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STUDIES ON EFFECT OF SOURCES OF SILICA ON RICE CROP IN SALINE SOIL OF BHAVANAMVARIPALEM VILLAGE

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ABSTRACT

Rice crop is susceptible to salinity and its yield is severely limited under salt stress environment. However, one favourable character of rice is that it is a silicate accumulator crop.It means Si increased cell-wall binding of Na^+ in the root, while decreasing its transport to the shoot. Different source of silica on rice crop at farmer's field in saline soil was studied. The experiment was laid out in randomized block design with four silicate sources as treatments and replicated four times. Four silicate sources *viz.,* potassium silicate, calcium silicate, paddy straw and paddy husk were evaluated for yield and yield components against control (without silica). Among different sources of silica, potassium silicate treatment recorded significantly higher grain yield (5686 kg ha^{-1})when compared to no silica treatment (4631 kg ha^{-1}). Higher potassium uptake of rice was observed in potassium silicate application treatment followed by calcium silicate application. Lower sodium uptake in rice was recorded in potassium silicate application treatment and it was on par with calcium silicate application treatment which was significantly superior to other treatments.

Keywords: Potassium silicate, calcium silicate, rice, salinity

INTRODUCTION

Rice (*Oryza sativa* L.) is a staple food for more than half of the world's population. Globally it is grown in 167 million hectares with total production of 759.6 million tonnes and productivity of 4.54 ton per hectare (FAO, 2018). Soil salinity is global issue in terms of plant growth in irrigated agricultural areas under arid and semi–arid climatic zones of the world.Lianghe and Michael (2000) reported that salinity adversely affected yield of rice particularlyin semi arid and arid climates and losses of rice yield were 40%. Numerous studies around the globe proved that Si fertilization had highly positive effects on plant growth under biotic and abiotic stresses (Rodrigues *et al*., 2003; Ma, 2004). These positive effects are usually more evident in Si accumulator plants. Rice plants accumulate Si in their shoot (0.1 to 6%) based on dry weight (Gong *et al*., 2003). Higher the Si accumulation in plant shoots, greater is the tolerance against salt stress in rice.Keeping this in view, a field experiment was designed with the objective to study the effect of different sources of silicon

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on growth and yield of rice crop under saline conditions.

MATERIALS AND METHODS

This experiment was conducted in farmer's field at Bhavanamvaripalem village, Pittalavanipalem Mandal, Guntur district during *Kharif*, 2017. The experimental soil was clay in texture and having EC of 3 dSm^{-1}.The experiment to assess the effect of five different sources of silica on rice *viz.,* potassium silicate, calcium silicate, paddy straw and paddy husk with one control (without silica) was laid out in randomized block design and replicated four times. Nitrogen was applied @120 kg ha^{-1} in three equal splits in the form of urea. First split of urea (nitrogen) was applied as basal dose at the time of planting of the crop remaining two equal splits of urea (nitrogen) was broadcasted at maximum tillering and panicle initiation stages. Phosphorus was applied @ 60 kg P_2O_5 ha^{-1} in the form of single super phosphate as basal and potassium @ 40 kg K_2O ha^{-1} in the form of muriate of potash was applied in two equal splits as basal dose at the time of transplanting and at panicle initiation stage.Potassium silicate @60 kg $ha^{-1}$and calcium silicate @120 kg ha^{-1}, paddy husk and paddy straw @ 1t ha^{-1} were applied through broadcasting before transplanting. 'BPT 5204' was the test variety for this experiment. Recommended agronomic management practices and plant protection measures were followed during crop growth.

RESULTS AND DISCUSSION

Silicon application through different sources showed significant differences in growth parameters of rice. Maximum plant height (83.6 cm) was recorded with potassium silicate application which was significantly superior to control and on par with all other sources of silica (Table1). This may be attributed to the fact that silicon helps in increasing the erectness of leaves thereby enhancing photosynthetic capacity which results in higher plant height. Similar findings were reported by Fallah (2012) in rice under hydroponic culture.

Higher number of tillers per hill was observed with potassium silicate application(15.4) and the lowest number of tillers (10.2) was recorded in control treatment. Tran Xuan (2017) reported that silicon application increased number of tillers upto 28% than control. Dobermann and Fairhurst (1997) and Jugal *et al*. (2015) also mentioned positive effect of silicon on rice plant growth.

Among the different sources of silicon, potassium silicate recorded the highest drymatter at harvest (6937 kg ha^{-1}) when compared to all other treatments. The lowest drymatter accumulation was recorded in control treatment (5893 kg ha^{-1}). Ahmad *et al*. (1992) reported higher drymass production by Si inclusion in saline environments than in non-saline environment.

Table 1. Influence of sources of silica on growth of rice

Silica sources	Plant height (cm)	No. of tillers $plant^{-1}$	Drymatter accumulation at harvest ($kg\ ha^{-1}$)
T_1- Control	75.7	10.2	5893
T_2-Potassium silicate	83.6	15.4	6937
T_3-Calcium silicate	82.7	13.3	6577
T_4- Paddy straw	81.0	12.4	6069
T_5-Paddy husk	79.5	11.2	5972
SEm±	2.3	0.5	243
CD(0.05)	6.9	1.5	731
CV (%)	5.7	7.9	8

The longer panicle (18.8 cm) was observed with potassium silicate application followed by calcium silicate (18.3 cm) application and significantly superior to other sources of silica. Kim *et al.* (2012) reported that yield attributes *viz.,* panicle length, spikelets per panicle and grains per panicle were significantly affected by silicon application.The highest number of total grains per panicle was observed in potassium silicate treatment (143) and found significantly superior than all other silica sources (Table 2). The number of filled grains was significantly influenced by silica sources. Significantly highest number of filled grains (127) was recorded with potassium silicate treatment, as compared to the other silica sources. The lowest number of filled grains (93) per $panicle^{-1}$ was observed in control (T_1). The test weight was significantly influenced by silica sources.The highest test weight of 19.03 g was observed with potassium silicate application followed by calcium silicate application and the lowest test weight was observed in control treatment (17.91 g).

Among the different sources of silicon nutrients, potassium silicate treatment recorded significantly higher grain yield (5686 $kg\ ha^{-1}$) and straw yield (6237 $kg\ ha^{-1}$**)** when compared to control treatment in grain (4631 $kg\ ha^{-1}$) and straw yields (5118 $kg\ ha^{-1}$**)** and it was on par with calcium silicate application treatment in both grain and straw of rice (Table 3). More grain yield and biomass accumulation under salt stress conditions due to introduction of silicate in growth environment was in line with the

Table 2. Influence of sources of silica on yield attributes of rice

Silica sources	Panicle length (cm)	Total No. of grains panicle^{-1}	No. of filled grains panicle^{-1}	Test weight (g)
T_1- Control	15.9	98	93	17.91
T_2-Potassium silicate	18.8	143	127	19.03
T_3-Calcium silicate	18.3	125	113	18.45
T_4- Paddy straw	16.7	108	103	18.40
T_5-Paddy husk	16.6	105	100	18.11
SEm±	0.6	5	3	0.36
CD(0.05)	1.9	15	9	1.09
CV(%)	7.2	8	6	5.05

findings of Al-aghabary *et al*.(2004) on chlorophyll quantity and antioxidative enzyme system of tomato and wheat plants. Effects of silicon on yield are related to the deposition of the element under the leaf epidermis which results a physical mechanism of defense, reduces lodging, increases photosynthesis capacity, decreases transpiration losses and ultimately increases the yield (Korndorfer *et al.,* 2004). Mobasser *et al*. (2008) and Malidareh *et al*. (2011) reported that increased amount of applied silicon enhanced the number of productive tillers and total number of tillers/m^2 and paddy yield.

The data revealed that the highest straw yield (6237 kg ha^{-1}) was recorded with potassium silicate treatment followed by calcium silicate treatment which was significantly superior to other treatment. The lowest straw yield (5118 kg ha^{-1}) was observed in control treatment. The accumulation of silicon in plant parts reduces its lodging and enhanced resistance against biotic and abiotic stress. The application of silicon enhanced photosynthetic activity, water and nutrient use efficiency, which ultimately results into better vegetative growth. The higher straw yield was mainly associated with increased plant height and number of tillers hill^{-1}. These results are in conformity with the findings of Singh *et al*. (2006) and Patil (2013).

In case of different sources of silicon application, potassium silicate application

Table 3. Influence of sources of silica on yield of rice

Silica sources	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest Index (%)
T_1- Control	4631	5118	47.5
T_2-Potassium silicate	5686	6237	47.6
T_3-Calcium silicate	5456	6002	47.6
T_4- Paddy straw	5058	5469	48.0
T_5-Paddy husk	4974	5347	48.1
SEm$\pm$	184	223	
CD(0.05)	555	672	
CV (%)	7	8	

recorded the lowest sodium uptake in grain (13.07 kg ha^{-1}) and straw (16.37 kg ha^{-1}) when compared to the other treatments. Sodium uptake was high in control *i.e.* T_1(16.49 kg ha^{-1} and 27.69 kg ha^{-1}) both in grain and straw of paddy crop. Yeo *et al.*(1999) reported that silicon does reduce salinity damage in rice by reducing the *bypass flow* (the percentage of the transpirational volume flow that crosses the root entirely in an apoplastic pathway) of sodium. Similar findings were reported by Singh *et al*. (2006) and Wader *et al*. (2013).

Among the different silicon sources, potassium silicate application recorded the highest potassium uptake in grain (33.74 kg ha^{-1}) and straw (141.80 kg ha^{-1}) followed by calcium silicate application (Table 4) and the lowest potassium uptake was observed in control plot both in grain and straw (17.51 and 67.52 kg ha^{-1}). Among the major salinity tolerance mechanisms increased K uptake due to Si application is one (Liang *et al.,* 1999). Liang *et al*. (2005) also recorded that potassium uptake increase and sodium uptake decrease might be a major tolerance strategy in higher plants when Si was included in the growth medium.

Data revealed that in different sources of silicon application, potassium silicate application recorded the highest K/Na ratio followed by calcium silicate.The NGSF (New Generation Silicate Fertilizer) application in the growth stage significantly enhanced potassium to sodium ratio in rice specifically under salt stress condition but noted non-significant impact of K:Na ratio in normal soil. The applied Si also improved K: Na ratio in saline (treated) as well as in normal (untreated) soil conditions.

Mukkram *et al.* (2011) has also reported that the maximum K:Na ratio was observed in plants exposed to high level of exogenous Si applied under both control and saline soil environment.

Table 4. Influence of sources of silica on sodium uptake by rice grain and straw

Silica sources	Sodium uptake by rice grain (kg ha^{-1})	Sodium uptake by rice straw (kg ha^{-1})	Potassium uptake by rice grain (kg ha^{-1})	Potassium uptake by rice straw (kg ha^{-1})	K/Na ratio in rice grain	K/Na ratio in rice straw
T_1- Control	16.49	27.69	17.51	67.52	1.06	2.43
T_2- Potassium silicate	13.07	16.37	33.74	141.80	2.58	8.05
T_3-Calcium silicate	14.02	18.80	24.41	108.75	1.74	5.78
T_4- Paddy straw	15.42	19.50	21.98	92.58	1.42	4.74
T_5-Paddy husk	16.35	22.45	20.83	83.68	1.27	3.72
SEm$\pm$	0.92	0.95	3.23	13.73		
CD(0.05)	2.77	2.85	9.75	41.35		
CV (%)	12.22	9.05	5.46	5.55		

CONCLUSION

Application of potassium and calcium silicate can improve rice yields in saline soils by inducing salinity tolerance in rice bythe reduction of Na uptake and selective enhancement of K uptake. Silica application can thus help in ensuring sustainable yields in Si accumulating field crops such as rice under arid climate and saline soils.

