	0.46 – 0.60	289.8	44.2	156.0	57.14	15.71	24.41
Pedon 2 Thiruvatiam							
Ap	0.00 – 0.18	276.0	28.7	384.6	31.34	12.85	26.72
Bw1	0.18 – 0.32	124.2	26.5	300.9	35.79	15.09	22.11
Bw2	0.32 – 0.58	86.2	26.5	295.2	55.83	20.86	21.15
Bw3	0.58 – 0.82	82.8	24.3	260.2	63.77	16.09	19.69
Bw4	0.82 – 1.20+	69.0	17.7	210.9	53.07	12.03	18.79
Pedon 3 Kasimmitta							
Ap	0.00 – 0.16	296.7	57.5	361.7	57.69	18.07	22.31
Bw1	0.16 – 0.34	276.0	54.2	164.1	47.67	16.66	21.32
Bw2	0.34 – 0.58	269.1	48.4	161.9	47.44	14.98	19.18
Bw3	0.58 – 0.79	262.2	47.6	156.7	41.21	13.17	18.87
Bw4	0.79 – 1.10+	234.6	28.7	156.7	38.65	16.87	17.30
Pedon 4 Aranyam kandriga							
Ap	0.00 – 0.26	303.6	60.4	492.1	63.93	21.31	32.83
Bt1	0.26 – 0.65	262.2	59.1	425.8	66.65	20.92	31.99
Bt2	0.65 – 1.03	248.4	57.8	291.0	67.06	21.28	31.01
Bt3	1.03 – 1.28	234.6	57.1	224.5	69.57	14.49	26.71
Bt4	1.28 – 1.62+	200.1	48.8	140.2	66.58	15.07	24.76
Pedon 5 Erikambattu							
Ap	0.00 – 0.15	345.0	49.8	537.4	57.40	13.07	32.11
Bw1	0.15 – 0.44	317.4	42.1	533.5	55.03	13.34	32.05
Bw2	0.44 – 0.75	296.7	37.3	485.7	44.75	13.08	26.99
Bw3	0.75 – 0.99	269.1	35.3	341.5	36.34	9.59	26.22
Bw4	0.99 – 1.30+	241.5	34.8	226.9	34.89	7.70	25.65
Pedon 6 Vethalathuduku							
Ap	0.00 – 0.20	269.1	73.4	398.4	67.08	21.70	27.29
Bw1	0.20 – 0.35	241.5	50.8	390.0	52.93	18.02	22.44
1C1	0.35 – 0.60	227.7	34.1	324.5	55.15	16.09	21.96
Bw2	0.60 – 1.00+	179.4	33.6	202.8	47.39	15.05	15.22
Pedon 7 Palamangalam							
Ap	0.00 – 0.24	331.2	47.6	616.5	42.01	15.05	24.35
Bw1	0.24 – 0.62	324.3	45.1	545.0	42.27	13.74	22.38
Bw2	0.62 – 0.92	317.4	42.8	390.3	42.46	12.29	21.86
Bw3	0.92 – 1.12	276.0	37.3	375.0	40.40	10.90	13.80
Bw4	1.12 – 1.50+	262.2	35.8	372.1	37.05	10.03	13.54
Range		**69.0 – 351.9**	**17.7 – 73.4**	**140.2 – 616.5**	**31.3 – 69.5**	**7.7 – 24.6**	**13.5 – 56.9**
Mean		**255.4**	**44.0**	**327.4**	**51.2**	**16.0**	**25.2**

Table 3. Micronutrient status of groundnut growing soils of Narayanavanam village of Chittoor district

Pedon No. & Horizons	Depth (m)	Available micronutrients (mg kg^{-1})			
		Zn	Cu	Fe	Mn
Pedon 1 Kalyanapuram					
Ap	0.00 – 0.18	0.32	0.65	7.66	12.86
Bt1	0.18 – 0.31	0.23	0.48	6.32	9.84
Bt2	0.31 – 0.46	0.22	0.47	5.81	8.21
Bt3	0.46 – 0.60	0.14	0.42	4.58	5.11
Pedon 2 Thiruvatiam					
Ap	0.00 – 0.18	0.83	0.37	9.21	8.07
Bw1	0.18 – 0.32	0.25	0.36	5.02	4.88
Bw2	0.32 – 0.58	0.14	0.31	3.78	3.55
Bw3	0.58 – 0.82	0.12	0.31	3.04	1.50
Bw4	0.82 – 1.20+	0.12	0.22	2.48	1.44
Pedon 3 Kasimmitta					
Ap	0.00 – 0.16	0.25	1.01	14.00	4.04
Bw1	0.16 – 0.34	0.16	0.37	5.43	3.38
Bw2	0.34 – 0.58	0.14	0.28	4.01	1.96
Bw3	0.58 – 0.79	0.14	0.27	3.63	1.69
Bw4	0.79 – 1.10+	0.13	0.22	3.41	1.67
Pedon 4 Aranyam kandriga					
Ap	0.00 – 0.26	0.51	0.36	9.13	7.09
Bt1	0.26 – 0.65	0.20	0.35	8.07	4.90
Bt2	0.65 – 1.03	0.17	0.32	4.50	1.62
Bt3	1.03 – 1.28	0.17	0.27	4.00	1.50
Bt4	1.28 – 1.62+	0.11	0.24	3.01	1.27
Pedon 5 Erikambattu					
Ap	0.00 – 0.15	0.48	1.06	7.92	6.70
Bw1	0.15 – 0.44	0.20	0.87	3.59	6.04
Bw2	0.44 – 0.75	0.18	0.60	3.28	5.47
Bw3	0.75 – 0.99	0.14	0.50	2.98	4.01
Bw4	0.99 – 1.30+	0.12	0.41	2.57	3.92
Pedon 6 Vethalathuduku					
Ap	0.00 – 0.20	0.33	0.71	8.80	2.75
Bw1	0.20 – 0.35	0.18	0.44	2.87	1.82
1C1	0.35 – 0.60	0.14	0.21	1.50	1.17
Bw2	0.60 – 1.00+	0.11	0.21	1.46	0.85
Pedon 7 Palamangalam					
Ap	0.00 – 0.24	0.65	0.58	5.20	3.51
Bw1	0.24 – 0.62	0.18	0.53	3.57	3.16
Bw2	0.62 – 0.92	0.16	0.31	2.61	2.43
Bw3	0.92 – 1.12	0.08	0.25	2.56	1.50
Bw4	1.12 – 1.50+	0.07	0.21	2.12	1.31
Range		**0.07 – 0.83**	**0.21 – 1.06**	**1.46 – 14.0**	**0.85 – 12.86**
Mean		**0.22**	**0.42**	**4.69**	**3.83**

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Andhra Pradesh J Agril. Sci : 7(4): 217-219, 2021

FACTORS INFLUENCING THE PURCHASE OF BRANDED MILLETS IN TIRUPATI CITY OF ANDHRA PRADESH

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Date of Receipt: 19-07-2021 Date of Acceptance: 05-10-2021

ABSTRACT

Growing lifestyle diseases have pushed consumers towards eating healthy and quality foods. With the rich nutritive value and their adaptability to grow in various climatic conditions, it is inevitable to change the food habits towards millet based food systems. This is evident from the recent surge in demand for millets among consumers. So understanding the factors influencing millets consumption millet purchase is the need of the hour. The study was purposively carried out in Tirupati city of Andhra Pradesh. Data were collected from 120 sample respondents using a random sampling technique. The result of the study showed that most of the respondents consume millets and their products for their health and nutritional benefits.

KEYWORDS: Branding, Purchase pattern, Millets.

INTRODUCTION

Agriculture is the largest enterprise in the nation. India's agriculture sector consists predominantly of small and marginal farmers. Agriculture and its related sector employs more than 50 percent of the nation's labor force and also contributes around 18 percent of the total nation's GDP (Anonymous, 2018). India's green revolution and the policy interventions such as input subsidy, price support, and procurement of food grains inclusion of PDS have largely focused on increasing the quantity of food production. However, not many policies have been drafted with the aim of increasing the quality of the food, i.e., nutritional security. Even though the government tries to overcome the issues through several national-level nutritional intervention programs, the prevalence of micronutrient malnutrition continues to be a major public health problem. Millets are one such important crops that could resolve the triple burden of under and over-malnutrition and hidden hunger.

Despite the many benefits of growing millets, there has been a downward trend in the consumption of millets in the country. Availability of other incentivized food grains, inconvenience in preparation, and changing customers' preference toward western foods were the major demand side problems. However, the prevailing COVID-19 pandemic has exposed the vulnerability and risk in the existing food system. With the rich nutritive value, it is inevitable to change the food habits towards a millet-based food system. This is evident from the recent surge in demand for millets among consumers. So understanding the factors influencing the purchase of millets is the need of the hour.

MATERIAL AND METHODS

The study was purposively carried out in Tirupati city of Andhra Pradesh. Data was collected from 120 sample respondents. Primary data was collected through google forms by random sampling method where respondents were selected randomly with the help of well-structured interview schedule. The data was collected during the month of April to May, 2021. The objective of the study was clearly explained to the respondents to seek their response and crosscheck were made to minimize the errors. The respondents were interviewed on the general characteristics of respondents such as age, income, educational details, occupation, family size, family type and other details regarding factors influencing the purchase of branded minor millets. Percentage analysis and Garrett's ranking technique were used to analyze the collected data.

Garrett's Ranking Technique

In the context of Garrett's ranking, the respondents were asked to rank each factor and those ranks would be converted into the present position by using the formula. "Garrett's ranking technique was used to rank the preference indicated by the respondents on different

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factors. As per this method, respondents have been asked to assign the rank for all factors and the outcomes of such ranking have been converted into score values with the help of the following formula:

$$\text{Per cent position} = \frac{(R_{ij} - 0.5)}{N_j} \times 100$$

where,

R_{ij} = Ranking given for the i^{th} variable by the j^{th} respondent

N_j = Number of variables ranked by the j^{th} respondent.

With the help of Garrett's table, the percent position estimated is converted into scores. Then for each factor, the scores of each individual are added, and then the total value of scores and mean values of the score are calculated. The factors having the highest mean value is considered the most important factor.

RESULTS AND DISCUSSION

General Characteristics of the respondents

General characteristics such as age, gender, occupation, education, and monthly income of the respondents were collected and analyzed. The results of the study was presented in the figure below.