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GENETIC VARIABILITY AND CHARACTER ASSOCIATION STUDIES IN CHICKPEA (*Cicer arietinum* L.) WITH SPECIAL REFERENCE TO TRAITS AMENABLE TO COMBINE HARVESTING

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ABSTRACT

The study was taken up with 100 advance chickpea breeding lines obtained from different institutes during *Rabi*, 2016-17 to assess the genetic variability and character association for traits contributing to combine harvesting. Two advance breeding lines-NBeG 864 (3.1 t ha^{-1}) and NBeG 862 (2.7 t ha^{-1}) which had the first pod bearing node 30 cm from above the ground; plant height greater than 50 cm and angle 60˚or above between the main axis and primary branch with significant yield advantage over machine harvestable check cultivar 'HC 5' were identified. Genetic variability as measured in terms of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) was moderate for height of the first pod and low for angle of the primary branch and plant height. Yield attributing traits *viz*., number of primary branches, number of secondary branches, 100 seed weight, shoot biomass and days to 50 per cent flowering exhibited moderate PCV and GCV values. Height of the first pod, days to 50 per cent flowering and 100 seed weight exhibited high heritability and high genetic advance indicating the scope for genetic improvement of the traits through phenotypic selection. Character association studies revealed shoot biomass as a major contributing character for seed yield in chickpea. Plant height and height of the first pod exhibited a strong positive association between themselves and with shoot biomass. Also, *inter se* correlations among the positively associated traits with seed yield *viz.,*100 seed weight, number of secondary branches and plant height with shoot biomass showed significance in breeding genotype s suitable for combine harvesting.

Keywords: Genetic variability, combine harvesting, chickpea, character association studies.

INTRODUCTION

Chickpea is one of the world's second most important food legumes. It is rich in protein, (18-22 %), possesses fibre, B vitamins, and various minerals. India is the principal producer and consumer of chickpeas globally with a cultivated area of 10.56 million ha, 11.37 million tonnes of production, and 1077 kg ha^{-1} productivity. The crop is grown in almost all parts of the country, mostly as a rainfed crop. Madhya Pradesh is the largest cultivator of chickpea with 40 per cent of total production. Rajasthan, Maharashtra, Karnataka, Uttar Pradesh and Andhra Pradesh contribute to 13%, 12%, 11%, 5 % and 6 %, respectively (AICRP on Chickpea, 2019). Introduction and widespread approval of short

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duration wilt resistant varieties such as JG 11, JAKI 9218 and KAK 2 and mechanization of agricultural operations has changed the scenario of crop growing in Andhra Pradesh. However, chickpea harvesting operations could not be mechanized as the existing varieties have semi-spreading growth habits and hence not suitable for combine harvesting. Development of chickpea varieties with semi-erect to erect plant structure, and 30% to 40% added plant height compared the already accessible cultivars, along with pod bearing starting from 25-30 cm and above the ground level would be considered more appropriate for mechanical harvesting. Improved cultivars suited for mechanical harvesting would benefit farmers by decreasing the cost of cultivation thus increasing net income. Therefore, rigorous efforts are being made by the lead centre of Andhra Pradesh state, situated at the Regional Agricultural Research Station, Nandyal to develop machine harvestable varieties with more desirable traits. Apart from the seed quality or character, these traits consist of suitable crop period, pest and disease resistance, and even improvement in dietary value.

MATERIAL AND METHODS

The experiment with 100 genotypes of chickpea was laid out during *rabi* 2016-17 at Regional Agricultural Research Station, Nandyal in a Randomized Block Design (RBD) and replicated thrice. Spacing of 30 cm x10 cm was adopted. Recommended agronomical practices for chickpea crop along with necessary timely plant protection measures were followed (ANGRAU, 2020).The data was recorded on important traits *viz.*, days to 50 per cent flowering, days to maturity, height of the first pod, angle of the primary branch, number of primary branches, number of secondary branches, plant height, 100 seed weight, shoot biomass and seed yield in each genotype as per standard methods. Genetic variability parameters were estimated according to Burton (1952) and Johnson *et al.* (1955).

Correlation coefficients among the characters at phenotypic and genotypic levels were analysed following Hayes *et al*. (1995) and Singh and Choudhary (1985) methods. Path analysis was completed according to Dewey and Lu(1959).

RESULTS AND DISCUSSION

Analysis of variance for all the ten characters indicated highly significant differences among the genotypes and shown a wide range of variability for characters considered. Angle of primary branch is an important trait for combine harvesting. Tall genotypes with semi-erect (65^0 to 74^0) to erect (75^0-90^0) growth habits are more suitable for combine harvesting. Other criteria considered include first pod of the genotypes should appear

Table 1. ***Per se*** **performance of top 20 chickpea genotypes for yield and traits amenable to combine harvesting during *rabi* 2016-17**

Entry No.	Entry name	Days to 50 % flow-ering	Days to matur-ity	Height of the first pod (cm)	Angle of the primary branch (°)	No. of primary branches	No. of secondary branches	Plant height (cm)	100 seed weight (g)	Shoot biomass (kg/ ha)	Seed yield (kg/ ha)
1	N BeG-864	43	97	30.7	66.0	2.3	7.3	52.3	27.3	6759	3188
2	N BeG-862	43	96	26.3	63.0	3.3	11.0	55.0	27.7	7561	2754
3	N BeG-868	41	93	34.3	63.0	3.7	9.7	46.3	23.0	4657	2682
4	N BeG 47 (C)	47	95	29.7	71.7	2.7	8.3	60.0	30.3	5224	2605
5	N BeG-857	52	94	26.3	68.7	2.7	9.3	53.0	26.7	5441	2593
6	ICCX-110057-F3-BP-P39-BP	48	95	32.7	68.3	4.3	12.0	55.7	20.0	6309	2582
7	ICCX-110067-F3-BP-P65-BP	54	94	33.7	70.0	5.0	7.7	54.3	26.3	6576	2555
8	GBM 2 (C)	51	94	34.7	62.0	3.3	12.0	60.3	31.7	7394	2538
9	RVSSG 48	35	94	25.3	65.3	3.7	7.3	52.0	28.3	4707	2499
10	DIBG 201	43	82	26.0	63.7	3.0	9.7	44.3	17.0	4540	2466
11	N BeG-855	43	94	34.0	65.0	3.7	6.0	53.7	27.3	5725	2460
12	ICCX-110068-F3-BP-P20-BP	54	93	36.0	70.0	4.7	9.0	53.7	24.7	5391	2432
13	ICCX-110051-F3-BP-P33-BP	52	93	32.7	67.7	3.7	8.7	55.0	25.0	4907	2360

Table 1 contd.

Table 1 contd.

14	ICCX-110067-F3-BP-P77-BP	47	93	31.3	68.7	3.0	8.3	50.7	33.0	4890	2282
15	ICCX-110067-F3-BP-P60-BP	31	85	26.3	70.0	2.7	9.7	51.0	17.7	5491	2277
16	ICCX-110067-F3-BP-P81-BP	47	95	31.3	68.3	3.0	11.0	51.3	25.7	4823	2260
17	ICCX-110067-F3-BP-P45-BP	57	97	37.7	63.7	4.0	12.3	54.0	22.3	4924	2255
18	ICCX-110067-F3-BP-P10-BP	52	95	33.7	67.3	3.7	8.7	61.0	29.3	4523	2232
19	ICCX-110066-F3-BP-P57-BP	33	83	26.7	69.0	3.0	10.7	52.3	26.7	4456	2227
20	ICCX-110052-F3-BP-P12-BP	52	92	36.0	67.7	4.0	6.0	47.7	22.7	4590	2221
21	HC 5 (C)	59	96	37.7	58.3	5.3	8.7	58.0	18.7	5124	1999
	Grand Mean	49	93	31.2	66.5	3.6	8.2	50.2	22.5	4540	1935
	SEm±	1.2	1.0	1.1	1.3	0.7	1.1	1.3	1.8	576	271
	CD at P≤ 0.05	3.3	2.7	3.2	3.6	2.1	3.1	3.6	5.1	1604	756
	CV %	**4.2**	**1.8**	**6.4**	**3.4**	**35.6**	**23.6**	**4.5**	**14.1**	**22.0**	**24.3**

Table 2. Estimates of genetic parameters for 10 characters in 100 chickpea genotypes during *rabi* 2016-17

Characters	Mean	Genotypic variance	Phenotypic variance	GCV (%)	PCV (%)	Heritability (%)	G A	GA as % of mean
Days to 50% flowering	48.7	67.39	68.78	16.86	17.03	97	16.74	34.38
Days to maturity	92.5	23.18	24.15	5.20	5.31	96	9.72	10.50
Height of the first pod (cm)	31.2	17.12	18.44	13.24	13.74	93	8.21	26.29
Angle of the primary branch (^{0})	66.5	12.51	14.20	5.32	5.66	88	6.84	10.28
Number of primary branches	3.6	0.24	0.79	13.51	24.59	30	0.55	15.28
Number of secondary branches	8.2	1.24	2.47	13.60	19.25	50	1.62	19.80
Plant height (cm)	50.2	19.53	21.20	8.79	9.16	92	8.74	17.39
100 seed weight (g)	22.5	15.39	18.77	17.43	19.25	82	7.32	32.50
Shoot biomass (kgha^{-1})	4540	1885.10	3072.20	15.98	20.40	61	70.06	25.79
Seed yield (kgha^{-1})	1935	247.56	512.21	13.55	19.49	48	22.53	19.40

Table 3.Phenotypic (r_p) and genotypic (r_g) correlation coefficients among 10 characters in 100 chickpea genotypes during *rabi* 2016-17

Character		DM	HFP	APB	NPB	NSB	PH	100 SW	SHB	SY
DF	r_p	0.5690**	0.4779**	-0.0137	0.5652**	-0.0235	0.2883**	-0.0239	0.1725	-0.0734
	r_g	0.5820	0.5017	-0.0167	1.0242	-0.0170	0.3011	-0.0233	0.2275	-0.1036
DM	r_p		0.3038**	0.0369	0.2762**	0.0001	0.2161**	0.0454	0.2372**	0.0495
	r_g		0.3252	0.0450	0.4995	0.0316	0.2289	0.0538	0.3250	0.1005
HFP	r_p			-0.0447	0.3862**	-0.0353	0.6060**	0.0676	0.2651**	-0.0102
	r_g			-0.0524	0.6455	-0.0638	0.6440	0.0741	0.3807	0.0131
APB	r_p				-0.0461	-0.2131**	-0.0402	-0.0269	-0.0847	-0.0314
	r_g				-0.0700	-0.3457	-0.0351	-0.0320	-0.0885	-0.0404
NPB	r_p					0.0587	0.2260**	-0.1997	0.1143*	-0.0924
	r_g					0.1543	0.4365	-0.4537	0.3410	-0.2314
NSB	r_p						0.1850**	0.0056	0.3160**	0.2925**
	r_g						0.2811	-0.0011	0.4331	0.3578
PH	r_p							0.3359**	0.5061**	0.2736**
	r_g							0.3963	0.6652	0.4158
100 SW	r_p								0.3786**	0.4306**
	r_g								0.5073	0.5362
SHB	r_p									0.7078**
	r_g									0.6397

r_p= Phenotypic correlation; r_g = Genotypic correlation; *, ** Significant at $P \leq 0.05$ and $P \leq 0.01$, respectively.
DF=Days to 50% flowering, DM=Days to maturity, HFP=Height of the first pod,APB=Angle of primary branch,NPB=Number of primary branches, NSB=Number of secondary branches, PH=Plant height, 100SW=100 seed weight and SHB=Shoot biomass.

Table 4.Phenotypic (r_p) and genotypic (r_g) path coefficients among 10 characters in 100 chickpea genotypes during *rabi* 2016-17

Character		DF	DM	HFP	APB	NPB	NSB	PH	100 SW	SHB	SY
DF	P_p	**-0.0923**	-0.0525	-0.0441	0.0013	-0.0522	0.0022	-0.0266	0.0022	-0.0159	-0.0734
	P_g	**-0.3406**	-0.1982	-0.1709	0.0057	-0.3488	0.0058	-0.1025	0.0079	-0.0775	-0.1036
DM	P_p	-0.0117	**-0.0206**	-0.0063	-0.0008	-0.0057	0	-0.0045	-0.0009	-0.0049	0.0495
	P_g	0.0599	**0.1030**	0.0335	0.0046	0.0514	0.0032	0.0236	0.0055	0.0335	0.1005
HFP	P_p	-0.0531	-0.0338	**-0.1111**	0.0050	-0.0429	0.0039	-0.0673	-0.0075	-0.0294	-0.0102
	P_g	-0.0907	-0.0588	**-0.1808**	0.0095	-0.1167	0.0115	-0.1164	-0.0134	-0.0688	0.0131
APB	P_p	-0.0006	0.0016	-0.0019	**0.0420**	-0.0019	-0.0089	-0.0017	-0.0011	-0.0036	-0.0314
	P_g	-0.0008	0.0021	-0.0024	**0.0463**	-0.0032	-0.0160	-0.0016	-0.0015	-0.0041	-0.0404
NPB	P_p	-0.0142	-0.0070	-0.0097	0.0012	**-0.0252**	-0.0015	-0.0057	0.0050	-0.0029	-0.0924
	P_g	0.1602	0.0781	0.1009	-0.0109	**0.1564**	0.0241	0.0683	-0.0710	0.0533	-0.2314
NSB	P_p	-0.0020	0	-0.0031	-0.0184	0.0051	**0.0865**	0.0160	0.0005	0.0273	0.2925**
	P_g	-0.0022	0.0042	-0.0084	-0.0455	0.0203	**0.1317**	0.0370	-0.0002	0.0570	0.3578
PH	P_p	-0.0142	-0.0107	-0.0299	0.0020	-0.0112	-0.0091	**-0.0494**	-0.0166	-0.0250	0.2736**
	P_g	0.0302	0.0230	0.0646	-0.0035	0.0438	0.0282	**0.1003**	0.0397	0.0667	0.4158
100 SW	P_p	-0.0045	0.0085	0.0127	-0.0050	-0.0374	0.0010	0.0629	**0.1874**	0.0709	0.4306**
	P_g	-0.0086	0.0199	0.0274	-0.0119	-0.1680	-0.0004	0.1468	**0.3703**	0.1879	0.5362
SHB	P_p	0.1192	0.1640	0.1832	-0.0585	0.0790	0.2184	0.3498	0.2617	**0.6912**	0.7078**
	P_g	0.0891	0.1273	0.1491	-0.0347	0.1335	0.1696	0.2605	0.1987	**0.3917**	0.6397

*, ** Significant at $P \leq 0.05$and $P \leq 0.01$, respectively; P_p= Phenotypic Path Co-efficient, P_g= Genotypic Path Coefficient;Phenotypic residual effect= 0.6407;Genotypic residual effect= 0.6759

above a height of 25-30 cm from the ground and plant height should be greater than 50 cm. In the study, 'NBeG 864', 'NBeG 862', 'NBeG 868', 'NBeG 47', 'NBeG 857', 'ICCX-110057-F3-BP-P39-BP', 'ICCX-110067-F3-BP-P65-BP', and 'GBM 2', were the top yielding genotypes suitable for machine harvesting fulfilling all the above mentioned criteria (Table 1). Among these,'NBeG 864' and 'NBeG 862' were promising as their yield was on par with commercial cultivars 'NBeG 47', 'GBM 2' and significantly superior to 'HC 5' which were grown as checks in the same experiment.

Quantifying the extent of genetic variability, heritability of traits and the expected gains through selection are fundamental parameters that help in choosing a breeding programme for improvement of any crop (Singh, 2000). Genetic variability for various traits was represented by phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV). Among the traits related to combine harvesting, height of the first pod exhibited moderate PCV (13.74) and GCV (13.24) values (Table 2). Angle of the primary branch and plant height recorded low PCV and GCV values. Yield attributing traits *viz*., number of primary branches, number of secondary branches, 100 seed weight, shoot biomass and days to 50 percent flowering also exhibited moderate PCV and GCV values. High heritability (>70 percent) was seen for all the combine harvestable characters, 100 seed weight, days to 50 per cent flowering and days to maturity. Khan *et al*. (2011), Saleem *et al*. (2008) and Mohamed *et al*. (2015) also reported high heritability for yield and yield attributes. Large magnitude of additive gene action in the inheritance of the traits can be readily exploited in plant breeding programmes. High heritability accompanied with high genetic advance reveals heritable portion of variability which can be attributed to additive gene action. In the study, this condition was observed for height of the first pod, days to 50 percent flowering and 100 seed weight indicating that selection based on these traits would be effective. Vishnu *et al.* (2018) reported moderate variability combined with high heritability and high genetic gain under selection for height of the first pod and plant height.

Character association studies among yield attributes and traits related to combine harvesting as measured in terms of correlations and path coefficients were presented in Tables 3 and 4. Shoot biomass (r_p = 0.7078**, r_g = 0.6397), 100 seed weight (r_p = 0.4306**, r_g = 0.5362), number of secondary branches (r_p = 0.2925**, r_g = 0.3578) and plant height (r_p = 0.2736**, r_g = 0.4158) exhibited highly significant and positive correlation with seed yield indicating the significance of selection for these traits in yield improvement of chickpea crop. Islam *et al.* (1984), Sanjay and Anil, (2009), Geetika *et al.* (2015), Mehra *et al*. (2016), Khorgade *et al.* (1995), Noor *et al*. (2003) and

Padmavathi *et al*. (2013) reported positive correlation for shoot biomass, 100 seed weight and number of secondary branches while the correlation of plant height was reported by Talebi *et al*. (2007), Kumar *et al*. (2004) and Tadesse *et al*. (2016). Among the traits related to combine harvesting, plant height and height of the first pod exhibited strong positive association between themselves and with shoot biomass indicating that increase in plant height and height of the first pod is associated with production of more biomass. Plant height also exhibited a positive correlation with days to maturity, days to flowering, number of primary branches and number of secondary branches. Additionally, a positive correlation was revealed between 100 seed weight and shoot biomass; days to 50 percent flowering and days to maturity and plant height and 100 seed weight. In *desi* chickpea genotypes, while breeding for taller plant types suitable for combine harvesting, the positive association between plant height and 100 seed weight should be considered carefully as the desirable seed size in *desi* chickpeas would be less than 30g. Such correlations among the traits observed in this study were also supported by Arshad *et al*.(2004) and Tadesse *et al*. (2016).

The correlation coefficients were further partitioned into direct and indirect effects by various yield contributing characters and represented as path coefficients. Shoot biomass exhibited a highly positive direct effect on seed yield. The direct effects of other positively correlated traits *viz*., 100 seed weight, plant height and the number of secondary branches were significantly less but their *via* contribution through shoot biomass has contributed for significant correlation.

CONCLUSION

The study has revealed that selection for high yield should be based on shoot biomass as this is the major contributing character for seed yield in chickpea. The *inter se* correlation among other associated traits 100 seed weight, number of secondary branches and plant height with shoot biomass are important in formulating selection criteria. Traits related to machine harvesting such as plant height and height of the first pod exhibited strong positive association between themselves and with shoot biomass indicating the significance of selection for these traits in breeding genotypes suitable for combine harvesting.

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EFFECT OF ORGANIC MANURES AND INORGANIC PHOSPHORUS FERTILIZERS ON AVAILABLE NUTRIENT STATUS OF SOIL UNDER CHICKPEA CULTIVATION

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ABSTRACT

The field experiment was conducted during *Rabi*, 2018 in randomized block design on clayey soils to study the effect of organic manures and inorganic phosphorus fertilizers on available nutrient status of soil under chickpea (variety JG-11) cultivation. Application of 100% RDP through BGD + Microbial Consortium significantly increased the availability of nitrogen, phosphorus content of the soil. However, there was no significant increase in the availability of potassium, sulphur, iron, copper and manganese. The availability of zinc increased significantly at all the stages of the crop.

Key Words: Biogas digest(BGD), chickpea, soil available nutrients

INTRODUCTION

The availability of nutrients from the soil to the crops is greatly influenced by the nature and age of crops, microbial activity, enzyme transformations and application of organic manures and inorganic fertilizers (Venkata Subbaiah *et al*., 2013). Use of chemical fertilizers alone may not maintain the of soil health and sustain productivity. Addition of organic manures in any form helps in maintaining the organic matter and fertility levels in soils. The type of organic manures added and the soils involved influence considerably the rate of decomposition as well as consequent chemical changes in the soil. The superiority of an organic material used will be determined by its decomposability and mineralization pattern of nutrient elements contained therein. Though much work has been reported on the use of biogas digest on the production of various crops,only a few findings were reported on the use of biogas digest on chickpea production.

MATERIAL AND METHODS

The field experiment was conducted at Agricultural College Farm, Bapatla on chickpea (*Cicer arietinum*) variety 'JG-11'during *Rabi*, 2018. The experiment was laid out in Randomized Block Design and replicated thrice. The experimental soil was clayey in texture,

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moderately alkaline in reaction with pH 8.26, non-saline (EC-0.42 dSm^{-1}), medium in organic carbon (0.53), with low available nitrogen (172 kg ha^{1}), high in available P_2O_5 (25.6 kg ha^{-1}) and K_2O (321 kg ha^{-1}) and sufficient in sulphur (17.2 ppm) and micro nutrients.The soil samples were collected prior to the experiment (at vegetative, reproductive and at harvest stages of the crop up to a depth of 30cm and processed and analysed.

Treatment details

T_1 – Control (Without P fertilizer); T_2 – 100% RDP through inorganic sources ; T_3 – 75% RDP through inorganic sources ; T_4 – 75% RDP (through inorganic) + 25% P through BGD (Biogas digest); T_5 – 50% RDP (through inorganic) + 50% P through BGD (Biogas digest); T_6 – 100% RDP (through inorganic) + Microbial Consortium ; T_7 – 75% RDP (through inorganic) + Microbial Consortium ;T_8 – 50% RDP (through inorganic) + Microbial Consortium ; T_9 – 100% RDP through BGD ;T_{10} – 100% RDP through BGD + Microbial Consortium; **RDF-** N: P_2O_5: S- 20:50:40 kg ha^{-1}; **Microbial consortium includes Rhizobium, PSB and KSB.