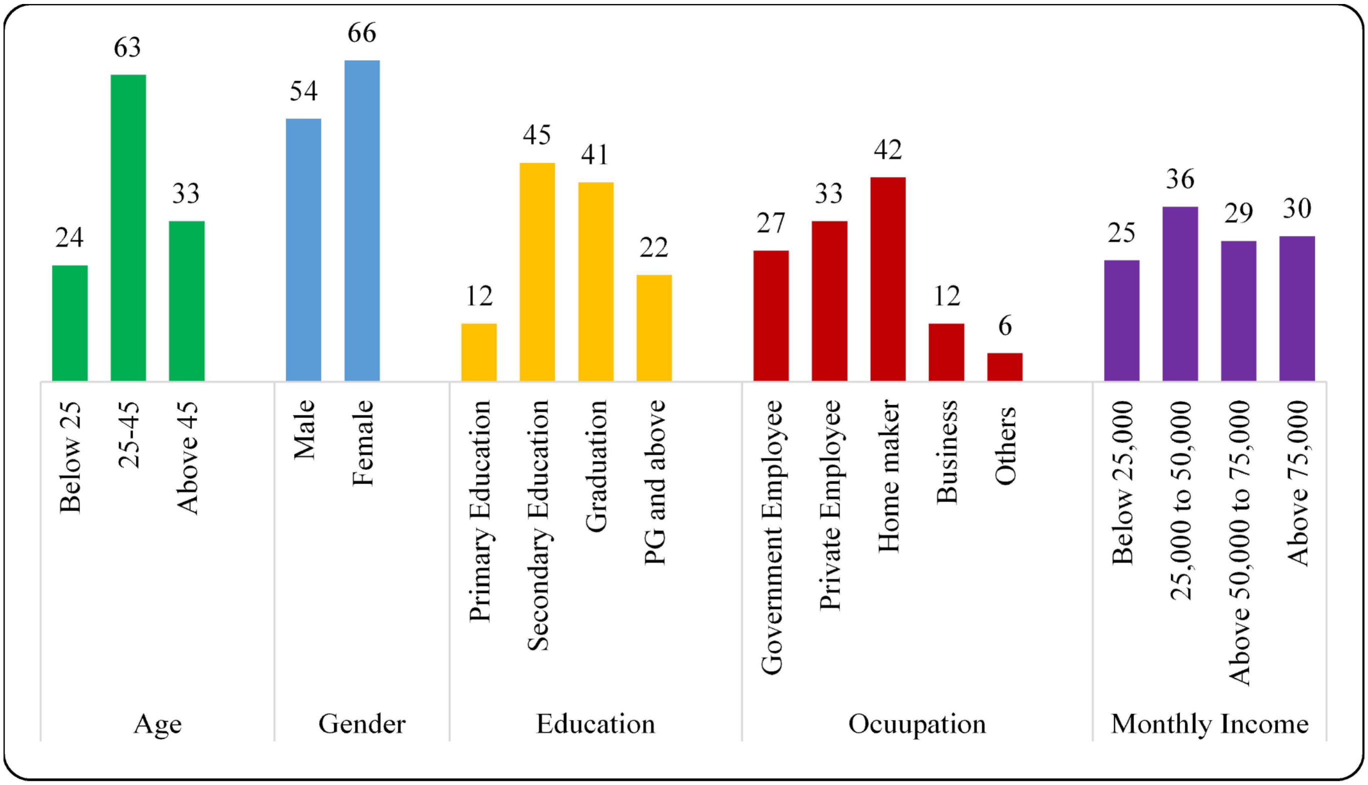

Figure 1. General Characteristics of the Respondents

Most of the respondents were in the age group of 25-45 (52.50%), followed by consumers among the age group of above 45 (27.50%). Most of the consumers were women (55.00%). Among the consumers many of them had secondary level of education (37.50%), followed by graduation (34.17%). As many of the consumers were women, the results also seen influencing in occupation of the consumers as many of them were homemakers (35.00%), followed by private employees (27.50%). In relation to monthly income, most of the consumers fall in the group of INR 25,000 to 50,000 (30.00%), followed by the respondents in the income group of above INR 75,000 (25.00%). The results are in conformity with the findings of Amarapurkar and Banakar (2017) and Priya (2019).

Factors Influencing Purchase of Millets

The factors influencing the purchase of minor millets were ranked using the Garrett ranking technique and the results were listed in Table 1.

Table 1. Factors influencing the purchase of Millets

S. No.	Reasons	Numbers	Frequency
1	Habit	39.50	5
2	Taste	54.33	2
3	Health benefits	59.00	1
4	Food preparation	47.50	4
5	Nutritional benefits	49.67	3

From the Table 1, it could be inferred that the factor viz., health benefits to overcome the disease with a mean score of 59 was the major influencing factor among the respondents followed by taste and nutritional benefits (to maintain fitness) had Garrett mean score of 54.33 and 49.67 respectively were other major factors which influencing consumption by the respondents. Growing of awareness towards health may be the influencing reason for increased consumption of minor millets. Easy in preparation and habit had a Garrett mean score of 47.50 and 39.50 respectively were the least factors influencing the consumption of minor millets among the respondents. This is consistent with the results of previous studies by Alekhya and Shravanthi (2019) and Kalidas & Mahendran (2017).

The study on factors influencing purchase of millets was carried out to understand the governing factors that pushes customers to purchase and consume millets. Most consumers take millets for their health and nutritional benefits. Thus, companies could use these factors as their USP to sell their products in the market.

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Andhra Pradesh J Agril. Sci : 7(4): 220-223, 2021

ECONOMIC ANALYSIS OF PAPAYA NURSERIES IN KADAPA DISTRICT OF ANDHRA PRADESH – A CASE STUDY

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Date of Receipt: 17-07-2021 Date of Acceptance: 07-10-2021

ABSTRACT

The present study aimed to estimate the costs and returns and to know the financial viability of papaya nurseries in Kadapa district of Andhra Pradesh during 2020-21. The primary data was collected from papaya nursery entrepreneurs randomly with pretested questionnaire. To workout the costs and returns simple averages and percentages were employed. Discounted measures like NPV, BCR and IRR were used to know the financial viability of investment on papaya nurseries. The results indicated that the nursery entrepreneurs have incurred the total costs of ₹ 629340.00 for raising 1,00,000 saplings and realized net returns of ₹ 315660. Net present worth (₹ 2710765.55), benefit : cost ratio (1.34) and internal rate of return (21.84%) at 8 per cent discount rate, shows that the investment on papaya nursery was financially viable.

KEYWORDS: costs, economic analysis, financial feasibility, papaya nurseries, returns.

INTRODUCTION

Horticulture has become one of the major growth drivers of Indian economy as it is more income generative than the agricultural sector. It gives employment across the three sectors i.e. primary, secondary and tertiary. During 2019-20, Horticultural crops occupied an area of 26.47 million ha yielding about 320.77 million tonnes, with a total area under fruit cover in India at 6.76 million ha with 102.02 million tonnes production. India ranks second in the production of fruits and vegetables in the world, after China. Amongst fruits, India ranks first in the production of Bananas (26.08%), Papaya (44.05%) and Mangoes (45.89%). The cosmic production base offers India great opportunities for export. During 2020-21, India exported Fruits worth of ‘ 4971.22 crores/674.53 USD millions. Fruits like mangoes, orange, grapes, bananas account to the major part of exports. The major destinations for fruits and vegetables are Bangladesh, UAE, Netherland, Nepal, Malaysia, UK, Sri Lanka, Oman and Qatar (Anonymous, 2020a).

The major problem faced by the growers of fruits and vegetables is the non-availability of true to type and healthy nursery plants. Most of the nurseries were still using traditional methods to raise the nursery plants. The quality and production of fruits and vegetables highly depends on the quality of nursery plants used. In this background the present study was carried out on "Economic analysis of papaya nurseries in Kadapa district of Andhra Pradesh" with major objectives of estimating the costs and returns and evaluating the financial feasibility of papaya nurseries.

MATERIAL AND METHODS

Andhra Pradesh ranks first in papaya production in the country with 1.78 million tones (Anonymous, 2020a). Kadapa district was one of the leading producer of papaya with highest number of papaya nurseries in the state. Hence Kadapa district was purposively selected for the study. A total of 25 nurseries were sampled randomly for the study. A well structured questionnaire was used to collect the data from the nursery owners.

To calculate the costs and returns, simple arithmetic averages and percentages were worked out. Discounting techniques like Net Present Worth, Benefit-Cost ratio and Internal Rate of Return were employed to know the financial viability of papaya nurseries (Singh and Nandi, 2020).

RESULTS AND DISCUSSION

A perusal of Table 1 revealed that majority of the sample owners of papaya nurseries were belonged to age group of 25 to 50 years and 50 per cent of the sample nursery owners were graduated. 50 per cent of sample owner's primary occupation was only nursery business

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Table 1. Socio-economic profile of sample nursery owners

S. No	Particulars	Per cent (%)
1	**Age particulars**	
	Young age (<25 years)	0.00
	Middle age (25-50 years)	75.00
	Old age (>50 years)	25.00
2	**Literacy level**	
	Primary Education	0.00
	Secondary Education	25.00
	Graduation	50.00
	Post Graduation	25.00
3	**Land Holding size**	
	Less than 1 ha	75.00
	1ha – 2ha	25.00
	2ha -5ha	0.00
	More than 5 ha	0.00
4	**Occupational particulars**	
	Nursery business	50.00
	Nursery + Agriculture	0.00
	Nursery + Horticulture	50.00

and the remaining 50 per cent were cultivating horticultural crops along with nursery business. The operational land holding data revealed that majority of farmers were having less than 1 ha.

Costs and Returns

Investment particulars of establishing papaya nurseries were presented in Table 2. Major costs incurred for establishing the papaya nursery was land costs which occupies 79.60 per cent followed by shade net costs (13.93%) and the remaining was for irrigation structures (6.46%). Thus, the total investment costs incurred for raising a papaya nursery was ₹ 25,12,500.

Table 2. Investment Particulars of papaya nurseries

S. No.	Particulars	Value (₹)
1	Land Value (per acre)	2000000.00 (79.60)
2	Shade net (1500 sq. m)	350000.00 (13.93)
3	Irrigation Structures	162500.00 (6.46)
	Total	**2512500.00**

On an average, 1,00,000 saplings were produced in a nursery for one cycle. Hence 1,00,000 saplings were taken as a unit for calculating costs and returns for the study. Costs of polythene bags account to ₹ 1,35,000 (21.45%). Vermi compost amounts to ₹ 3,000 (0.48%). Seed costs incurred to raise 1,00,000 papaya saplings was ₹ 95,062.50 (15.11%). Labour wages involved in sowing amounts to ₹ 20,500 (3.26%). Papaya is a highly sensitive crop; it is being attacked by various pests and diseases, so pesticides are to be used on a large scale. Cost of chemicals used for spraying valued to ₹ 30,000 (4.80%) which requires 20 man days. wages for spraying amounts to ₹ 14,000 (2.24%). Hence, total labour wages incurred was ₹ 34,500 (5.48%), total material costs amount to ₹ 2,63,062.50 (41.80%) and maintenance costs valued ₹ 2,00,000 (31.78%). Interest on working capital was ₹ 19,902.50 (3.16%). Therefore, the total operational costs are ₹ 5,17,465 (82.22%). Total fixed costs account to ₹ 1,11,875 (17.78%), which includes rental value of owned land at ₹ 33,750 (5.36%), depreciation ₹ 28,125 and interest on fixed capital was ₹ 50,000 (7.94%). Hence the total costs incurred in papaya nurseries were ₹ 6,29,340. (Table 3). From the results it was concluded that major costs in raising the papaya nurseries was maintenance cost, cost of polythenen bags and seed costs. Similar results were found by Majilinda (2012) in his study on economic analysis of fruit tree nurseries in Albania.

Out of the raised 1,00,000 saplings, the survival rate was only 70 per cent hence, the total returns obtained from selling papaya seedlings was ₹ 9,45,000 and the and the net returns are ₹ 3,15,660.

Table 3. Cost structure of papaya nurseries (per 1,00,000 papaya saplings)

Particulars	Amount (₹)
OPERATIONAL COSTS	
Human labour costs	
Sowing	20500.00 (3.26)
Spraying	14000.00 (2.24)
Total labour costs	**34500.00 (5.48)**
Material costs	
Cost of seed	95062.50 (15.11)
cost of polythene bags	135000.00 (21.45)
Vermicompost	3000.00 (0.48)
Plant protection chemicals	30000.00 (4.8)
Total material cost	263062.50 (41.80)
Maintenance per plant	200000.00 (31.78)
Interest on working capital @ 8%	19902.50 (3.16)
Total operational costs	517465.00 (82.22)
FIXED COSTS	
Rental value of owned land	33750.00 (5.36)
Depreciation	28125 (4.47)
Interest on fixed capital @ 10%	50000.00 (7.94)
Total fixed costs	111875.00 (17.78)
Total costs	**629340.00 (100.00)**
Total income	**945000.00**
Total cost	**629340.00**
Net income	**315660.00**

Financial Viability of Papaya Nurseries

Financial viability of the investments on papaya nurseries were assessed by employing Net Present Worth, Benefit Cost Ratio and Internal Rate of Return and the results were present in Table 4. The net present worth of papaya nurseries was as high as ₹ 27,10,765.55, ₹ 19,33,864.13, ₹ 13,60,887.81 and ₹ 5,97,961.98 at 8, 10, 12 and 16 per cent discount rates respectively. The high positive net present value even at higher discount rates indicated the soundness of the investment made on Papaya nurseries. The benefit-cost ratio worked out to be 1.34, 1.28, 1.22 and 1.11 at 8, 10, 12 and 16 per cent discount rates respectively, indicating that at 8 per cent discount rate, each rupee of investment made in these nurseries would bring a net income of 0.34 on the papaya nurseries. These values proved that the investment on papaya nurseries was financially viable. These findings are in conformity with the findings reported by Ashoka *et al.* (2019) for investment in chilli nurseries.

The internal rate of return was found to be 21.48 per cent for papaya nurseries. The internal rate of returns was more than the bank rate of interest (15%) and hence nursery business was viable.

The net income obtained from each one cycle of Papaya seedlings production of 1,00,000 saplings was ' 315660. Further the discounted measures like NPV, BCR and IRR calculated for 30 years revealed that the papaya nurseries were financially viable at 8, 10, 12 and 16 per cent discount rate. This indicates the high profitability of the investments in papaya nurseries. But the major problem faced by the papaya nurseries was pests and disease infestation. Huge losses will incur during the periods of heavy infestation. Hence development of varieties resistant to pests and diseases was very important.