Available nitrogen content in the soil was determined by alkaline potassium permanganate method (Subbiah and Asija, 1956). Available phosphorus in the soil samples was extracted with 0.5 M $NaHCO_3$ of pH 8.5 and the phosphorus in the extract was estimated colourimetrically by the ascorbic acid method using a spectrophotometer at 660 nm (Watanabe and Olsen, 1954). Available potassium in the soil was extracted using neutral normal ammonium acetate and potassium in the extract was determined flame photometrically (Muhr *et al*., 1965).Available sulphur was determined by extracting with 0.15 per cent calcium chloride dihydrate and sulphur in the extract was determined by the turbidimetric method using a spectrophotometer at 420 nm (Hesse, 1971). Available zinc, copper, manganese and iron in the soils were determined in the DTPA extract, using atomic absorption spectrophotometer (Lindsay and Norvell, 1978).

Microbial consortium (liquid formulation) applied in the proposed treatments includes *Rhizobium*, PSB and KSB. These are applied in the form of liquid formulations. *Rhizobium* was applied as seed treatment @ 5-6 ml per kg of chickpea seed. Both PSB and KSB were applied based on the recommendation @ 0.5 L per acre. PSB and KSB were initially mixed with a small amount of soil collected from respective plots and the soil was uniformly spread in the same plot from where it was collected. The recommended dose of fertilizers (RDF) for chickpea were - 20:50:40 N: P_2O_5: S kg ha^{-1} were applied.

Table1.Effect of organic manures and inorganic phosphorus fertilizer on soil available N, P_2O_5, K (kg ha^{-1}) and S (ppm)

TREATMENTS	VEGETATIVE				REPRODUCTIVE				HARVEST STAGE			
	N	P_2O_5	K	S	N	P_2O_5	K	S	N	P_2O_5	K	S
T_1 – Control (without P fertilizer)	199	24.8	314	19.8	187	24.2	310	18.7	178	23.8	308	18.1
T_2 – 100% RDP through inorganic sources	209	38.8	342	21.9	199	32.4	334	19.9	186	27.7	329	19.2
T_3 – 75% RDP through inorganic sources	204	38.2	320	20.6	190	31.9	316	19.4	179	27.1	315	18.7
T_4 – 75% RDP (through inorganic) + 25% P through BGD (Biogas digest)	220	39.2	350	23.2	215	32.8	343	20.9	201	28.1	338	19.9
T_5 – 50% RDP (through inorganic) + 50% P through BGD (Biogas digest)	249	40.1	360	23.8	233	33.9	350	21.2	221	28.6	345	20.4
T_6 – 100% RDP (through inorganic) + Microbial Consortium	215	39	348	22.8	203	32.6	339	20.6	190	27.9	333	19.7
T_7 – 75% RDP (through inorganic) + Microbial Consortium	208	38.4	339	21.6	195	32.1	332	19.7	183	27.3	326	18.9
T_8 – 50% RDP (through inorganic) + Microbial Consortium	202	37.7	318	20.3	189	31.6	313	18.8	179	26.2	311	18.3
T_9 – 100% RDP through BGD	262	40.5	361	24.3	251	34.5	354	21.8	240	29.6	349	20.6
T_{10}– 100% RDP through BGD + Microbial Consortium	269	41.5	370	25.1	257	35.3	363	23.4	244	30.1	358	21.1
SEm±	11.9	0.45	13.9	1.19	12.48	0.61	13.7	1.10	10.4	0.52	13.6	1.03
CD(0.05)	35.5	1.40	NS	NS	37.1	1.80	NS	NS	31	1.60	NS	NS
CV(%)	9.24	7.4	7.06	9.29	10.20	6.8	7.06	9.36	9.0	8.2	7.11	9.19

Characteristics of the biogas digest

S.No.	Property	Value
1	pH	7.8
2	EC(dS m^{-1})	0.79
3	Total N (%)	1.5
4	Total P (%)	1.1
5	Total K (%)	0.8
6	Total S (%)	0.42
7	Fe(ppm)	1153
8	Cu(ppm)	456.2
9	Mn (ppm)	146.3
10	Zn (ppm)	121.7

RESULTS AND DISCUSSION

Available Nitrogen

Significantly highest values of soil available nitrogen(269 kg ha^{-1}, 257 kg $ha^{-1}$and 244 kg ha^{-1}) were recorded in treatment T_{10} which received 100% RDP through BGD + microbial consortium and this was on par with treatment T_9 which received 100% RDP through BGD (262 kg ha^{-1}, 251 kg $ha^{-1}$and 240 kg ha^{-1}). Lowest values were recorded (199 kg ha^{-1}, 187 kg $ha^{-1}$and 178 kg ha^{-1}) in control plot which received no P fertilizer at vegetative, reproductive and harvest stages, respectively.

Between the inorganic treatments T_2 and T_3, T_2 which received 100% RDP through inorganic source recorded higher values of soil available nitrogen (209 kg ha^{-1}, 199 kg ha^{-1} and 186 kg ha^{-1}) at all growth stages of chickpea (Table 1).Highest values of soil available nitrogen were recorded in treatments which received P through organics and this might be due toaddition of biogas slurry and mineralization of native as well as applied nitrogen fertilizer. Similar results of high nitrogen availability due to the addition of biogas slurry were also reported by Jeptoo *et al.* (2013) and Megha Viswakarma (2016).

Efficacy of the inorganic fertilizer was pronounced when they are combined with biofertilizers. The results were in close conformity with findings of Venkata Subbaiah *et al*. (2013)who reported that application of inorganic, organic and biofertilizers applied to maize crop increased the availability of soil nutrients.

Available Phosphorus

Among the different treatments, significantly highest (41.5 kg P_2O_5 ha^1, 35.3 kg P_2O_5 ha^1 and 30.1 kg P_2O_5 ha^1) available phosphorus was recorded in T_{10} treatment which received 100% RDP through BGD + Microbial Consortium and it was on par with T_9 treatment that received 100% RDP through BGD (40.5 kg P_2O_5 ha^1, 34.5 kg P_2O_5 ha^1 and 29.6 kg P_2O_5 ha^1).

At the vegetative stage, available P_2O_5 in the soil increased by 67% in T_{10}, 63% in T_9, 61.7% in T_5 and 54.4% in T_2 treatments over control. However, this increase was 45.8% in T_{10}, 42.5% in T_9, 40% in T_5 and 33.8% in T_2 treatments over control at the reproductive stage and 26.5% in T_{10}, 24.4% in T_9, 20% in T_5 and 16.4% in T_2 treatments over control during harvest.

Table2. Effect of organic manures and inorganic phosphorus fertilizer on soil DTPA extractable Mn &Zn(mg kg^{-1})

TREATMENTS	Manganese			Zinc		
	Vegetative	Reproductive	Harvest	Vegetative	Reproductive	Harvest
T_1 – Control (without P fertilizer)	9.71	9.65	9.58	0.83	0.79	0.78
T_2 – 100% RDP through inorganic sources	9.98	9.95	9.91	0.78	0.75	0.72
T_3 – 75% RDP through inorganic sources	9.91	9.73	9.70	0.79	0.78	0.74
T_4 – 75% RDP (through inorganic) + 25% P through BGD (Biogas digest)	10.12	10.04	9.97	0.93	0.91	0.88
T_5 – 50% RDP (through inorganic) + 50% P through BGD (Biogas digest)	10.19	10.13	10.08	0.94	0.92	0.89
T_6 – 100% RDP (through inorganic) + Microbial Consortium	10.06	9.99	9.94	0.84	0.82	0.81
T_7 – 75% RDP (through inorganic) + Microbial Consortium	9.95	9.93	9.91	0.87	0.85	0.83
T_8 – 50% RDP (through inorganic) + Microbial Consortium	9.89	9.72	9.64	0.89	0.85	0.84
T_9 – 100% RDP through BGD	10.25	10.21	10.13	0.98	0.96	0.92
T_{10}– 100% RDP through BGD + Microbial Consortium	10.33	10.27	10.16	0.99	0.98	0.94
SEm±	0.40	0.40	0.39	0.03	0.03	0.03
CD(0.05)	NS	NS	NS	0.11	0.10	0.11
CV(%)	6.99	6.97	6.99	7.09	6.55	7.39

Table3. Effect of organic manures and inorganic phosphorus fertilizer on soil DTPA extractable Fe and Cu (mg kg^{-1})

TREATMENTS	Iron			Copper		
	Vegetative	Reproductive	Harvest	Vegetative	Reproductive	Harvest
T_1 – Control (without P fertilizer)	6.28	6.16	6.15	3.44	3.38	3.31
T_2 – 100% RDP through inorganic sources	6.19	6.15	6.14	4.03	3.83	3.72
T_3 – 75% RDP through inorganic sources	6.21	6.16	6.15	3.60	3.43	3.39
T_4 – 75% RDP (through inorganic) + 25% P through BGD (Biogas digest)	6.91	6.36	6.29	4.12	3.90	3.74
T_5 – 50% RDP (through inorganic) + 50% P through BGD (Biogas digest)	6.93	6.41	6.31	4.17	3.94	3.79
T_6 – 100% RDP (through inorganic) + Microbial Consortium	6.67	6.28	6.18	4.07	3.86	3.72
T_7 – 75% RDP (through inorganic) + Microbial Consortium	6.76	6.30	6.19	4.02	3.81	3.70
T_8 – 50% RDP (through inorganic) + Microbial Consortium	6.82	6.34	6.26	3.58	3.41	3.34
T_9 – 100% RDP through BGD	7.06	6.45	6.33	4.28	3.99	3.82
T_{10}– 100% RDP through BGD + Microbial Consortium	7.10	6.49	6.37	4.35	4.04	3.86
SEm±	0.29	0.25	0.25	0.20	0.19	0.14
CD(0.05)	NS	NS	NS	NS	NS	NS
CV(%)	7.51	7.01	6.95	9.05	9.17	7.10

Application of organics might lead to the formation of a coating on sesquioxides and may cause a reduction in phosphate fixing capacity of soil. Similar findings of an increase in available phosphorus in soil due to application of organics were reported by Bharadwaj and Omanwar (1994) who recorded that application of inorganic fertilizers, poultry manure or vermicompost along with phosphorus solubilising bacteria increased the availability of soil available P_2O_5. Venkata Subbaiah *et al*. (2013) also reported that PSB in the applied Microbial Consortium might have helped in reducing P fixation by its chelating effect and also solubilized the unavailable form of P. Recovery of P from organic manure is slightly better than from fertilizer as CO_2 released by decomposition improves the availability of phosphorus in soil (Gopalakrishnan, 2007).

Available Potassium and Sulphur

Data indicated that highest available potassium and sulphur was recorded in treatment T_{10} which received 100% RDP through BGD + Microbial Consortium during vegetative, reproductive and harvest stages, respectively. Among all the treatments, lowest available potassium and sulphur was recorded in T_1 treatment which did not received P fertilizer at all stages of the crop growth period(Table 2).

Among all the treatments, treatments which received 100% RDP through organics or combination of organics and inorganics recorded higher values than those which received RDP through the inorganic source. This might be due to the beneficial effect of manure on the reduction of K fixation, mineralization addition from manure, higher CEC and holding higher amounts of exchangeable K on exchange sites (Bulluck *et al.* 2002). Similar results of higher potassium and sulphur availability when the entire nutrient requirement is met through biogas slurry was reported by Nasir *et al.* (2012). This might be due to the fact that biogas slurry contains a considerable amount of sulphur in addition to other macro and micronutrients. Organic matter which is the major source of soil sulphur when added to the soil results in oxidation of S to sulphate ions brought about by soil microorganisms. The results were in close conformity with the findings of Nawalkar *et al*. (2007) and Venkata Subbaiah *et al*. (2013).

Available Micronutrient Status

The effect of organic manure, inorganic phosphorus fertilizer and their combination on the micronutrient status of the soil were presented in Tables 3&4. Micronutrient availability of soil was not significantly influenced by the source of P supply (BGD, inorganic and combined application of organics and inorganics).However, iron content was increased in all the treatments over control at all growth stages of the chickpea. Enhancement in the available Fe, Mn and Cu were observed which might be due to the organic substances and their ability to form stable water-soluble complexes preventing the reaction with other soil constituents, and, thus, increase the Fe content by releasing it from the native reserves (Venkata Subbaiah *et al*., 2013).

Significantly highest zinc availability was recorded in treatment T_{10} (100% RDP through BGD + Microbial Consortium) at vegetative, reproductive and harvest (0.99 mg kg^{-1}, 0.98 mg kg^{-1} and 0.94 mg kg^{-1}) stages, while the lowest values (0.83 mg kg^{-1}, 0.79 mg kg^{-1} and 0.78 mg kg^{-1}) were recorded in treatment T_2 which received 100% RDP through inorganic source at all the three stages of chickpea, respectively. In case of completely inorganic treatments (T_2 and T_3), T_3 which received 75% RDP recorded higher value (0.79 mg kg^{-1}, 0.78 and 0.74 mg kg^{-1}) than T_2 treatment which received 100% RDP (0.78 mg kg^{-1}, 0.75 mg kg^{-1} and 0.72 mg kg^{-1}) at all the growth stages of chickpea.

Among all the treatments, those which received organic source of P recorded higher values at all the three stages of crop growth over other treatments. Lowest soil available zinc in T_2 (100% RDP through inorganic) might be due to the fact that phosphorus had antagonistic effect on zinc making the availability of zinc much lesser. Application of BGD reduced the pH of the soil, thus, prevented the micronutrient cations to get precipitated as insoluble hydroxides. The formation of organic chelates which decreased the susceptibility of Zn adsorption, fixation and precipitation resulting in enhanced availability in soil. Similar results were reported by Vipan and Singh (2010) in rice-wheat cropping system and Venkata Subbaiah *et al*. (2013)in the maize-onion cropping system.

CONCLUSION

Application of 100% RDP through BGD + Microbial Consortium significantly increased the availability of N and P_2O_5 but available K_2O, S, iron, copper and manganese were not significantly increased but the availability of zinc increased significantly at all the stages of the crop.

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EFFECTIVENESS OF INTERCROPPING ON SOIL BORNE PESTS INFESTATION IN POTATO

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ABSTRACT

Bio-efficacy of different treatment schedules of intercropping, viz., T_1 (potato+onion), T_2 (potato+garlic), T_3 (potato+tomato), T_4 (potato+coriander), T_5 (potato+radish), T_6 (control) and T_7 (recommended insecticide) were evaluated against cutworm, Agrotis ipsilon (Hufner), mole cricket, Gryllotalpa africana, P.de. Beau. and potato tuber moth (PTM), Phthorimaea operculella (Zeller) with potato variety 'Kufri Jyoti' during rabi season of 2017-2018 and 2018-2019 (November to February). A great deal of variation in the incidence of potato tuber damaging soil pests was observed with different intercrops. Among the different intercropping systems, tuber damage caused by different soil pests was maximum when intercropped with tomato (T_3) and minimum with onion (T_1) and garlic (T_2), respectively. However, intercropping method was not as effective as recommended insecticide (T_7) in reducing soil pest incidence on potato.

Keywords: Effectiveness, Intercropping, Potato, Soil Pest, Tuber Damage

INTRODUCTION

Among the vegetables crops, potato (*Solanum tuberosum* L.) plays an important role along with other essential vegetables in our daily diet. It ranks first among vegetables in per capita consumption in most of the countries. Potato is cultivated in almost all the states of India and under very diverse conditions. According to 2011 census (Source: censusindia.gov.in), the population in India had already crossed 1.2 billion and it has been continuing to expand further at annual growth rate of 1.4% and food security for the growing population is a major concern. Pest infestation is one of the major deterrents for achieving higher production in agriculture crops. It is estimated that herbivorous insects eat about 26 per cent of the potential food production and India loses about 30 per cent of its crop every year due to pests and various viral diseases (Sharma and Rao, 2012). The insect pests inflict crop losses to the tune of 40 per cent in vegetable production (Gaurav, 2011). Misra and Agrawal (1998) registered a comprehensive list of insect and non-insect pests damaging this vegetable crop in India. Nearly about 100 insect pests and non-insect pests generally infest potato crop in different parts of the world (Simpson, 1977). Among these insect pests, cutworm, *Agrotis ipsilon* (Hufner) (Noctuidae: Lepidoptera); Mole cricket, *Gryllotalpa africana*, P.de. Beau. (Gryllotalpidae:

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Orthoptera) and potato tuber moth (PTM), *Phthorimaea operculella* (Zeller) (Gelechiidae: Lepidoptera) are the major soil pests that cause tuber damage and also decrease potato yield. In addition to the loss of tubers, they also cause damage to the foliage of the crop (Konar *et al*., 2003; Konar and Paul, 2005). They cut the tender shoots near the ground level and feed on the cut leaves. To minimize shoot and tuber damage caused by soil borne pests on potato, a number of modern synthetic insecticides are applied randomly. To minimize the crop loss by this pest, the growers depend on pesticides as control tactics. As a result, the chances of health hazards are increased as in many recipes potato is used just after a little boiling. To avoid pest problems, cultural practices such as intercropping of potato with other crops provide opportunity in managing the potato pest. This field study was conducted with a view to know the effectiveness of intercropping in reducing the soil pest infestation on potato.

MATERIAL AND METHODS

The field trial was conducted in two consecutive crop seasons of 2017-18 and 2018-19 in Randomized Block Design at District Seed Farm (situated at 23.2324° N latitude 87.8615° E longitude and 30 m altitude above MSL), Department of Agriculture, Government of West Bengal, Burdwan, West Bengal. The potato cv. 'Kufri Jyoti' was grown as a sole crop with and without pesticide applications and as intercrop with onion (cv. N53), tomato (cv. L-37), coriander (cv. Local), radish (cv. Local) and garlic (cv. Local) in 2:1 ratios. Each treatment was replicated thrice and crops are grown duly following the recommended agronomic practices. Weekly observations were recorded on the shoot damage on potato crop caused by soil pests in each plot. The percentage of plant damage (on the basis of cut leaves and shoots) by soil borne pests (cutworm, mole cricket and PTM) was recorded accordingly. Similarly, the extent of infestation in tuber by different soil pests was recorded by counting the number of healthy and damaged tubers in each plot at the time of harvesting. The weight of healthy and damaged tubers for each treatment was also taken and the data generated were analysed by SPSS software version and by statistical analysis (Gomez and Gomez, 1984).

Treatment details

T_1: Potato + Onion (2:1); T_2: Potato + Garlic (2:1); T_3: Potato + Tomato (2:1); T_4: Potato + Radish (2:1); T_5: Potato + Coriander (2:1); T_6: Potato sole (without application of any pesticide); T_7: Application of insecticide (First spray with thiamethoxam 25 WG @125 g a.i. ha^{-1} after emergence+ Second spray with thiamethoxam 25 WG @ 125 g a.i.ha^{-1} after 15 days of first spray).

RESULTS AND DISCUSSION

The results (Table 1) revealed that (2017-18) total number of healthy tubers/plot recorded was maximum in T_7 (potato + insecticide), followed by T_6 (potato as sole crop). T_7 recorded highest tuber yield in respect of both numbers of tubers/plot (465.3) and tuber weight

Table 1. Yield of potato under the influence of different intercropping during 2017-18

Treatment	Healthy Tubers		Damaged tubers (number and weight basis)							
			Cutworm		Mole cricket		PTM		Total	
	Number /plot	Weight (t ha^{-1})	Number /plot	Weight (t ha^{-1})	Number plot	Weight (t ha^{-1})	Number /plot	Weight (t ha^{-1})	% Number damage	% Weight of damage
T_1	344.7	24.1	39.7	2.8	7.0	0.47	2.00	0.19	12.38	12.55
(potato + onion)	(18.57)	(4.95)	(6.33)	(1.81)	(2.73)	(0.98)	(1.55)	(0.82)		
T_2	293.3	21.6	42.7	2.9	9.0	0.60	4.00	0.35	15.96	15.13
(potato + garlic)	(17.13)	(4.69)	(6.56)	(1.85)	(3.07)	(1.04)	(2.11)	(0.92)		
T_3	253.7	19.0	55.7	3.9	13.0	1.35	7.67	0.64	23.14	23.66
(potato+tomato)	(15.94)	(4.41)	(7.49)	(2.10)	(3.67)	(1.36)	(2.84)	(1.06)		
T_4	281.0	20.5	50.3	3.6	10.7	1.11	7.67	0.67	19.64	20.79
(potato +radish)	(16.77)	(4.57)	(7.12)	(2.01)	(3.33)	(1.26)	(2.84)	(1.08)		
T_5	274.7	20.6	43.7	3.1	9.3	0.89	6.00	0.53	17.68	17.99
(potato +coriander)	(16.58)	(4.58)	(6.64)	(1.90)	(3.12)	(1.17)	(2.54)	(1.04)		
T_6	371.0	26.5	86.0	5.9	18.3	1.58	12.33	0.91	23.92	24.05
(Control)	(19.27)	(5.19)	(9.29)	(2.53)	(4.33)	(1.44)	(3.57)	(1.18)		
T_7	463.3	34.0	30.3	2.2	3.7	0.34	1.00	0.11	7.02	7.23
(Insecticide)	(21.53)	(5.87)	(5.54)	(1.65)	(2.03)	(0.91)	(1.17)	(0.77)		
SEm (±)	0.24	0.25	0.12	0.19	0.30	0.21	0.18	0.31	-	-
C.D. $_{(0.05)}$	0.77	0.84	0.38	0.60	0.99	0.64	0.56	0.97	-	-

Note: Figures in parentheses indicate $\sqrt{x + 0.5}$ transformed values

Table 2. Yield of potato under the influence of different intercropping during 2018-19