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Table 4. Financial viability of investments in papaya nurseries

Particulars	Discount rate %			
	8%	**10%**	**12%**	**16%**
Present value of discounted costs (in ₹)	7927839.71	6974570.04	6251261.04	5239490.60
Present value of discounted benefits (in ₹)	10638605.26	8908434.17	7612148.85	5837452.58
NPV (in ₹)	2710765.55	1933864.13	1360887.81	597961.98
BCR	1.34	1.28	1.22	1.11
IRR	21.84			

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Andhra Pradesh J Agril. Sci : 7(4): 224-229, 2021

EFFICACY OF NATIVE ISOLATES OF *Bacillus thuringiensis* Berliner ON MORTALITY OF 3rd INSTAR LARVAE OF FALL ARMY WORM, *Spodoptera frugiperda* (J.E. Smith)

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Date of Receipt: 23-08-2021 Date of Acceptance: 08-10-2021

ABSTRACT

Four native isolates of *Bacillus thuringiensis* Berliner *viz.*, V13, CF24, CFo76 and W85 (collected from soils from in and around different locations from Tirupati, Chittoor Dt., Andhra Pradesh, India) were tested at five different concentrations against third instar larvae of Fall Army Worm *Spodoptera frugiperda* (J.E. Smith). Among the four native isolates tested, V13 isolate showed highest per cent larval mortality (86.66%), Lowest values of LC_{50} (6.28×10^2 CFU/ml) and LT_{50} (69.02 h) for third instar larvae of FAW, indicating that the isolate V13 could be used as a potent *Bt* native isolate for the management of third instar larvae of *S. frugiperda.*

KEYWORDS: *Bacillus thuringiensis*, LC_{50}, LT_{50}, Native isolates, per cent larval mortality, *Spodoptera frugiperda*

INTRODUCTION

Maize is the third most important cereal crop after rice and wheat in India, sharing about 2 per cent the world's maize production. About 71 per cent of maize in India is being produced during the *kharif* season in different states *viz.,* Karnataka, Madhya Pradesh, Tamil Nadu, Maharashtra, Telangana, Uttar Pradesh and Rajasthan with Karnataka being the leader. Bihar, Andhra Pradesh and Tamil Nadu are the states in India that accounts to 40 per cent of maize crop in *rabi* season (Anonymous, 2017).

Among the biotic constraints that limit the maize production, insect pests *viz.,* stem fly, stem borer, cornworm, aphids, shoot fly *etc.* are the major insect pests inflicting maximum yield loss. Fall ArmyWorm, *Spodoptera frugiperda* popularly known as FAW is native to tropical and subtropical Americas. FAW is a polyphagous pest which majorly prefers plants/crops belonging to Poaceae family and most commonly recorded in wild and cultivated grasses like maize, rice, sorghum and sugarcane (Anonymous, 2020). It has been reported that around 353 host plant species of 76 plant families *viz.*, Poaceae (106), Asteraceae (31) and Fabaceae (31) are preferred as host by FAW (Montezano *et al.,* 2018).

Invasion and existence of *S. frugiperda* in India was confirmed by the University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka during May-June, 2018 and since then this insect has become a major threat to maize cultivation in India (Sharanabasappa *et al*., 2018). It has been reported that damage by this insect pest causes a three per cent reduction in grain yield (Lima *et al*., 2010) and with an annual loss up to US dollars 400 million in Brazil (Figueiredo *et al.,* 2015). During the year, 2018 due to this pest in India, production of maize fell by 3.2 per cent equivalent to 27.8 million tons of grain.

Farmers rely predominately on the use of synthetic insecticides for managing this insect pest. Use of insecticides as a sole tool in management of insect pests has potential draw backs, that includes effect on the environment, non-target organisms and natural enemies coupled with outbreak of secondary pest and resurgence (Togbe *et al.,* 2014). An attractive alternative tool for management of insect pests is the use of biological pesticides due to their ecofriendly and target selective characteristics (Ali *et al.,* 2015) and microbial agent containing insecticides are considered as good replacement due to the absence of mammalian toxicity (Sabbour, 2003). Biopesticides like *B.t, and Beauveria bassiana* can provide an alternative and environment friendly option to control several important insect pests (Taggar *et al.,*2014).

Over 100 bacteria have been identified as insect pathogens, among them, *B.t.* has got maximum importance

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as a microbial agent (Muhammad *et al.,* 2016). *B.t* is a gram positive, spore forming bacterium having insecticidal properties and is benign to natural enemies, quite safe to mammals and also environmentally acceptable (Ali *et al.,* 2015). *B.t* produces crystal toxins that activates into protoxins in the insect gut due to alkaline pH of 9.0-9.5. due to insertion of protoxins on receptor proteins of midgut membrane, results in formation of pores in the gut resulting gut paralysis and septicemia causing the death of larvae.

MATERIAL AND METHODS

The research work was carried out at Insectary and Insect pathology laboratory, Department of Entomology, S.V. Agricultural College, Tirupati during 2020 –21.

Rearing and maintenance of *S. frugiperda*

Rearing of *S. frugiperda* was done at the Insectary, Department of Entomology, S.V. Agricultural College, Tirupati at temperature of 25 ± 2°C, relative humidity of 75.00 ± 5.00 per cent and photoperiod of 12 h light / 12h dark. Eggs of *S. frugiperda* were collected from surrounding farmer's maize fields and were kept in plastic troughs (200mm diameter and 100 mm height).First instar larvae were reared in groups on a corn flour based artificial diet, late instars were reared individually up to pupation (Barreto *et al.*,1999).

Larvae took 15-20 days to complete the larval duration and pupated in rearing troughs. The pupae were collected and were shifted to adult rearing cages (35 × 25 × 45 cm) provided with a maize seedling as oviposition substrate. A cotton swab dipped in 10 per cent honey solution was provided as food material for the emerging adults. Eggs laid by the adults on the maize seedlings were collected and the hatched larvae were reared on the artificial diet up to third instar (identified by change of instar, width of head capsule *i.e.,* 0.81 to 0.95 mm and duration (4 to 6 days from hatching) and these third instar larvae were used for bioassay studies.

Culturing of *B.t.*

Forty ml of Luria Bertani broth was taken in 50ml conical flask and sterilized in autoclave at 121°C, 15 lbs pressure for 15 minutes. After cooling, the broth was inoculated with one loop of each native *B.t* isolate in different conical flasks. The flasks with culture broth were subjected to shaking for 48 h. Serial dilutions were prepared at 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4} and 10^{-5} dilutions and 100 µl of each dilution was taken and spread on Luria agar plate with 'L shaped' rod. The plates were kept in incubator for overnight at 37°C. After 24 h colony count was taken based on the standard formula. (Aneja, 2003).

The number of bacteria colony or CFU /ml =

$$\frac{\text{No. of colonies}}{\text{Volume taken} \times \text{Dilution factor}}$$

After colony counting, a standard concentration of 1.5×10^7 CFU/ml was prepared for all the isolates from which serial dilutions *viz.,* 1.5×10^7; 10^6; 10^5; 10^4; 10^3 CFU/ml were made and used for the bioassay experiments.

Bioassay studies of *B.t.* against third instar larvae of *S. frugiperda*

Five grams artificial diet cubes were dipped in different dilutions of native *B. t.* isolates for 4 to 5 min then air dried. Ten third instar larvae of *S. frugiperda* were released on to the artificial diet and were allowed to feed on treated artificial diets. The experiment was replicated three times. Thirty larvae were tested for each dilution and a total of five concentrations were used for each isolate. Commercial formulation (Dipel) was also prepared into different concentrations and used as check. The diet treated with distilled water was served as control. Larval mortality was recorded after 24 h of treatment at regular intervals and continued to till pupation or death of the larvae. Per cent larval mortality was recorded by dividing number of larvae died out of total number of larvae treated.

Statistical analysis

The recorded larval mortality was converted into percentage values by using the following formulae and then transformed to arc-sine values. Mean values were separated by DMRT.

Per cent larval mortality =

$$\frac{\text{No. of larvae died due to infection}}{\text{Total no. of larvae treated}} \times 100$$

The larval mortality percentage data obtained from *B.t* bioassay, were subjected to Probit analysis for determining LC25, LC50, LC75 and LC99 values with the help of SPSS package.

RESULTS AND DISCUSSION

Among native isolates and commercial formulation tested, the mean larval per cent mortality recorded at different concentrations were presented in Table1.

Among the native isolates tested (at 1.5 × 10^7 CFU/ml) the highest mortality was observed in V13 isolate (86.66%) followed by W85 isolate (73.33%) which were significantly different from each other. The larval mortality of V13 isolate (90.00%) was on par with Dipel (commercial formulation), whereas no mortality was recorded in the control treatment.

The present investigation revealed that the mortality has increased with an increasing in the concentration indicating a positive correlation between the mortality of the larvae and the dose applied. In accordance to the present study, Pavani (2019) evaluated 15 native *B.t.* isolates against third instar larvae of *Spodoptera litura* at different concentration and found that the mean percent larval mortality (which were in the range of 33.33 to 90.00%) was dose dependent.

In the present investigation though all the native isolates tested showed promising results (around 80.00% mortality against third instar larvae of *S. frugiperda*) the commercial formulation Dipel had shown highest mortality (90.00%) surpassing the native isolates, this probably is due to role of strain in the commercial formulation Dipel *i.e., B.t kurstaki.*

Nethravathi and Huger (2010) also investigated the efficacy of *B.t* isolates against five-day-old larvae of cabbage leaf webber and diamond back moth and found that the standard controls; Dipel and HD1, had the highest mortality rates (90.00 and 80.00% against leaf webber, respectively), compared to the native isolates 2422c (80.00%). Similarly, for *Plutella xylostella*, the mortality rates with the reference strains were 99.97 and 86.67 per cent which can comparable to native strain 2458c with 80.00 per cent mortality.

Similarly, Lalitha and Muralikrishna (2012) reported a mortality range of 10 to 93.33 per cent among the 114 native *B.t* isolates against first and third instar *S. litura* larvae. While the highest mortality was recorded in the

Table 1. Mean per cent mortality of third instar larvae of *S. frugiperda* at different concentrations of native *B.t.* isolates

Concentrations CFU/ml	Isolates				
	V13	**CFo76**	**W 85**	**CF24**	**Dipel**
10^3	30.00^{klm} (33.21)	13.33^{o} (21.14)	23.33^{mn} (28.78)	16.67^{no} (23.85)	36.67^{ijk} (37.22)
10^4	36.67^{ijk} (37.22)	26.67^{lmn} (30.99)	33.33^{jkl} (35.22)	30.00^{klm} (33.21)	50.00^{efg} (45.00)
10^5	43.33^{ghi} (41.15)	40.00^{hij} (39.23)	43.33^{ghi} (41.15)	43.33^{ghi} (41.15)	63.33^{c} (52.77)
10^6	63.33^{c} (52.75)	46.67^{fgh} (43.07)	56.67^{cde} (48.84)	53.33^{def} (46.92)	76.67^{b} (61.21)
10^7	86.66^{a} (68.83)	60.00^{cd} (50.77)	73.33^{b} (59.00)	63.33^{c} (52.77)	90.00^{a} (71.57)
Isolate means	43.33^{b} (38.85)	31.11^{c} (30.86)	38.33^{c} (35.49)	34.44^{d} (32.97)	52.79 (44.61)
Control			0.00%		

	Isolates	**Concentrations**	**Isolate × concentration**
Sem±	1.083	1.186	2.653
CD	3.071	3.364	7.523

* : Values in the parenthesis are angular transformed values and mean values followed by same alphabet in column are not significantly different

Table 2. Lethal concentration (LC_{25}, LC_{50}, LC_{75} and LC_{99}) values for native *B.t* isolates against third instar larvae of *S. frugiperda*

Lethal concentration	V13	CFo76	W85	CF24	DIPEL
LC25	6.28 X 10^2	1.02 X 10^4	1.95 X 10^3	4.4 X 10^3	1.79 X 10^2
Fiducial limits	2.24 X 10^1 to 3.36 X 10^3	3.88 X 10^2 to 5.12 X 10^4	3.68 X 10^1 to 1.17 X 10^4	1.03 X 10^2 to 2.45 X 10^4	0.21 X10^1 to 1.36 X 10^3
LC50	2.64 X 10^4	1.31 X 10^6	2.16 X 10^5	5.78 X 10^6	9.68 X 10^3
Fiducial limits	5.66 X 10^3 to 8.71 X 10^4	2.76 X 10^5 to 2.42 X 10^7	4.78 X 10^4 to 1.40 X 10^6	1.27 X 10^5 to 6.46 X 10^6	1.23 X 10^3 to 3.55 X 10^4
LC75	1.11 x 10^6	1.69 X 10^8	2.39 X 10^7	7.59 X 10^7	5.24 X 10^5
Fiducial limits	2.98 X 10^5 to 1.08 X 10^7	1.21 X 10^7 to 1.86 X10^{15}	2.93 X 10^6 to 3.56 X 10^9	6.70 X 10^6 to 3.96 X10^{10}	1.39 X 10^5 to 4.85 X 10^6
LC99	1.05 × 10^{10}	2.48 × 10^{16}	2.44 × 10^{15}	2.32 × 10^{16}	9.24 × 10^9
Fiducial limits	3.25 × 10^8 to 3.00 × 10^{15}	4.44 × 10^{10} to 1.66 × 10^{24}	1.02 × 10^{10} to 5.33 × 10^{21}	2.69 × 10^{10} to 3.10 × 10^{23}	2.37 × 10^8 to 5.11 × 10^{16}
Regression equation	Y= -1.84 + 0.41X	Y= -1.96 + 0.32X	Y = -1.76 + 0.33X	Y = -1.84 + 0.32X	Y = - 1.02 + 0.32X
Chi-square	0.917	0.461	0.231	0.286	0.576

* Y = a + bx; where Y = Probit; X = Concentration (CFU ml^{-1}); a = intercept; b = slope

reference strain, HD1(93.33 and 76.67 per cent in first and third instar larvae, respectively).