Treatment	Healthy Tubers		Damaged tubers (number and weight basis)							
			Cutworm		Mole cricket		PTM		Total	
	Number /plot	Weight (t ha^{-1})	Number /plot	Weight (t ha^{-1})	Number plot	Weight (t ha^{-1})	Number /plot	Weight (t ha^{-1})	% Number damage	% Weight of damage
T_1	357.67	23.18	45.00	2.38	5.00	0.57	1.33	0.13	12.55	11.73
(potato + onion)	(18.92)	(4.86)	(6.74)	(1.69)	(2.33)	(1.03)	(1.34)	(0.79)		
T_2	334.33	21.99	54.00	2.81	6.67	0.65	2.33	0.26	15.86	14.47
(potato + garlic)	(18.29)	(4.74)	(7.37)	(1.81)	(2.66)	(1.07)	(1.67)	(0.86)		
T_3	283.67	16.84	67.33	4.05	12.33	1.21	9.33	0.79	23.87	26.43
(potato+tomato)	(16.75)	(4.16)	(8.62)	(2.13)	(3.57)	(1.30)	(3.12)	(1.13)		
T_4	291.33	19.20	64.33	3.36	10.00	1.07	7.00	0.55	21.82	20.60
(potato +radish)	(17.08)	(4.43)	(8.04)	(1.96)	(3.23)	(1.25)	(2.73)	(1.02)		
T_5	307.00	20.31	58.67	3.05	8.67	0.93	4.67	0.46	19.00	17.94
(potato +coriander)	(17.53)	(4.56)	(7.69)	(1.88)	(3.02)	(1.19)	(2.25)	(0.97)		
T_6	394.00	25.60	97.33	6.77	16.67	1.81	11.67	1.05	24.18	27.33
(Control)	(19.86)	(5.10)	(9.88)	(2.69)	(4.14)	(1.51)	(3.48)	(1.24)		
T_7	494.33	33.50	37.67	1.97	2.00	0.22	0.67	0.07	7.54	6.32
(Insecticide)	(22.24)	(5.83)	(6.17)	(1.57)	(1.55)	(0.84)	(1.05)	(0.75)		
SEm ($\pm$)	0.13	0.22	0.14	0.12	0.13	0.10	0.14	0.31	-	-
C.D. $_{(0.05)}$	0.41	0.71	0.43	0.38	0.42	0.33	0.45	0.95	-	-

Note: Figures in parentheses indicate $\sqrt{x + 0.5}$ transformed values

Table 3. Yield of potato under the influence of different intercropping (Pooled data of 2017-18 and 2018-19)

Treatment	Healthy Tubers		Damaged tubers (number and weight basis)							
			Cutworm		Mole cricket		PTM		Total	
	Number /plot	Weight ($t\ ha^{-1}$)	Number /plot	Weight ($t\ ha^{-1}$)	Number plot	Weight ($t\ ha^{-1}$)	Number /plot	Weight ($t\ ha^{-1}$)	% Number damage	% Weight of damage
T_1	351.19	23.64	42.35	2.59	6.00	0.52	1.67	0.16	12.47	12.14
(potato + onion)	(18.75)	(4.90)	(6.54)	(1.75)	(2.54)	(1.00)	(1.46)	(0.81)		
T_2	313.82	21.80	48.35	2.86	7.84	0.63	3.17	0.31	15.91	14.80
(potato + garlic)	(17.72)	(4.72)	(6.98)	(1.83)	(2.88)	(1.06)	(1.90)	(0.89)		
T_3	268.68	17.92	61.51	3.98	12.67	1.28	8.50	0.72	23.53	25.05
(potato+tomato)	(16.15)	(4.29)	(8.08)	(2.11)	(3.62)	(1.33)	(2.99)	(1.10)		
T_4	286.17	19.85	57.32	3.48	10.35	1.09	7.34	0.61	20.73	20.70
(potato +radish)	(16.92)	(4.50)	(7.60)	(1.99)	(3.28)	(1.25)	(2.79)	(1.05)		
T_5	290.85	20.46	51.19	3.08	8.99	0.91	5.34	0.50	18.34	17.97
(potato+coriander)	(17.06)	(4.57)	(7.18)	(1.89)	(3.07)	(1.18)	(2.40)	(0.99)		
T_6	382.50	26.05	91.67	6.34	17.49	1.70	12.00	0.98	24.05	25.69
(Control)	(19.57)	(5.15)	(9.59)	(2.61)	(4.24)	(1.48)	(3.53)	(1.21)		
T_7	478.82	33.75	33.99	2.09	2.85	0.28	0.84	0.09	7.28	6.78
(Insecticide)	(21.89)	(5.85)	(5.87)	(1.61)	(1.82)	(0.88)	(1.14)	(0.77)		
SEm (±)	0.15	0.19	0.10	0.24	0.28	0.22	0.11	0.20	-	-
C.D. $_{(0.05)}$	0.46	0.62	0.33	0.75	0.92	0.70	0.33	0.63	-	-

Note: Figures in parentheses indicate $\sqrt{x+0.5}$ transformed values

(34.0 t ha^{-1}), followed by T_6 (371.0 and 26.5 t ha^{-1}, respectively). It was due to the fact that in both the treatments potato was grown as sole crop. Among the treatments with intercropping, T_1 recorded maximum number of tubers/plot (344.7) followed by T_2 (293.3), T_4 (281.0), T_5 (274.7) and T_3 (253.7), respectively, whereas, on weight basis highest marketable tuber yield was recorded in T_1 (24.1 t ha^{-1}) followed by T_2 (21.6 t ha^{-1}), T_5 (20.6 t ha^{-1}), T_4 (20.5 t ha^{-1}) and T_3 (19.0 t ha^{-1}), respectively. Tubers damaged by three soil borne pests, *viz.,* cutworm, mole cricket and potato tuber moth (PTM) were recorded during harvesting of the crop. The damage caused by cutworm, both on number and weight basis (per plot) was highest in the T_6 (86.0 and 5.9 t ha^{-1}) followed by T_3 (55.7 and 3.9 t ha^{-1}), T_4 (50.3 and 3.6 t ha^{-1}), T_5 (43.7 and 3.1 t ha^{-1}), T_2 (42.7 and 2.9 t ha^{-1}), T_1 (39.7 and 2.8 t ha^{-1}) and T_7 (30.3and 2.2 t ha^{-1}). Tuber damaged by mole cricket ranged from 3.7 to 18.3/plot on number basis and 0.34 to 1.58 t ha^{-1} on weight basis. Whereas damage caused by PTM ranged from 1.00 to 12.33 in number and 0.11 to 0.91 t ha^{-1} on weight basis, respectively in number and weight basis. Per cent damage was seen lowest in T_7 (7.02% and 7.23%, number and weight basis, respectively), followed by T_1 (12.38% and 12.55%), T_2 (15.69% and 15.13%), T_5 (17.68% and 17.99%), T_4 (19.64% and 20.79%), T_3 (23.14% and 23.66%) and T_6 (23.92% and 24.05%), respectively.

During the 2nd year (2018-19) of field investigation, the number of healthy tubers was highest in T_7 (494.33) followed by T_6 (394.00). In both the treatments potato was grown alone, but among the intercropped treatments significantly highest number of healthy potato tubers/plot was recorded in T_1 (357.67) followed by T_2 (334.33), T_5 (307.00), T_4 (291.33) and T_3 (283.67). On the other hand, the yield of healthy tubers (weight basis) was maximum in T_7 (33.50 t ha^{-1}) followed by T_6 (25.60 t ha^{-1}), T_1 (23.18 t ha^{-1}), T_2 (21.99 t ha^{-1}), T_5 (20.31 t ha^{-1}), T_4 (19.20 t ha^{-1}) and T_3 (16.84 t ha^{-1}). Cutworm, mole cricket and PTM caused considerable damage to the crop. The minimum damage caused by cutworm, mole cricket and PTM was recorded in intercropped treatments i e. T_1 on number basis (45.00, 5.00 and 1.33/plot, respectively). The tuber damage caused by PTM was very less in number and weight basis in all the treatments. Per cent damage by soil pests was lowest in T_7 (7.54% and 6.32% number and weight basis, respectively) followed by T_1 (12.55% and 11.73%), T_2 (15.86% and 14.47%), T_5 (19.00% and 17.94%), T_4 (21.82% and 20.60%), T_3 (23.87% and 26.43%) and T_6 (24.18% and 27.33%), respectively (Table 2).

The data regarding the potato tuber yield under different intercropping treatments during 2017-18 and 2018-19 was pooled (Table 3) which depicted that potato intercropped with onion and garlic was better than the potato inter-cropped with tomato, coriander and radish. It was evident that cutworm was the predominant pest among the soil pests and caused maximum tuber damage/plot on number and weight basis irrespective of all treatments. The mole cricket was found next important soil pest, which also caused greater yield loss of potato, whereas, damage by PTM was found little in all treatments. Maximum tuber yield (33.75 t ha^{-1}) was observed in T_2 followed by T_6 (26.05 t ha^{-1}), but, among the intercropped treatments T_1 and T_2 gave maximum tuber yield (23.64 t ha^{-1} and 21.80 t ha^{-1}, respectively). It was also proved that lowest percentage of damage (number and weight basis) by the soil pests was recorded in T_7 (7.28% and 6.78%, respectively) over control T_6 (24.05% and 25.69%), however, among the intercropped treatments it was minimum (on number and weight basis) in T_1 (12.47% and 12.14%) and T_2 (15.91% and 14.80%), respectively. These findings are in agreement with the earlier studies of Konar *et al*. (2010). Konar *et al*. (2010) reported that potato intercropped with onion and garlic was found most effective in reducing the incidence of cutworm and mole cricket. Rodge and Yadlod (2009) reported that the intercropping with coriander, onion, palak and radish in *rabi* season with solanaceous vegetable crops is profitable. Mogahed (2003) also reported that the average yield of potato was significantly higher in intercropped plots (onion and garlic) than sole crop.

CONCLUSION

A great variation in the incidence of tuber damage by soil pests was recorded in potato grown along with intercrops. Among the intercropped treatments, the potato tuber damage caused by different soil pests (cutworm, mole cricket and potato tuber moth) recorded was maximum when potato is intercropped with tomato and minimum when intercropped with onion and garlic, respectively. However, intercropping method is not as effective as recommended insecticide application in reducing tuber damage by soil pests in potato crop.

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EXPORT PERFORMANCE OF GRAPES IN INDIA

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ABSTRACT

The study(2018-19) focused on the export performance of fresh grapes in India during pre-WTO and post-WTO period and destination- wise growth rate from 2001-02 to 2016-17.To analyse the export data and arrive at appropriate results, Growth Rate analysis, Instability analysis and Markov Chain analysis were used.The results indicated that the export of fresh grapes with the pre-WTO and post-WTO period when compared, the growth rate of post-WTO period decreased in terms of quantity, value and unit value of export. However,the overall growth rate was positive. The Netherlands, The United Kingdom, The United Arab Emirates, Bangladesh and Germany are major importers of fresh grapes from India, and these countries have a positive growth rate during the study period. The results of the Transitional Probability Matrix of fresh grapes export from India showed that The Netherlands was one of the stable markets of Indian fresh grapes as reflected by the probability of retention.It might be due to increasing demand for fresh grapes in that country and as a crop it was not cultivated extensively in the Netherlands. However, Germany did not continue as a loyal importer of India's fresh grapes. It might be due to rigid competition by other countries such as the Netherlands.

Keywords: Grapes, Export performance, Growth rate analysis, Instability analysis and Markov chain analysis

INTRODUCTION

Grape is one of the delicious refreshing and nutritious fruit. It is universally consumed as table fruit. More than 70 per cent of the world grape production is used for wine making and also to produce raisins and juice. Whereas, in India, it is primarily produced for table purpose and nowadays value-added products are also produced.Grape is produced in the world over an area of 7.94 mha with105.56 million tons during 2016-17.The major producers are China, Italy, the USA, Spain, France, Turkey, Chile, Argentina, Iran and India. World trade for grapes is about 4.9 million tons and the contribution of India is about 2.98 percent (FAO, 2016). The pattern of world trade in grapes reveals that Europe and Asia are largely importing regions, whereas, Europe and South America is the largest exporting region. Italy is the major exporter in Europe and Chile is the main exporter in South America. South Africa is another major exporters of grapes. India produces 2.59 million tons of grapes from 0.12 mha with the productivity of 21.23 tons per ha and accounts for 2.45 per cent of the world's production during 2016-17.India is also one of the major exporters of fresh grapes in the world. The country has exported 231.12 thousand MT of grapes to other countries in the world accounting for Rs.2065

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crores of value during the year 2016-17.Major importing countries of Indian fresh grapes were the Netherlands, the United Kingdom, the United Arab Emirates, Bangladesh and Germany.The main objective of the study conducted during 2001-02 to 2016-17 was to estimate the growth and instability in the export of Indian fresh grapes, extent of export potentiality and direction of export of fresh grapes from India and also to assess the policy imperatives to encourage export of fresh grapes from India.

MATERIAL AND METHODS

Growth Rate Analysis

Time series data on quantity and value of export of fresh grapes from India for the period from pre-WTO and post- WTO period and destination wise export of fresh from 2001-02 to 2016-17 were collected during 2018-19 from Food and Agriculture Organization (FAO), Agricultural and Processed Food Products Export Development Authority (APEDA), Directorate General of Commercial Intelligence and Statistics (DGCI&S), Government of India (GoI) and National Horticultural Board databases.The exponential function model is used to compute the annual compound growth rates in quantity and value of export.

$y = ab^t e^u$

y = Dependent variable for which growth is to be estimated

a = Intercept

b = Regression coefficient

t = Time variable

e = Exponent term (2.3018)

u = Disturbance term

The logarithmic form of equation is log y=log a + t log b+u

The compound growth rate (g) in percentage is computed from the relationship.

g = (anti log of log b) – 1 ×100 or g = (b-1)× 100

The standard error of the growth rate was estimated and tried for its significance with‘t’ test. If the compound growth rate is positive, the variable starts increasing, if the compound growth rate is negative, the variable starts decreasing year by year. The growth rates worked out with the above equation were converted into percentage for better understanding and effective comparisions. Growth rates were tested for their significance using the student ‘t’ test.

Instability Analysis

In order to study the variability in quantity and valueexport of grapes, an index of instability is developed as a measure of variability. The coefficient of variation (CV) is calculated using the following formula:

$$\text{Co}-\text{efficient of variation (CV)} = \frac{\text{Standard deviation}}{\text{Mean}} \times 100$$

The formula suggested by Cuddy and Della (1978) is used to compute the index of instability.

$$\text{Index of Instability} = \frac{\text{Standard Deviation}}{\text{Mean}} \times 100 \times \sqrt{1} - R^2$$

Coefficient of variation is multiplied by the square root of the difference between the unity and coefficient of multiple determinations (R^2) in the cases, wherein, R^2 is significant.

Markov Chain Analysis

A Markov chain is a stochastic process which describes the finite number of possible outcomes s_i = (I = 1, 2,…..r), which a discrete random variable at t = 1, 2,…..T can take during a number of time periods. The assumptions that underlie a model are:

a) The probability of an outcome on the trial depends only on outcome of the preceding trial, and

b) The probability is constant for all time periods (Lee *et al.,* 1970).

In the current application, the share of export of fresh grapes from India (X_{it}) to a particular country (j^{th}) at time 't' is considered as a random variable, and this depends on only its past import with that country. Following the first order stationary Markovien property as discussed above, the model can be specified as follows:

$$X_{jt} = Ó^{n}_{I=0} \quad X_{i\ t-1}. \ P_{ij} + e_{jt}$$

Wherein,

X_{jt}= is the export of fresh grapes from India to jth country during the year 't'

X_{it-1}=

is the export to ith country during the year t-1

P_{ij}= is the probability that exports will shift from ith country to jth country

e_{jt}= the error term independent of X i t -1

n = the number of importing countries

The transitional probability (P_{ij}) is the center of the Markov chain model analysis and will have the following properties.

$0 < P_{ij} < 1$

P_{ij} = 1, for all 'i'

The transitional probability P_{ij} indicates the possibility that exports will switch over from country 'i' to country 'j' with passage of time. The probabilities P_{ij} for i = j indicates the gains or losses in exports of each of the importing country. The probability P_{ij} for i=j (diagonal probabilities) indicate probability of retention of an importing country.

RESULTS AND DISCUSSION

Growth and Instability in the Export of Indian Grapes

Table 1 indicates explanation of growth, instability and average export in quantity, value and unit value of grapes during the pre-WTO period (1985-86 to 1995-96) and post-WTO period (1996-97 to 2016-17). During the pre-WTO period, the export value of fresh grapes registered a higher growth of 37.83 per cent which increased from 3.06 crores during 1985-86 to 54.76 crores during 1995-96 and export quantity increased from 3,462 tons to 22,151 tons at the rate of 23.98 percent over the years. A modest growth of 11.16 percent was observed

Table1. Compound growth rates and instability of export of fresh grapes from India during 1985-86 to 2016-17

Description (*)		Pre-WTO (1985-86 to 1995-96)	Post-WTO (1996-97 to 2016-17)	Overall Period (1985-86 to 2016-17)
Compound growth rate (%)	Quantity	23.98	15.83	**14.61**
	Value	37.83	22.57	**22.33**
	Unit value	11.16	05.83	**06.09**
Instability index (%)	Quantity	17.77	32.36	**58.64**
	Value	15.39	58.43	**97.56**
	Unit value	06.81	28.03	**30.12**
Average	Quantity	09.38	83.88	**58.27**
	Value	19.00	532.14	**355.61**
	Unit value	16.92	50.04	**39.94**

in unit value realised, with instability indices of 17.77 percent, 15.39 percent and 6.81 percent in export quantity, value and unit value realized respectively during the study period. The average quantity of export, value and unit value realized for this period was 9.38 thousand MT, Rs.19.00 crores and Rs.16.92 per kg.

During the post-WTO period, quantity of fresh grapes exported over the period witnessed a growth of 15.83 percent. The value and unit value of grapes increased at the rate of 22.57% and 5.83 % over the years, respectively. Similarly, 58.64%,97.56% and 30.12 per cent of instability were observed in the case of export quantity, value and unit value realized from export of grapes. The average of quantity export, value and unit value realized for this period were 83.88 thousand MT, Rs. 532.14 crores and Rs. 50.04 per kg. For the overall study period, the growth rate to the tune of 14.61 per cent was observed in the case of the export quantity of grapes. On the other hand, export value and unit value were seen to be growing, at the rate of 22.33 per cent and 6.09 per cent, respectively. Instability indices were 58.64 %, 97.76 % and 30.12% of for export quantity, value and unit value respectively during the study period. The average of quantity export, value and unit value realised for this period were 58.27 thousand MT, Rs. 355.61crores and Rs. 39.94 per kg, respectively.

Compound annual growth rates of export quantity and value of Indian fresh grapes with the pre-WTO and post-WTO when compared, the pre-WTO period has higher than those during post-WTO though, the increase in actual quantity and value during the post-WTO were much higher than that of the pre-WTO period. The WTO agreements and trade liberalization might have given a greater boost to the export of Indian grapes and intervention of Central and State Government as well as Mahagrapes and

Table2. Destination wise growth rates and instability in export of fresh grapes from India during (2001-02 to 2016-17)

Description	Export Quantity		Export Value		Unit Value	
	Compound growth rate (%)	Instability index (%)	Compound growth rate (%)	Instability index (%)	Compound growth rate (%)	Instability index (%)
Netherlands	22.00	25.91	30.63	42.25	7.09	14.50
United Kingdom	05.90	26.32	13.53	36.27	7.20	16.81
United Arab Emirates	08.63	23.03	16.00	30.11	6.76	15.84
Bangladesh	21.59	67.35	33.42	63.42	9.47	34.40
Germany	12.13	80.17	21.58	107.86	8.46	28.38
Other Countries	25.55	42.77	36.58	60.12	8.79	17.74
Total	**16.57**	**25.47**	**25.29**	**40.18**	**7.46**	**25.11**

Source: Computed by researcher based on DGCI&S Data

NAFED, had helped to increase exports of high-quality grapes from India.

Export Potentiality of Indian Grapes

Table 2 explains destination wise growth rates and instability in the export of fresh grapes from India during 2001-02 to 2016-17. Export of fresh grapes is mainly concentrated to European countries (greater than 50 percent of the total export from India). Major markets for India's fresh grapes included in the study are The Netherlands, The United Kingdom, The United Arab Emirates, Bangladesh and Germany. These countries together accounted for 58 percent of India's total quantity of fresh grapes export and remaining countries were categorized as others.

Export trend analysis of fresh grapes during 2001-02 to 2016-17 showed that quantity of fresh grapes export grew at the rate of 16.57 percent, whereas, value increased at a much higher rate of 25.29 percent and unit value realized (Rs/kg) increased at the rate of 25.11 percent. The stable markets for India's fresh grapes during the study period were the Netherlands and the United Arab Emirates as evidenced from lower instability index. Netherlands is the major export destination for India's fresh grapes, quantity exported to the Netherlands increased at the rate of 22 percent over the years, whereas, the value realised increased at the rate of 30.63 percent with instability indices of 25.91per cent, 42.25 percent and 14.50 percent in quantity, value and unit value, respectively. Whereas, growth rate of quantity exported to the United Arab Emirates was 08.63 percent with the instability of 26.32 percent during the study period.

Quantity exported to the United Kingdom registered a lower compound growth rate of 5.90 percent compared to all other countries, but export value increased at the rate of 13.53

Table 3. Transitional Probability Matrix for Fresh Grapes Export from India (2001-02 to 2016-17)

Countries	Netherlands	United Kingdom	United Arab Emirates	Bangladesh	Germany	Other countries
Netherlands	**0.6897**	0.0000	0.0000	0.1143	0.0000	0.1960
United Kingdom	0.0323	**0.4822**	0.3537	0.0240	0.1078	0.0000
United Arab Emirates	0.0923	0.6069	**0.2311**	0.0383	0.0000	0.0314
Bangladesh	0.0000	0.0000	0.2900	**0.4282**	0.0000	0.2818
Germany	0.7784	0.0000	0.0000	0.2216	**0.0000**	0.0000
Other countries	0.2130	0.0000	0.0000	0.0000	0.0080	**0.7791**

Source: Computed based on Grapes Data from DGCIS GOI

percent, and 7.20 percent growth was observed in the value received per kg of grapes. Instability indices of 26.32 percent, 36.27 percent and 16.81 percent were observed for quantity exported, value and unit value, respectively.

Bangladesh emerged as another important market during the study period. Export to this country was impressive, as export quantity augmented at the rate of 21.59 percent. Export value also grew impressively at the almost same rate of 33.42 per cent but these are associated with high instability 67.35 percent and 63.42 percent, respectively. The quantity exported to Germany grew at the rate of 12.13 percent and 21.58 percent, 8.46 percent growth observed in the case of value and unit value realized from this country during the same period with the instability of 80.17% and 107.86 %, 28.38 %, respectively. This shows that Germany is the unstable market for the Indian grapes.

India's grapes export to other countries grew at the rate of 25.55 percent in terms of quantity and 36.58% and 8.79 % in value and unit value realized with moderate instability of 42.77 %, 60.12% and 17.74% in export quantity, value and unit value realized respectively during the study period.