Thilagavathi *et al*. (2020) reported the toxicity of four *B.t.* isolates against third instar larvae of *P. xylostella* and the isolate CC recorded the maximum mortality of 95.33 per cent comparable to the standard check HD1 98.31 per cent.

Determination of Lethal Concentration (LC) of *B.t* isolates against *S. frugiperda* (Table 2)

For all the four native isolates of *B.t* tested; LC25 values ranged from 6.28 × 10^2 to 1.02 × 10^4 CFU/ml. The lowest LC25 value was recorded in V13 (6.28 × 10^2 CFU/ml) followed by W85 with 1.95 × 10^3 CFU/ml. whereas the highest value was recorded in the isolate CFo 76 with 1.02 × 10^4CFU/ml

The LC50 values for the four native isolates tested were in the range from 2.64 × 10^4 to 5.78 × 10^6 CFU/ml. The lowest LC50 was recorded in V13 isolate (2.64 × 10^4 CFU/ml) followed by W85 isolate (2.16 × 10^5CFU/ml), while the highest LC50value was noted in the isolate CF24.

The LC75 for the four native isolates tested ranged from 1.11 × 10^6 to 1.69 × 10^8 CFU/ml, with the lowest LC75 in V13 (1.11 × 10^6CFU/ml) followed by W85 2.39 × 10^7 CFU/ml. The highest LC75 value was recorded in the isolate CF24 (7.59 × 10^7CFU/ml).

LC99 values of the four native isolates ranged from 1.05 × 10^{10} to 2.48 × 10^{16} CFU/ml. The lowest LC99 value was observed in V13 (1.05 × 10^{10}CFU/ml.) followed by W85 with 2.44 × 10^{15}CFU/ml. Meanwhile the highest LC99 value was recorded in CFo76 with 2.48 × 10^{16} CFU/ml while for the CF24 was 2.32 × 10^{16}CFU/ml. which was similar to the CFo76 isolate. Similar to the per cent larval mortality from earlier bioassay results (Table 1) the lowest LC25, LC50, LC75 and LC99 was observed in commercial Dipel (Table 2) indicating its highest efficacy.

Table 3. Lethal time (LT) values for native *B.t* isolates against third instar larvae of *S. frugiperda*

Strain	Regression equation	X^2	LT_{50}	Lower limit	Upper limit	LT_{90}	Lower limit	Upper limit
V13	Y = -4.98 + 2.71X	1.27	69.02	56.97	81.91	205.03	154.85	337.17
CFo76	Y = -5.06 + 2.43X	0.77	121.19	99.08	167.80	408.44	255.99	1130.94
W85	Y = -4.88 + 2.57X	0.22	78.54	65.17	94.81	247.26	178.45	455.04
CF24	Y = -5.11 + 2.54X	0.45	103.65	86.37	132.75	331.81	222.78	746.67
Dipel	Y = -4.15 + 2.38X	1.47	54.72	42.47	66.36	188.55	139.73	325.43

* Y = a + bx; where Y = Probit; X = time; a = intercept; b = slope

However, among the native isolates tested the lowest LC25, LC50, LC75 and LC99was observed in the isolate V13 ranking it as most effective isolate. Valicente and Lana (2008) conducted bioassay studies of *S. frugiperda* with *B. t* and determined the LC50 by using doses ranging from 10^3 to 10^9 spores /ml against two-day old healthy fall army worm larvae. LC50 was 8.21×10^6 spores /ml for strain 344 while strain 1644 showed LC50 of 2.07×10^6 spores /ml.

Murali Krishna *et al.* (2018) recorded the least lethal concentration in HD1 strain of *B.t.* as 9.56×10^4 CFU/ml followed by 9.76×10^4 CFU/ml with F493 isolate and 1.90×10^5 CFU/ml with N30 isolate when screened against third instar larvae of *S. litura.*

Determination of Lethal Time (LT) of *B.t* isolates against *S. frugiperda*

Among the four native isolates tested, the least LT50 value was recorded in the V13 isolate with 69.02 hours followed by W85 with 78.54 hours. Whereas for the commercial check, Dipel the LT50 value was 54.72 hours. Regression equation, fiducial limits and chi square values were presented in Table 3.

Prabagaran *et al.* (2002) reported that LT values of live *B.t.* strains, *viz.,* PBT-782, PBT 372, PBT-574, PBT801 and PBT-716 were 25.46, 36.81, 48.18, 50.35 and 73.53 h, respectively.

Similar to the present investigation, Murali Krishna *et al.* (2018), reported that four isolates (E468, E493, N30, N115) among 21 *B.t.* isolates were found to be potent isolates with a median lethal time of 74.28 h 78.52 h, 88.68 h, and 95.70 h, respectively.

Among the four native isolates tested, V13 isolate showed the highest per cent larval mortality (86.66%), Lowest values of LC50 (6.28×10^2 CFU/ml) and LT50 (69.02 h) indicating that the isolate V13 could be the most potential *B.t* native isolate for the management *S. frugiperda.*

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Andhra Pradesh J Agril. Sci : 7(4): 230-234, 2021

CONSTRAINTS FACED BY FARMERS IN FLOWER CULTIVATION UNDER POLYHOUSE TECHNOLOGY IN CHITTOOR DISTRICT OF ANDHRA PRADESH

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Date of Receipt: 27-07-2021 Date of Acceptance: 11-10-2021

ABSTRACT

To sustain the self sufficiency in food production, we need effective technologies which can improve the productivity and sustainability of our major farming systems. Polyhouse technology, one among improved technologies which ensures stability in agriculture production. But farmers are facing different constraints while adopting polyhouse technologies. Therefore, in the present study an attempt has been made to study the status and constraints in flower cultivation under polyhouse conditions in Chittoor district of Andhra Pradesh. Three mandals of Chittoor district *viz.,* Kuppam, Gangavaram, Palamaner, were selected purposively looking to the more number of respondent who adopted polyhouse technology. The data were collected from each respondent through personal interview method with the help of structured schedule. For better understanding, all the constraints were divided into three categories *viz.,* production, technological and marketing constraints. The overall findings of the study reveal that major production constraints were high initial investment (82), non-availability of credit (72) and technological constraints were the lack of scientific knowledge about crop production under polyhouse (79), lack of technical guidance about production techniques (68) and marketing constraints were the fluctuations in price and seasonal demand (77), middlemen malpractices (63) were the major constraints faced by farmers in adopting polyhouse technologies.

KEYWORDS: Constraints, Intial Investment, Marketing, Production.

INTRODUCTION

Protected agriculture has emerged as the premier option for the productive use of land and other resources in the current era of declining land holdings followed by a major change in weather and environment. It has the potential to increase the utilization of scarce resources, such as land, water, electricity etc. It has come as a bonanza for marginal as well as small farmers who are from their small land holdings and limited capital can earn a decent livelihood. The main benefit of polyhouse cultivation is that it provides the youth and rural population with opportunities for self-employment. The idea has inspired farmers to cultivate exotic vegetables and flowers throughout the year. The main crops grown in the polyhouses are tomato, capsicum, cucumber, melons, rose, gerbera, carnation and chrysanthemum.

India's 'flower power' continues to flourish, with the nation arising as the world's second largest producer of flowers, exceeded only by China. Based on recent data released by the National Horticulture Board in India during 2017-18, the total land area with respect to loose flower cultivation was 3,24,000 hectares, from which a production of 19,62,000 million tons was obtained (Singh, 2019); Primarily, the growth curve of protected cultivation technology in Indian subcontinent is continuously increasing due to favorable government policies on subsidies under different government schemes like MIDH (Mission for Integrated Development of Horticulture previously known as NHM, (National Horticulture Board) NHB, (Technology Mission) TM, (Rashtriya Krishi Vikas Yojana) RKVY etc.

MATERIAL AND METHODS

The present study was conducted in Chittoor district of Andhra Pradesh state. Three mandals of Chittoor district *viz.,* Kuppam, Gangavaram, Palamaner was selected purposively for the study.

Garrett's ranking technique was adopted for analyzing the production, technical and marketing constraints faced by floriculture polyhouse farmers. In this method the respondents were asked to assign the rank for all the factors and the outcome of such ranking have been converted into score value with the help of following formula.

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Table 1. Constraints faced by farmers cultivating marigold and chrysanthemum flowers under polyhouses

S. No.	Particulars	Mean score	Rank
PRODUCTION CONSTRAINTS			
1	High Intial Investment	82 (15.1)	1
2	High Cost of Planting material	50 (9.09)	6
3	High labour charges	28 (5.09)	10
4	Non availability of credit	72 (13.09)	2
5	High cost of fertilizers and pesticides	59 (10.27)	4
6	Pest and diseases attack	65 (11.81)	3
7	Commercial electricity connection	18 (3.27)	11
8	Non availability of irregular water	45 (8.18)	7
9	Non availability of skilled labour	55 (10)	5
10	Change in climate	35 (6.36)	9
11	Perishability of produce	41 (7.45)	8
TECHNICAL CONSTRAINTS			
1	Lack of scientific knowledge about crop production under polyhouse	79 (19.36)	1
2	Non availability of required quantity and quality planting material at right time	47 (11.52)	5
3	Limited and irregular power supply	20 (4.5)	8
4	Non-availability of quality inputs like pesticides and insecticides at right time	59 (14.46)	3
5	Non-availability of quality polyhouse equipments at local market	32 (7.8)	7
6	Lack of technical guidance about production techniques	68 (16.6)	2
7	Lack of relevant literature in local language	53 (13.1)	4
8	Difficulties in following the recommended practices	40 (9.8)	6

Cont...

Table 1. Cont...

S. No.	Particulars	Mean score	Rank
MARKETING CONSTRAINTS			
1	Fluctuation in market prices due to seasonal demand	77 (25.7)	1
2	Lack of marketing facilities at local place	46 (15.38)	4
3	Lack of exclusive markets for polyhouse crops	63 (21.07)	2
4	Existence of middlemen malpractices	54 (18.06)	3
5	Lack of specilized supply chain management (SCM) including cold chain	36 (12.04)	5
6	Difficulty in grading at production level	23 (7.69)	6

(Source: Estimates from the survey data of the study, 2021)

$$\text{Per cent position} = \frac{(R_{ij} - 0.5)}{N_j} \times 100$$

where,

R_{ij} is the rank given for i^{th} item by the j^{th} individual.

N_j is the number of variables ranked by the j^{th} individual.

With the help of Garrett's table, the percent position estimated is converted into scores. Then for each factor, the scores of each individual are added and then total value of scores and mean value of score is calculated. The factors having highest mean value is considered to be the most important factor.

RESULTS AND DISCUSSION

Constraints encountered in production and marketing of marigold and chrysanthemum flowers

In production constraints, the high initial investment received the maximum Garret score of 82 and was ranked as the first followed by availability of credit which was with a Garret score of 70. Pest and disease attack and high cost of pesticides and fertilizers were ranked as third and fourth constraints with a Garret score of 65 and 59 respectively. Non- availability of skilled labour (55), high cost of planting material (50), availability of water (45), perishability of produce (41) and change in climate (35) were ranked fifth, sixth, seventh, eighth and ninth respectively. Huge initial investment is the major problem faced by the majority of the farmers. Mostly farmers are relying on money lenders and friends and relatives. Availability of credit was also one of the major problems faced by the growers, though there is government subsidy to the growers, it was paid in installments. So, initially the farmer has to bear the costs and for both the crops variable costs are also high.

Ozkan *et al.* (1997) studied the production structure and main marketing problem of the export-oriented cut flower industry in Turkey. The study concluded that cut flower companies were not highly mechanised but did use a computer accounting system, transportation of cut flowers to the foreign markets was the largest expense item in the cut flower industry, companies faced difficulties in keeping skilled human resource although there was unemployment. The major suggestions from the managers were to increase competition, price-cutting, cut transportation expenses for export and continuous labour supply.

Naagarajan and Jayavasuki (2016) studied the area under cultivation, production and export of floriculture in India from 1999 to 2014. The major problems faced in the production of flowers as indicated by producers included scarcity of labour, huge investment, non-availability of quality indigenous planting material and incidence of pests.

Sudhagar (2013) studied production and marketing constraints experienced by high-tech floriculture units in Hosur taluk of Tamil Nadu. The major problems faced in the production of cut-flowers as expressed by the hi-tech growers included huge investment in cut-flower production, irregular supply of electricity, scarcity of labour, non-availability of quality indigenous planting material, poor harvest during the rainy season and pest and disease attack on crops.

Sahu *et al.* (2011) studied the growth of floriculture, its role in promoting socio-economic status of floriculturists and emphasised the problems faced by floriculturists of Panskura and Kolaghat Blocks, Purba Medinipur district of West Bengal. It was observed that major constraints faced by the farmers were inadequate cold storage, poor conditions of village roads, frequent fluctuation in the demand and price, lack of good seeds and fertilizers, damage to buds and petals by fly ash from Kolaghat thermal power plant and lack of training facility for farmers engaged in floriculture.

In technological constraints, the lack of scientific knowledge about crop production under polyhouse was ranked as the first constraint with a garret score of 79 followed by lack of technical guidance about production techniques (68), non- availability of quality inputs like pesticides at right time (59) and lack of relevant literature in local language (53), non-availability of required quantity and quality planting material at right time (47), difficulties in following recommended practices(40), non-availability of quality polyhouse equipments at local market(32), limited and irregular power supply (20) were ranked as second, third, fourth, fifth, sixth, seventh and eighth constraints respectively.

Sharma *et al.* (2014) explored economic feasibility and problems related to flower cultivation in Kangra, Sirmaur and Mandi districts of Himachal Pradesh. They found that lack of training and technical know-how, non-availability quality planting material, post-harvest management of plants, less number of cold stores as well as the high cost of cold storage, non-availability of the local market, lack of organized market and transportation cost were major problems faced by sample farmers.

Bhosale *et al.* (2011) conducted a case study of a farmer growing cut flowers i.e. gerbera on an area of 0.1 hectares under polyhouse. The case study was conducted in Dawdi village of Pune district of Maharashtra. It was observed that major constraints faced by the farmer were price fluctuation, high labour charges, high costs of fertilizers, high taxes on polyhouse construction material. The major suggestions from the farmer were to control price fluctuation, ensure input availability at lower rates and reduce taxes on polyhouse construction material.

Among the marketing constraints, the fluctuations in price and seasonal demand received the highest rank with a Garret score of 77 followed by middlemen malpractices (54) , lack of marketing facilities at local place (46), lack of exclusive markets for polyhouse crops (63) and lack of specialized supply chain management including cold chain (36), difficulty in grading at production level (23) were ranked as second, third, fourth and fifth and sixth constraints respectively.

Amarnath and Vendhan (2017) reported that lack of continuous supply of cut flowers and high price fluctuations were the major problems of intermediaries.

Bagade *et al* (2008) studied the cut flower production and marketing in Ratnagiri district, Maharashtra, India, reported that major marketing constraints included the high cost of packing material and problems with storage, market functionaries, and market infrastructure.

The farmers can take the bank loans instead of depending on the money lenders. As the horticulture officers regularly visit the farms of the growers, the farmers have to utilize this opportunity and gain knowledge about the production and technical aspects. Following practices such as seedling treatment, soil drenching etc., can reduce the incidence of pests and diseases. The production is not continuous in the farms, so the farmers are not able to sell directly to the consumers. The farmers can go for co-operative marketing and directly sell to the end consumer which will increase their share in consumer’s rupee.

While analyzing overall constraints as perceived by the farmers, it was found that the high intial investment, non-availability of credit were major production constraints. crops. In technological constraints, the lack of scientific knowledge about crop production under polyhouse, lack of technical guidance about production techniques. Among the marketing constraints, the fluctuations in price and seasonal demand, middlemen malpractices were the major constraints faced by farmers in adopting polyhouse technologies.

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Andhra Pradesh J Agril. Sci : 7(4): 235-242, 2021

GROWTH AND YIELD ENHANCEMENT THROUGH DROUGHT MITIGATION IN COWPEA (*Vigna unguiculata* L.) GROWN UNDER RESIDUAL MOISTURE CONDITIONS

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Date of Receipt: 24-08-2021 Date of Acceptance: 12-10-2021

ABSTRACT

A field experiment on physiological approaches for drought mitigation in cowpea (*Vigna unguiculata* L.) was conducted during *rabi* 2019, at MARS, UAS, Raichur. The experiment was laid out in randomized complete block design with three replications and thirteen treatments. Basal dosage of fertilizer 25 : 50 kg N: P_2O_5 ha^{-1} was applied to all the treatment plots with foliar spray of treatments at 50% flowering stage. Among the treatments, foliar spray of pulse magic and chickpea magic @ 8 g l^{-1} had the profound effect in improving the growth attributes *viz*., plant height, leaf area index, leaf area duration, crop growth rate, specific leaf weight and net assimilation rate, ultimately seed yield. Further, the above said treatments respectively recorded higher number of pods per plant (16.21 and 15.34), seeds per pod (13.67 and 13.14), test weight (13.38 and 13.21 g) and seed yield (1387.00 and 1346.00 kg ha^{-1}), which was superior than other treatments. The superiority of the treatments in terms of yield enhancement might be due to its positive influence on growth and yield attributes.

KEYWORDS: Flowering stage, foliar spray, pulse magic, chickpea magic, seed yield

INTRODUCTION

Pulses are the most important crops of the world because of their high nutritive value. In India pulses have been described as a "poor man's meat and rich man's vegetable". The importance of vegetable protein has been well recognized throughout the world. India with its predominantly vegetarian population, has a distinction of being the world's producer cum consumer of grain legumes. Among various pulse crops, cowpea (*Vigna unguiculata* L.) is an important food legume and grown over an area of 0.5 million ha in Karnataka. Physiological reasons for variation in productivity may be attributed to poor source-sink relationship, poor translocation efficiency at later stages of crop growth, shedding of floral parts and low harvest index.

Drought is one of the major abiotic constraint resulted in poor crop stand in cowpea encountered by poor farmers in marginal areas of India (Harris *et al*., 1999).

Drought causes drastic changes in growth, yield and as a result affect global grain production. The relative decrease in potential crop yield due to abiotic stress factors including drought, ranges from 54 to 82 per cent. Therefore, for sustaining food security, high priority should be given to minimize the detrimental effects of drought. Cultivation of drought tolerant crop varieties alone would not help to overcome the situation. It necessitates the development of alternate management technologies to mitigate water stress in crop plants for sustainable growth and yield (Bray *et al*., 2000). However, an alternative approach would be through incorporation of morphological and physiological mechanisms of drought tolerance in high yielding genotypes. Several morphological and phenological traits have been listed to play a significant role in crop adaptation to drought stress (Ludlow and Muchow, 1990). Through the present investigation, the conditions of cool winter followed by terminal drought which is prevalent in the north eastern dry zone and northern dry zone of Karnataka is trying to mitigate by using drought mitigating chemicals in cowpea, which includes seed priming with $CaCl_2$ and foliar spray of urea, salicylic acid (SA), boron, cycocel, chickpea magic and pulse magic, which induce the plants to become adaptive to water stress situations for a specified period. Pulse magic is a crop booster developed and released by UAS, Raichur for increasing the yield of pulse crops. It contains 10 per cent nitrogen, 40 per cent phosphorous, 3 per cent micronutrient and 20 PPM plant growth regulator. Chickpea magic is also another novel product of Zonal Agricultural Research Station, Kalaburagi, University of Agricultural Sciences, Raichur of Karnataka which is released to enhance chickpea yield. Urea is known to

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increase the level of storage of N compounds, such as amino acids and proteins thus, foliar spray of urea directly affects N metabolism under stressful conditions and therefore amino acids synthesis (Dong *et al*., 2004). Osmopriming with calcium chloride solutions has proved effective in improving germination rate and plant stand establishment. Calcium also involved in the regulatory mechanism that activates plant to adjust to adverse environment like drought. The exogenous application of plant growth regulators (PGR) like CCC (Farooq and Bano, 2006) and salicylic acid (Azooz and Youssef, 2010) were effective in mitigating the adverse effects of water stress and enhanced the crop stability against extreme water deficit conditions. Cycocel acts as growth retardant by promoting root growth (for more water absorption) and suppressing leaf area development (for reducing transpiration loss of water) and delaying on set of leaf senescence. Salicylic acid delays the leaf senescence processes and also favour stem reserve utilization by the developing grains especially during the water deficit situations. Boron improves drought tolerance in plants by improving sugar transport, flower retention and pollen fertility. It detoxifies the accumulated free radical through activation of dismutase, and also elevate calcium and ABA mediated signalling (Valenciano *et al*., 2011). On the basis of roles and advantages of these chemicals, the investigation was carried to provide best drought mitigating practices with low cost of cultivation which directly helps the farmers in mitigating drought conditions.

MATERIALS AND METHODS

The field experiment was conducted during *rabi* 2019 at Main Agricultural Research Station, Raichur, UAS, Raichur under drought condition. It is situated at a 16º15' N latitude and 77º 20' E longitude with 389 meters above mean sea level. Experimental area received 0 mm of no rainfall during the cropping period (October to February), so it was maintained under residual moisture conditions in the field. The experiment was laid out in Randomized Complete Block Design (RCBD) with 13 treatments. The treatments *viz*., T_1- Seed priming with $CaCl_2$ @ 2%, T_2- Foliar spray with urea @ 2%, T_3- Foliar spray with CCC @ 100 ppm, T_4- Foliar spray with SA @ 100 ppm, T_5-Foliar spray with boron @ 0.1%, T_6-Seed priming with $CaCl_2$ @ 2% + foliar spray with urea @ 2%, T_7- Seed priming with $CaCl_2$ at 2% + foliar spray with CCC @ 100 ppm, T_8- Seed priming with $CaCl_2$ at 2% + foliar spray with SA @ 100 ppm, T_9- Seed priming with $CaCl_2$ at 2% + foliar spray with boron @ 0.1 %, T_{10}- Foliar spray with chickpea magic @ 8 g l^{-1}, T_{11}- Foliar spray with pulse magic @ 8 g l^{-1}, T_{12}- Water spray and T_{13}- Control with 3 replications using cowpea variety IT-38956-1 with a spacing of 30 × 10 cm. The foliar spraying was taken at 50% flowering. Basal dosage of fertilizer 25:50 kg N: P_2O_5 ha^{-1} was applied to all plots. Five plants were tagged at random in net plot area for recording various growth parameters like plant height (cm), leaf area index (Sestak *et al*., 1971), leaf area duration (days) (Power *et al*., 1967), crop growth rate (g cm^{-2} day^{-1}) (Watson, 1952), specific leaf weight (g cm^{-2}) (Radford, 1967), net assimilation rate (g cm^{-2} day^{-1}) (Watson, 1952) and also yield attributes was calculated and analyzed statistically using the 'F' test and critical difference (C.D) was calculated by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Growth parameters

The increment in the crop yield was due to increase in growth attributes in all stages of crop growth except 40 DAS as shown in Table 1 and 2. Among the treatments, foliar spray of pulse magic T_{11} recorded significantly higher plant height (33.47 and 44.77 cm) followed by foliar spray of chickpea magic T_{10} (32.70 and 43.77 cm) as compared to all other treatments. A significant lower plant height was recorded in control T_{13} (27.68 and 39.44 cm) at all stages of crop growth. Similar results obtained in the studies of Patil *et al.* (2018) and Avinash *et al*. (2020) in pigeonpea with foliar application of pulse magic @ 10 g l^{-1} showed significantly higher plant height at all the stages except at 45 and 90 DAS. Increase in plant height in barley might be due to stimulation of cell elongation, cell division and enlargement (Jalilian *et al*., 2014). Whereas, Hurde and Parjosavulesc (1981) and Zhang *et al*. (2009) reported that application of CCC reduced the plant height in soybean and alfalfa respectively.

From the present investigation it is revealed that leaf area index (LAI), leaf area duration (LAD), crop growth rate (CGR), specific leaf weight (SLW) and net assimilation rate (NAR) are gradually increased which is because of increased plant height and dry matter accumulation in plant due to the fact that the treatments sprayed with pulse magic T_{11} (8 g l^{-1}), chickpea magic T_{12} (8 g l^{-1}) and seed priming T_8 ($CaCl_2$ @ 2%) + foliar spray of SA (100 ppm). Pulse magic and chickpea magic are having similar composition but in different concentrations,

Table 1. Influence of drought mitigating chemicals on plant height, leaf area index and leaf area duration at different growth stages of cowpea

Treatment	Plant height (cm)			Leaf area index			Leaf area duration (days)	
	40 DAS	**60 DAS**	**80 DAS**	**40 DAS**	**60 DAS**	**80 DAS**	**40 – 60 DAS**	**60 – 80 DAS**
T_1 : Seed priming with $CaCl_2$ @ 2%	17.23	29.55	40.77	2.43	3.96	2.75	63.83	67.05
T_2 : Foliar spray with urea @ 2%	17.22	29.69	42.10	2.45	4.04	2.83	64.92	68.73
T_3 : Foliar spray with CCC @ 100 ppm	17.47	28.93	39.54	2.38	4.07	2.86	64.52	69.31
T_4 : Foliar spray with SA @ 100 ppm	18.00	29.85	40.34	2.46	4.39	3.17	68.47	75.52
T_5 : Foliar spray with boron @ 0.1%	18.06	29.10	41.10	2.36	3.90	2.69	62.67	65.97
T_6 : Seed priming with $CaCl_2$ @ 2% + foliar spray with urea @ 2%	17.25	29.78	41.59	2.46	4.35	3.12	68.15	74.73
T_7 : Seed priming with $CaCl_2$ at 2% + foliar spray with CCC @ 100 ppm	17.34	28.99	39.21	2.41	4.23	3.00	66.43	72.26
T_8 : Seed priming with $CaCl_2$ at 2% + foliar spray with SA @ 100 ppm	16.78	30.13	42.23	2.48	4.47	3.29	69.48	77.58
T_9 : Seed priming with $CaCl_2$ at 2% + foliar spray with boron @ 0.1%	17.01	29.18	41.24	2.37	3.93	2.67	63.02	66.08
T_{10} : Foliar spray with chickpea magic @ 8 g l^{-1}	17.66	32.70	43.77	2.51	4.92	3.61	73.89	84.95
T_{11} : Foliar spray with pulse magic @ 8 g l^{-1}	17.55	33.47	44.77	2.54	5.25	3.82	77.97	89.92
T_{12} : Water spray	17.51	28.66	40.34	2.35	3.75	2.56	60.97	63.08
T_{13} : Control	17.11	27.68	39.44	2.29	3.56	2.39	58.55	62.49
S.Em (±)	**0.43**	**0.86**	**1.09**	**0.06**	**0.12**	**0.09**	**1.93**	**1.90**
C.D. at 5%	**NS**	**2.52**	**3.17**	**NS**	**0.36**	**0.25**	**5.63**	**5.54**

that chiefly contain major nutrients, plant growth regulators and micronutrients. Mir *et al.* (2010) concluded that the factors of phytohormone and nutrient interactions in crop growth and production cause positive reactions to crop growth rates, which helps in photosynthesis and enhances metabolic rate, cell division and cell elongation which thereby, allow the plants to grow faster. The increase in growth attributes towards maturity is due to indeterminate growth pattern, higher rate of CO_2 assimilation during crop growth. Increase in LAI of cowpea plants might be due to established root system, improved emergence and seedling growth of primed seeds. CGR is influenced by LAI, leaf angle and amount of radiation energy intercepted. The favourable effect on NAR throughout the crop growth is due to early emergence, better leaf development and increase in total dry matter accumulation. Salicylic acid delays the leaf senescence processes and also favour stem reserve utilization by the developing grains especially during the water deficit situations. Calcium plays a critical role in signalling anti-drought responses and in many defence mechanisms that are induced by drought (Sadiqov *et al.*, 2002). The results are in close conformity with the investigation of Surendar *et al.* (2013) and Thakur *et al.* (2017) in blackgram and Avinash *et al.* (2020) in pigeonpea with foliar application of pulse magic @ 10 g l^{-1}. Sadeghipour and Aghaei (2012) reported the leaf area index of common bean was increased by application of SA @ 0.5 mM under drought condition. The obtained results were in line with findings of Vijaysingh (2017) in blackgram showing significantly higher crop growth rate with foliar application of pulse magic @ 10 g l^{-1}. Ganiger *et al.* (2003) reported that the application of growth regulators and urea at 35 days after sowing increased the growth of cowpea. Arun *et al.* (2020) revealed that the influence of seed priming increased the NAR at all water regimes as compared to control in cowpea.

Whereas, these growth parameters has a major role in increasing the yield parameters. This may be due to better availability of nutrients and better translocation of photosynthates from source to sink and may be due higher accumulation of photosynthates in the seeds.

Total dry weight

Maximum total dry weight was recorded with the foliar application of pulse magic @ 8 g l^{-1} (T_{11}) followed by foliar spray of chickpea magic @ 8 g l^{-1} (T_{10}) at all the stages of crop growth. Figure.1. The least was found with control (T_{13}). The PGRs and micronutrients present in these chemicals act on various physiological processes and ultimately increment in the dry matter content. These results were well supported with the results of Avinash *et al.* (2020) in pigeonpea and Thakur *et al.* (2017) in black gram showing significant higher total dry matter accumulation and its distribution to leaves, stem and pods with foliar application of pulse magic @ 10 g l^{-1}

Yield and yield components

Crop productivity depends on interaction of various growth and attributes functions in plants. The data on the number of pods per plant, pod length, pod weight, number of seeds per pod, test weight and seed yield per hectare indicate major variations in the use of drought mitigating chemicals in cowpea at 50 % flowering stage is depicted in Figure 2. Grain yield is the economic part of the total dry matter, this is the end product of the plants life cycle and it is of much interest to mankind. The pod length (16.84 cm & 15.64 cm), pod weight (1.61g and 1.58 g) was greater with the foliar spray of pulse magic (T_9) followed by chickpea magic (T_8) respectively, as compared to control (T_{13}). Yield is a compound character and is a sum total of the contribution made by a number of physiological characters. The above said parameters respectively recorded higher values in the plot sprayed with pulse magic (16.21, 13.67, 13.38 g and 1387 kg ha^{-1}) and it was on par with chickpea magic spray (15.34, 13.14, 13.21 g and 1346 kg ha^{-1}) followed by seed priming + foliar spray of SA (14.92, 12.23, 12.43g and 1279 kg ha^{-1}) as compared to control (11.52, 8.17, 10.08 g and 1021 kg). The maximum harvest index was observed in foliar spray of pulse magic @ 8 g l^{-1} (T_{11}) (41.89%) which was on par with foliar spray of chickpea magic @ 8 g l^{-1} (T_{10}) (40.28%) significantly greater than control and the rest of the treatments. Among these treatments minimum harvest index was observed in control (T_{13}) (32.57%) and followed by water spray (T_{12}) (33.21%). The increased HI (41.89%) could be attributed to the increased mobilization of metabolites to reproductive sinks. Extreme water stress induces flower shedding or pod set loss, thereby forcing assimilates to invest in vegetative development.

Flower drop decreased due to foliar spray of pulse magic. This helps in flower development, pod setting and increased number of pods per plant. Pod number plays an important role in yield determination. Our results are well supported with the findings of Patil *et al.* (2018) and

Table 2. Influence of drought mitigating chemicals on crop growth rate, specific leaf weight and net assimilation rate at different growth stages of cowpea

Treatment	Crop growth rate (g cm^{-2} day^{-1} × 10^{-2})			Specific leaf weight (g cm^{-2} × 10^{-2})			Net assimilation rate (g cm^{-2} day^{-1} × 10^{-2})	
	40 DAS	60 DAS	80 DAS	40 DAS	60 DAS	80 DAS	40 – 60 DAS	60 – 80 DAS
T_1 : Seed priming with $CaCl_2$ @ 2%	0.153	0.166	0.940	0.940	0.802	0.835	0.063	0.067
T_2 : Foliar spray with urea @ 2%	0.185	0.223	0.878	0.878	0.851	0.835	0.078	0.084
T_3 : Foliar spray with CCC @ 100 ppm	0.196	0.208	0.935	0.935	0.880	0.880	0.083	0.081
T_4 : Foliar spray with SA @ 100 ppm	0.237	0.219	0.876	0.876	0.986	0.931	0.095	0.078
T_5 : Foliar spray with boron @ 0.1%	0.157	0.236	0.907	0.907	0.825	0.852	0.068	0.084
T_6 : Seed priming with $CaCl_2$ @ 2% + foliar spray with urea @ 2%	0.219	0.217	0.898	0.898	0.953	0.898	0.088	0.078
T_7 : Seed priming with $CaCl_2$ at 2% + foliar spray with CCC @ 100 ppm	0.202	0.213	0.921	0.921	0.894	0.877	0.083	0.079
T_8 : Seed priming with $CaCl_2$ at 2% + foliar spray with SA @ 100 ppm	0.246	0.234	0.901	0.901	0.991	0.971	0.097	0.088
T_9 : Seed priming with $CaCl_2$ at 2% + foliar spray with boron @ 0.1%	0.160	0.219	0.961	0.961	0.851	0.862	0.069	0.085
T_{10} : Foliar spray with chickpea magic @ 8 g l^{-1}	0.256	0.261	0.928	0.928	0.996	1.009	0.096	0.090
T_{11} : Foliar spray with pulse magic @ 8 g l^{-1}	0.285	0.286	0.927	0.927	1.056	1.083	0.102	0.091
T_{12} : Water spray	0.137	0.146	0.921	0.921	0.812	0.795	0.061	0.063
T_{13} : Control	0.114	0.121	0.965	0.965	0.823	0.780	0.053	0.055
S.Em (±)	**0.0062**	**0.0065**	**0.026**	**0.026**	**0.027**	**0.027**	**0.003**	**0.002**
C.D. at 5%	**0.0180**	**0.0190**	**NS**	**NS**	**0.077**	**0.079**	**0.007**	**0.007**

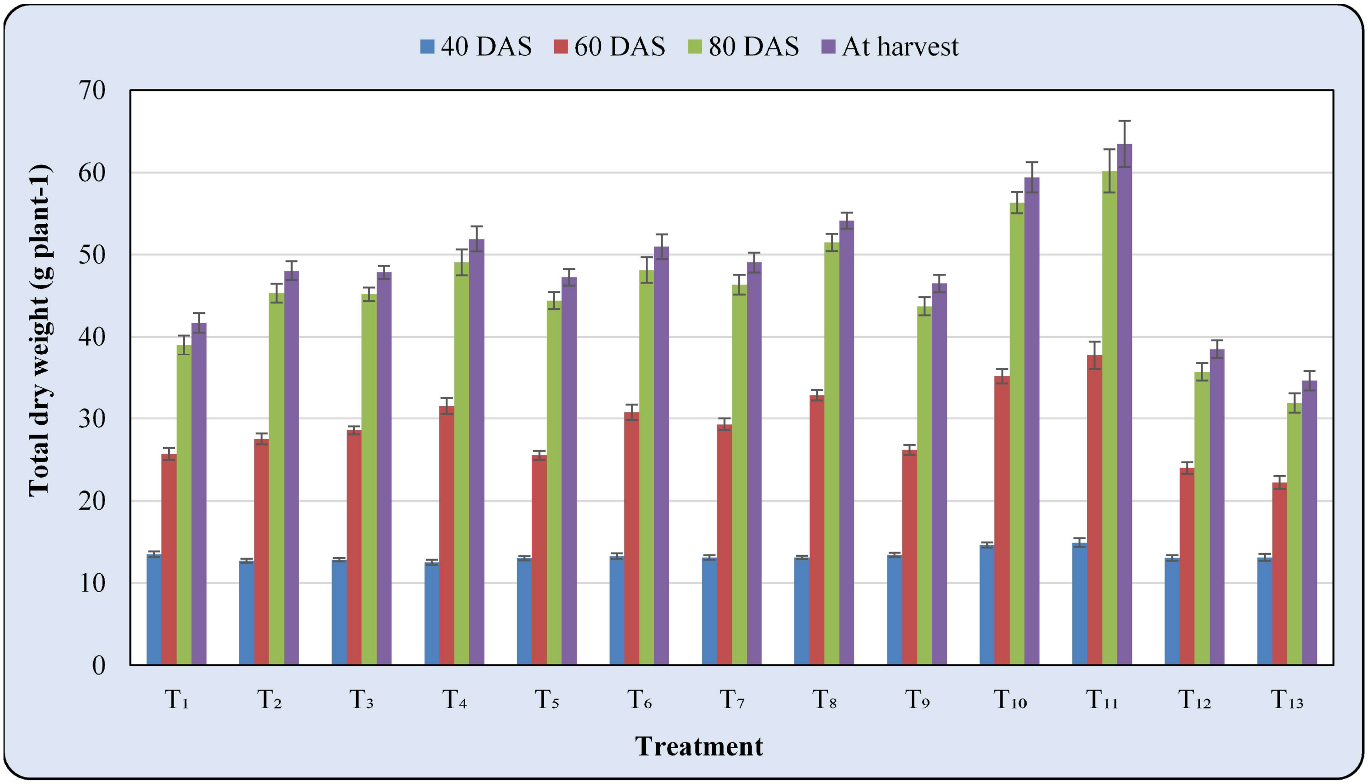

Figure 1. Effect of drought mitigating chemicals on total dry weight of cowpea at different growth stages.

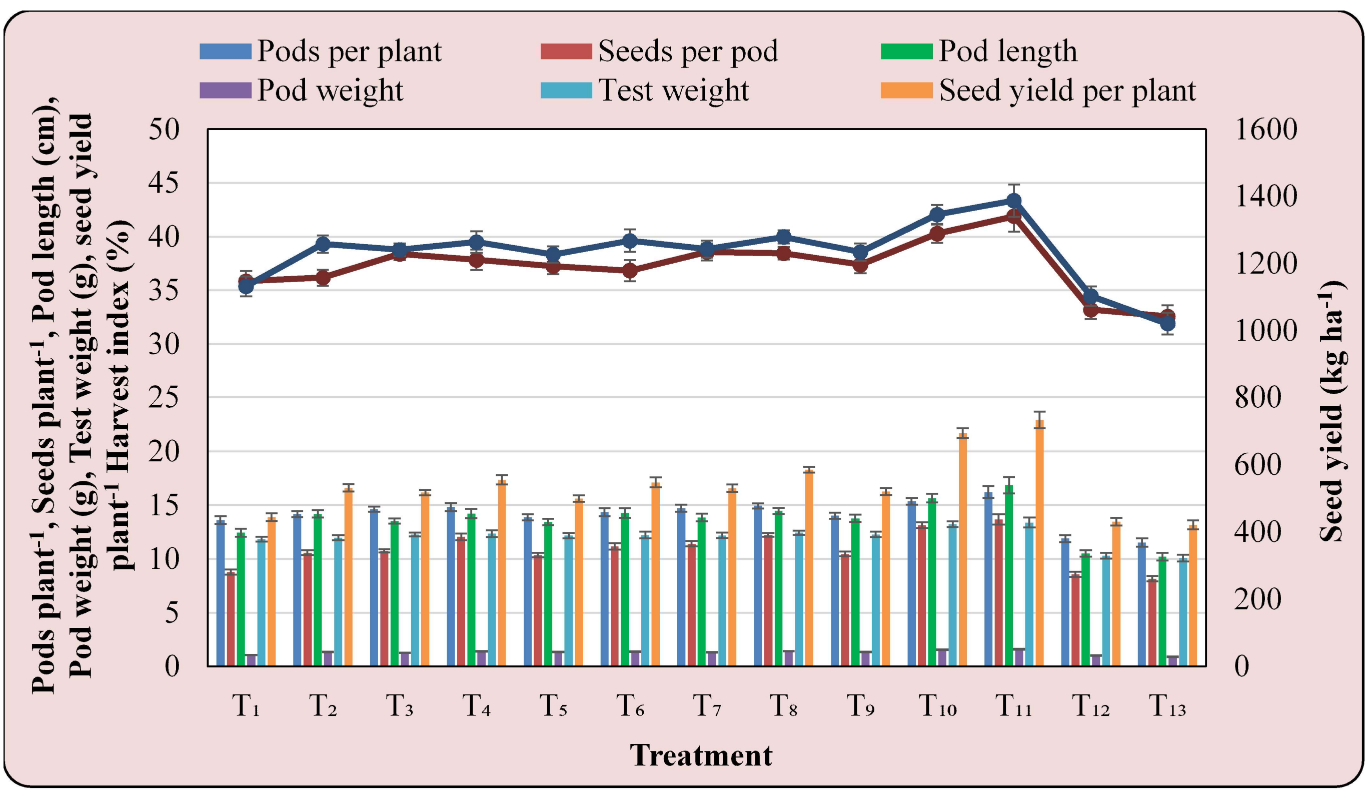

Figure 2. Effect of drought mitigating chemicals on yield and yield components of cowpea at harvest.

Avinash *et al*. (2020) in pigeonpea and Teggelli *et al*. (2016) in transplanted pigeonpea by foliar application of pulse magic @ 10 g l^{-1}. Thakur *et al*. (2017) noticed that the significantly higher number of pods with the foliar application of pulse magic @ 10 g l^{-1} in blackgram, as a result increased yield. Rajabi *et al*. (2013) recorded that the foliar application of 1.2 mM SA in chickpea increased the maximum number of pods per plant as compared with control. Ramesh (2004) reported that seed hardening with $CaCl_2$ @ 2 % increased seed yield per plant in chickpea. Manjunath and Dhanoji (2011) obtained significantly higher seed yield by seed hardening with $CaCl_2$ @ 2 % as compare to control in chickpea. Marimuthu and Surendran (2015) in blackgram found that application of NPK+ foliar spray of diammonium phosphate @ 2 % + foliar spray of pulse wonder at 50 % flowering resulted in higher seed yield. Ali and Mahmoud (2013) reported that application of SA @ 150 ppm produced the higher seed yield over control in mung bean. It can be inferred from the above discussion that growth and yield characters are significant from the point of higher productivity in cowpea.

Through the investigation it can be concluded that a single spray of pulse magic @ 8 g l^{-1} at 50 per cent flowering stage is found to be more effective to enhance the productivity especially in dryland. This might be due to maintaining higher leaf area index, crop growth rate, net assimilation rate, increased sink strength and finally higher yield.

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Andhra Pradesh J Agril. Sci : 7(4): 243-248, 2021

CONSTRAINTS IN PURCHASING FRUITS AND VEGETABLES THROUGH E-COMMERCE SECTOR

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Date of Receipt: 21-08-2021 Date of Acceptance: 10-12-2021

ABSTRACT

The present study is intended to understand the Consumer perception towards fruits and vegetables. E-Commerce business of selling vegetables and fruits through internet has been recently introduced in some metropolitan cities where online retail outlets of both vegetables and fruits have been expanding. A representative sample of 80 consumers from Bengaluru and Tirupati cities purchasing fruits as well as vegetables through online retail outlets were taken for the present study. Primary data was collected through personnel interviews with the help of a well-structured questionnaire based on objectives required. The data collected was analysed using both quantitative and qualitative research techniques. Mainly the data collected was tabulated and analysed using appropriate statistical tools such as Percentage analysis and Garrett's ranking technique. From the investigation it was found that majority of sample consumers having experience over internet usage was more than 5 years. 68.75 per cent of the consumers verify retail stores while purchasing fruits and vegetables online. Consumers purchase fruits and vegetables frequently through internet. Consumers face the problem of seasonality due to online purchase of fruits and vegetables was about 55.00 per cent.

KEYWORDS: Consumer Perception, E-commerce, Fruits and Vegetables.

INTRODUCTION

India has been growing drastically in terms of internet use, from 2010 and the percentage of users has gone up from 7.5 per cent to 50 per cent. Now-a-days the onset of lockdown and a push towards digitization proved to be a blessing to e-commerce as consumers resorted to online shopping. It became a backbone for supplying essentials to the more than 1.3 billion people of India. The growth of e-commerce in India will help the country to become a major force in the e-commerce business with an estimated growth potential that will be of $100 billion by the year 2024.

E-commerce (Electronic Commerce) is the activity of online buying and selling of commodities over the internet. It draws on technologies such as mobile commerce, electronic funds transfer, supply chain management, internet marketing, online transaction processing *etc.* It provides direct interaction between the consumers and the products (or) services that can shape up fruitful relationships. Today, the volume of trade digital payments using e-commerce has also been expanding. There has been an increase in e-commerce business due to good access to internet in both rural and urban areas.

Online fruits and vegetables shopping has became more popular now-a-days with the growing internet connectivity and raising popularity of electronic shopping. As, about 30 per cent of fruits and vegetables production is being wasted which is more than their consumption. As, one can see a clear need waiting to be served through technology-based intervention. Entrepreneurs have identified the opportunity of opening online fruit and vegetable stores.In this hustle and bustle of modern lifestyle with long working hours and heavy traffic people associate shopping at fruit and vegetable market as tiresome and stressful. People are willing to spend their time and energy on purchasing of fresh fruits and vegetables through e-commerce which can increase their healthy consumption and reduced the wastage at retailer's level. Most of the existing e-retailers offer their services in metros and major urban centres targeting the urban population having a wide consumer base *viz.*, working couples, nuclear families, students fending for themselves, new mothers, senior citizens and large families.

E-commerce websites and services in Bengaluru and Tirupati cities are on rise now-a-days as people's demand and preferences for online purchasing of fruits and

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vegetables keeps on increasing. Their main goal is to provide the consumers with digital support and services that highlight their product and specialties to the users. The e-commerce website development in both the cities offers consumers multiple product options, trust, transparency and they have the best and the finest strategies to deliver the products.

Fruits and vegetable service focus on user interface (UI) and user experience (UX) which are very crucial to a website as they contribute to the presence, overall look and appearance of the website. The e-commerce designers play a key role in converting and integrating websites on the various trends and competitions making them strong and successful in the online market. Their procurement model includes a convenient mix of warehousing and just-in-time (JIT) deliveries from a host of suppliers including FMCG companies.

As, the consumer find a wide collection of goods, great pricing and convenience with exceptional levels of customer services *i.e.,* preferred delivery times, same day deliveries and also attract consumers to purchase a large variety of products by providing a sales promotion or discount code, making it more cost effective. Timely delivery of fresh and desired produce is done by efficient and reliable suppliers within the allotted time. They are also open to take product feedback from their consumers.

Some of the established e-commerce sectors like bigbasket.com, villageagro.com, freshmigo.com, ninjakart.com, jiomart.com, reliancefresh.com etc. in Bengaluru and Tirupati cities are offering wide collection of goods. Hence, there is a need to study the consumer behavior and their preferences towards online purchasing of fruits and vegetables.

MATERIAL AND METHODS

The survey was conducted in Tirupati and Bengaluru city. E-Commerce business of selling vegetables and fruits through internet has been recently introduced in some metropolitan cities. Thus Bengaluru (tier-1) and Tirupati (tier-2) cities where online retail outlets of both vegetables and fruits have been expanding were selected purposively for the present study. A representative sample of 40 respondents from Bengaluru and 40 respondents from Tirupati cities purchasing fruits as well as vegetables through online retail outlets were selected by using simple random sampling technique. Primary data along with secondary data were collected for the study. Primary data was collected through personnel interviews with the help of a well-structured questionnaire based on objectives required. Secondary data was collected from the appropriate sources such as articles, journals, company reports, etc. The data collected was analyzed to attain the stated objectives by using frequencies, percentages and Garrett's ranking technique.

Tools and Analysis

The data collected were subjected to appropriate set of statistical tools to arrive at valid conclusions. Data was statistically analyzed using SPSS program.

Frequencies and Percentages

Some of the data were also interpreted in terms of their frequencies and percentages wherever necessary to know the distribution patterns of respondents according to variables.

Garrett's Ranking Technique

To find out the most significant factor which influences the respondent, Garrett's ranking technique was used. As per this method, respondents have been asked to assign the rank for all factors and the outcomes of such ranking have been converted into score value with the help of following formula:

$$\text{Per cent position} = \frac{(R_{ij} - 0.5)}{N_j} \times 100$$

where,

Rij = rank given for ith factor by jth individual

Nj = number of factors ranked by jth individual

With the help of Garrett's table, the percent position estimated is converted into scores. Then for each factor, the scores of each individual are added and then the total value of scores and mean values of the scores are calculated. The factors having highest mean value is considered to be the most important factor.

Age plays a major role in segmenting the market as consumers of different age groups possess distinct needs and wants. It is observed from the table that, majority of the consumers are in age group of 21-40 years (86.3%) followed by age group of below 20 and 41-60 years each with 5.00 per cent and above 60 years (3.75%). Thus, it

Table 1. Socio-economic characteristics of sample consumers

S. No	Particulars		No. of respondents	Per cent (%)
1	Age group	Below 20	4	5.00
		21-40	**69**	**86.3**
		41-60	4	5.00
		Above 60	3	3.75
2	Educational qualification	SSC	8	10.00
		Intermediate	1	1.25
		Graduation	**45**	**56.25**
		Post-graduation and above	26	32.50
3	Occupation	Business	4	5.00
		Govt. sector employee	2	2.50
		Private sector employee	**36**	**45.00**
		Student	38	47.50
4	Marital status	Married	8	10.00
		Un-married	**72**	**90.00**
5	Family size	2 members	5	6.25
		3 members	10	12.50
		4 members	**45**	**56.25**
		Above 5 members	20	25.00
6	Annual income	1-4 lakhs	20	25.00
		5-9 lakhs	16	20.00
		10 lakhs	**23**	**28.75**
		Above 10 lakhs	21	26.25

was observed that the majority of the consumers were in middle age group of 21-40 years as this age group consumers mostly use mobiles which is a key source for their frequent usage of internet (Changohit, 2006).

Out of the total sampled consumers, 56.25 per cent of the consumers hold a graduation degree, 32.50 per cent of the consumers hold post-graduation degree, and 10.00 per cent of the consumers hold a qualification up to SSC and 1.25 per cent of the sampled consumers have occupied the category of intermediate. Thus, it was found that the majority of the consumers were graduates as they have profound knowledge on internet. post-graduates also use mobiles frequently and are habituated to online shopping.

Occupation plays a vital role in selecting the product, specific brand and consumers purchase behavior. It was observed that among sampled consumers, 47.50 per cent were private sector employees, 45.00 per cent were government sector employees, 5.00 per cent consumers were doing business, 2.50 per cent were students. Thus, it was observed that the majority of the consumers were private sector employees and government sector employees. They get mostly attracted to e-commerce easily as they are busy in their work schedule and long working hours.

Out of 80 sample consumers, 90.00 per cent of consumers were un married and 10.00 per cent were married. The marital status of the consumers reveals that greater per cent of sample consumers were un-married because most of the un-married people like students, working men and women have no time to buy fruits and vegetables outside with their busy schedules.

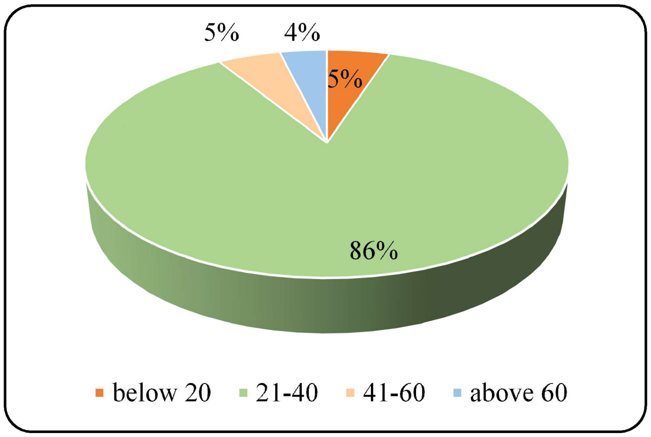

Fig.1 Age

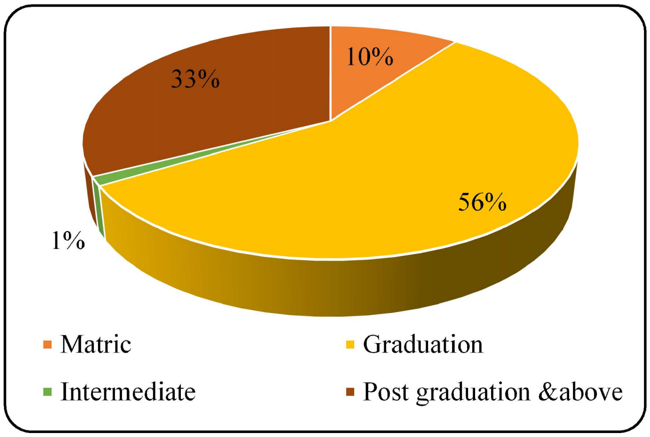

Fig. 2 Education

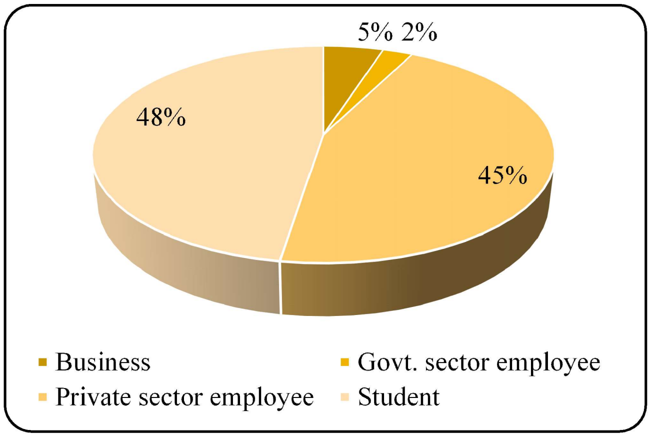

Fig. 3. Occupation

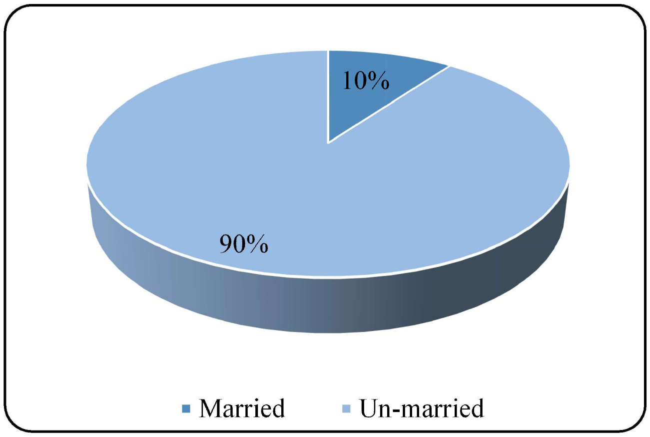

Fig. 4. Family size

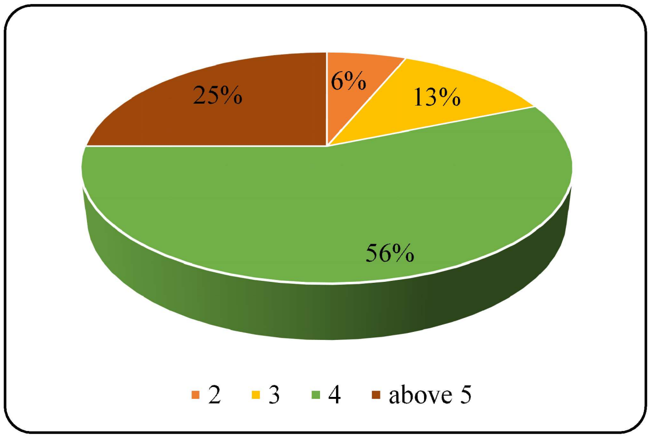

Fig. 5. Family size

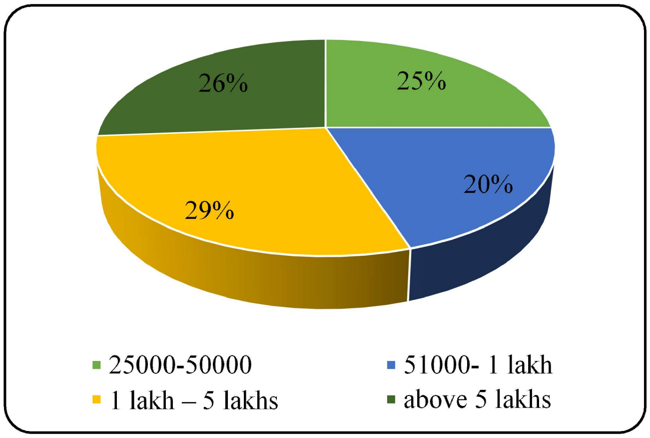

Fig. 6. Annual income

Table 2. Constraints in purchasing of fruits and vegetables through E-commerce

S. No.	Particulars	Total score	Garretts mean score	Rank
1.	Fluctuation in Price	4915	51.74	1
2.	Perishability	4855	51.11	2
3.	Seasonality	4781	50.33	3
4.	Reach of Delivery	4554	47.94	4
5.	Bad Past Experience	4003	42.14	5
6.	Storage	3671	38.64	6
7.	Technical Issues	3168	33.35	7
8.	Transportation	3100	32.63	8
9.	Unavailability of Internet	2752	28.97	9

Out of 80 sampled consumers,56.25 per cent of the sampled consumers had four members in the family, 25.00 per cent of the consumers had above five members in the family, 12.50 per cent of the consumers had 3 members in the family and 6.25 per cent of the consumers had two members in the family. Thus, the majority of the respondents had four members in the family as there are more proportion of small families in the present society when compared to singles and joint families (Rani *et al.,* 2018).

Income levels of the people plays a major role in selecting the product in terms of quality and quantity. It was found that out of 80 sample sizes of consumers, the annual income of 28.75 per cent of the consumers is around 10 lakhs whereas 26.25 per cent of the consumers earn above 10 lakhs per annum, 25.00 per cent earn around 1-4 lakhs per annum and 20.00 per cent of the consumers earn 5-9 lakhs per annum. It is, thus, observed that the majority of the consumers fall under the income group of 10 lakhs. As fruits and vegetables occupies a premium market, income levels of the people have an absolute effect on its sales. Hence, the high income *i.e.,* above 10 lakhs per annum has a major role in segmenting the market (Taruna, 2017).

Constraints in purchasing of fruits and vegetables through E-commerce sector

Information regarding constraints in purchasing of fruits and vegetables through e- commerce sector was analysed with the help of Garett ranking technique (Kanchan *et al.,* 2015) and it is collected and presented in the Table 2.

It is observed that 'fluctuation in price' was the first ranked constraint in purchasing of fruits and vegetables through e-commerce sector with mean score of 51.74, 'perishability' was the second ranked constraint with mean score of 51.11, 'seasonality' is the third constraint with mean score of 50.33, 'reach of delivery' is the fourth ranked constraint with mean score of 47.94, 'bad past experience' is the fifth ranked constraint with mean score of 42.14, 'storage' is the sixth ranked constraint with mean score of 38.64, 'technical issues' is the seventh ranked constraint with mean score of 33.35, 'transportation' is the eighth ranked constraint with mean score of 32.63, 'unavailability of internet' is the least ranked constraint with mean score of 28.97. Majority of the consumers have opted for fluctuation of price as a major constraint for purchasing fruits and vegetables through e-commerce. The consumers felt that due to the market forces like demand and supply the online prices of fruits and vegetables will be fluctuating (Ramesh and Arumugam, 2019).

Constraints in purchasing fruits and vegetables purchased through e-commerce sector reveals that majority was high with the fluctuation in price.

It is required to provide a wide variety of products to satisfy the needs and wants of customers because consumers were not convinced with the range of product available with online stores.

Certain age group people think that there is insufficient information with online shopping websites. Therefore, maximum information should be provided to the consumers.

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