Direction of Indian Fresh Grapes Exports

The dynamics export trend was important for drafting export oriented programs and improve or withstand current export trends. Therefore, understanding of changing in export trade across the export destinations was important. The dynamics of changes in degree and direction of export of Indian fresh grapes was analysed with the help of Markov Transitional Probability Matrix. The stochastic process and finite Markov Chain process, was used in the study for analysis of the changes in the direction of exports of Indian fresh grapes to capture the net effect of transferring pattern of export trade over a period of time. This was provided by examining gains and losses in the export share of fresh grapes by major importing countries by deriving Transitional Probability Matrices (Table 3).

The results of the study revealed that except Germany all other countries had high retention in terms of export share over a period of time. Among the major importing counties, Netherlands was one of the most stable market of Indian fresh grapes as reflected by the probability of retention at 0.6897, with 69 percent of export share over the study period hence, The Netherlands,the most loyal and reliable market for importing the Indian fresh grapes. Export of fresh grapes to The Netherlands was retained to the tune of 69 per cent of its previous year's share in the current period; of the remaining 32 per cent of The Netherlands market share, 11 per cent was directed to Bangladesh, and 20 per cent to other countries. This high retention of the market share of Indian grapes by The Netherlands might be due to increasing demand for fresh grapes in that country and temperate crop such as grapes is not cultivated extensively in the Netherlands.

The United Kingdom had moderate probability retention of 0.4822, which retains its export share of 48.22 per cent. This implied that it had lost more than half of its share to other importing countries; of the remaining 52 per cent of The United Kingdom market share, 23.11 per cent was directed to United Arab Emirates, 10.78 per cent to Germany, 3.2 percent to The Netherlands and 2.4 percent to Bangladesh.

Bangladesh also had moderate probability retention of 0.4282, with retains its export share of 42.82 percent. This implies that it had lost most of its share to other importing countries and of the remaining 57.18 percent of Bangladesh market share, 29 percent was lost to United Arab Emirates, and 28.18 percent to other countries.

The countries United Arab Emirates had the retention of 23.11 percent of its original share. This implies that they were also the stable importers of Indian fresh grapes, whereas, countries with less quantity of fresh grapes imported from India, were pooled under the 'other countries' has showed high stability, which retained 77.91 per cent of its original share.

The entire share of fresh grapes market of Germany was directed to The Netherlands and Bangladesh with 77.84 percent and 22.16 percent, respectively. Total percent of Germany's share of grapes import from India was directed to The Netherlands and Bangladesh. However, Germany gained 10.78 per cent of United Kingdom market share and 0.8 percent of 'other countries' market share.

The Netherlands is the major gainer among importers of Indian fresh grapes over a period of time, which is having a transfer probability of 0.7784 from the Germany, 0.2130 from the 'other countries', 0.0923 from the United Arab

Emirates and 0.0323 from the United Kingdom. The probability that the Netherlands would gain in the export share of Indian fresh grapes over the study period at the cost of the Germany, the United Kingdom, the United Arab Emirates and other countriesis 77.84 percent, 3.2 percent, 9.2 percent and 21.30 percent, respectively. Hence, The Netherlands loses about 31.03 per cent of its total imports.

The United Kingdom could retain its original share of 45.50 per cent and gained 60.69 per cent from The United Arab Emirates. Whereas, it lost its share to the refrain of 35.37 per cent to The United Arab Emirates, 10.78 percent to Germany, 3.2 percent to Netherlands and 2.4 percent to Bangladesh.

Bangladesh sustained its original share of 42.82 per cent and gained 22.16 percent from Germany, 11.43 percent from the Netherlands, 3.83 percent from the United Arab Emirates, and 2.40 percent from the United Kingdom. Whereas, it lost 29 percent to the United Arab Emirates and 28.18 percent to other countries. Therefore, Bangladesh lost about 57.18 percent and retained the rest.

The United Arab Emirates had retained its original share of 23.11 percent and gained 35.37 per cent from United Kingdom and 29 percent from Bangladesh. Whereas, it lost 60.69 percent to the United Kingdom, 9.23 percent to United Arab Emirates, 3.38 percent to Bangladesh, 3.14 per cent to other countries.

Other countries retained its original share of 77.91 percent and gained 28.18 percent from Bangladesh, 19.60 percent from Netherlands and 3.14 percent from United Arab Emirates. Whereas, it lost 21.30 percent to the Netherlands and 0.80 percent to Germany. Therefore, the total loss of other countries is 22.09 percent.

CONCLUSION

The results indicated that the export of fresh grapes of India when compared with the pre-WTO and post-WTO period, the growth rate of post-WTO period decreased in terms of quantity, value and unit value of export. However, the overall growth rate was positive. The Netherlands, The United Kingdom, The United Arab Emirates, Bangladesh and Germany are major importers of fresh grapes from India, and these countries have a positive growth rate during the study period. There is a necessity to encourage exports, and liberalise the government regulations and development of necessary infrastructure as well as improve upon the productivity in order to retain India’s position in the world fresh grapes exports. There is a necessity to sensitize the farmers on export procedures and export quality standards. Farmers should be encouraged to create farmer producer organisations (FPOs) and bring value addition for increasing the returns. Government can also focus on export promotion in major importing countries to augment the import potential for Indian grapes.

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SIGNIFICANCE OF VALUE CHAIN ANALYSIS FOR CHILLI - THE CASE OF KARNATAKA CHILLI MARKET

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ABSTRACT

Value chain analysis for chilli in Karnataka revealed that fixed costs formed a smaller proportion of the total cost of dry chillies processing (ranging from 13.17% in the case of medium size processing units to16.98% in the case of large units). However, large units had relatively greater proportion of fixed costs as they mechanized most of the stages of processing in order to reap economies of scale. Among the various components of variable costs, raw material (*i.e.* the dry chillies) accounted for the highest percentage, ranging from 13.39% in respect of large processors to 18.82% in the case of small size processors.In all the three value chains identified, the value addition cost in chain 1 (VAC 1) was the highest with Rs.380 and the lowest is in case of VAC2 with Rs.267. Among the various persons involved in the value chain, the wholesaler and processor played an important role; the former being important in grading, packing and transportation; and the latter being crucial in converting raw chillies into value-added products. The retailer was only involved in the task of moving the produce (raw or processed) to the consumer.

Key Words: Chilli, Value addition, value chain analysis, Market arrival analysis

INTRODUCTION

Due to rising demand for the processed food products, particularly in urban areas, there is great scope for value addition in agricultural produce. Currently, India is one of the largest producers and exporters of chillies in the world. Andhra Pradesh State is the largest producer of chilli in India and contributes about 26% to the total area under chilli, followed by Maharashtra (15%), Karnataka (11%), Orissa (11%), Madhya Pradesh (7%) and other states contributing nearly 22% of the total area under chilli. Well known for its pungency and colour, it is estimated that 25 -30 % of chilli produce is used for preparation of chilli powder. Due to change in the lifestyle among the consumers, the demand for the processed chilli is growing rapidly.Chillies are also consumed raw and for making powder and chutney. In the village, the preparation tasks are completed at the home itself but to a large extent the consumption of chilli in urban areas is in the processed form. Chilli paste and powder are having huge demand. Chilli powder is also used as ingredient for sambar powder and other masala powders. There are many products in the market, wherein, chilli is the chief ingredient. Thus, the value chain of chilli has become an important research topic at present.The main

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objective of this study is to identify various channels for major value-added products of chillies. The specific objectives are (1) to analyse the market arrival of chillies - raw and processed and (2) to assess the value addition cost in chilli's value chain.

MATERIAL AND METHODS

The study used both secondary data and primary data. Secondary data were sourced from official documents of the National Horticultural Board, Karnataka State Department of Horticulture, APEDA and KAPPEC. Primary data were collected during October and November 2019, from the sample of 100 chilli farmers randomly selected from eight villages. The farmers of the villages Srinivasapur (15), Veerapur (10), Honnatti (15), Hanumapur (15), Malakanahalli (10), Godihal (10), Krishnapur (10), and Ranibennur rural (15) in Ranibennur Taluk, Haveri district of Karnataka were randomly selected. Fifteen chilli processing firms were selected through stratified random sampling method.

Value Addition Cost *i.e.* cost incurred during the processing of the chilli is calculated. Three main Value Addition Costs (VAC1, VAC2 and VAC3) were considered and the activities includes - Drying, Grading, Sorting, Packing, Assembly, and Handling. However, all these are studied by considering five different actors involvement *viz.,* Farmer, Village trader, Wholesaler, Commission Agent and Retailer, wherein, at each actor activity the value of chilli was calculated and added.

RESULTS AND DISCUSSION

Chillies production in India

India is bestowed with diverse climate and soil which is suitable for diversified crop cultivation. Chillies are cultivated in almost all states of the country. However, Telangana and Karnataka states have the production of 30 per cent and 20 per cent, respectively of chilli production.

Market arrivals of chillies in Karnataka markets

In Karnataka, 67 markets are functionary for dry chilli, 45 markets for green chilli and hardly 20 markets for red chilli. Thus, the market demand for dry chillies is more.

Table 1 shows that the market arrivals of dry chillies were rising in Karnataka's regulated markets for the past three years, while there was a drastic decrease in the market arrivals for green chillies. Thus, it was observed from the data on chillies production, that the decline in market arrivals was due to direct sale to the consumer, or it may be partly due to post-harvest damages or it was sold directly to the processing firms for further processing into chilli powder, and other industries. During the last three years, the production of chillies has declined partly because of a decrease in chillies exports coupled with poor rainfall and adverse climatic conditions. (Krishi Marata Vahini, 2019)

Fresh chillies are processed into value added products such as sauce, paste, canning and freezing; while dry chillies are processed into powder and red chilli paste, oleoresin

Table 1. Arrivals of green and dry chillies at RMC yards

(Values ofProduction and Arrivalin '000' MT)

Year	Chillies production	Dry Chillies Arrival	Green Chillies Arrival	Direct market /damage/Institutional sales
2015-16	569.68	118.90	23.42	427.36
2016-17	607.94	130.03	17.70	460.21
2017-18	260.14	164.96	18.24	76.93

Source: Krishi Maaraata Vahini, Karnataka.

extraction and also used for food decoration purpose. Chillies are widely used in dry form; the major portion of dry chilli is processed into chilli powder and it accounts for 91 % and the rest is wastage.

The cost of production of chilli powder is estimated for three different sizes of firms, *viz.,* small, medium and large-scale firms (Table 2). Structured questionnaire was utilized to gather the information and for analysis purpose costs are divided into two parts, *viz.,* fixed costs and variable costs. Depreciation was calculated at 5% and on an average Rs.2,836 was spent by small scale firms, while, in the case of medium and large-scale units it was Rs.3,543 and Rs.12,523/-, respectively. Depreciation on equipment was also calculated at 5% and it amounted to Rs.1,132, Rs.2,456/- and Rs.8,876/- in small, medium and large industries, respectively. Small scale units in general had no insurance, while, medium and large-scale units were insured and the amounts spent were Rs.2,143/- and Rs.9,987/-, respectively. Interest on fixed capital was calculated at the rate of 10% for each unit which averaged Rs.7,563/-, Rs. 13,255/- and Rs.16,523/- for small, medium and large units, respectively. Wages to permanent labour amounted to Rs.6,250/-, Rs.10,000/- and Rs.18,000/-. The overall fixed cost in different units based on the size of operation ranged from Rs.17,000/- to Rs.66,000/- per month.

Variable costs of chilli powder for three different sizes was Rs.93,824/-, Rs.2,06,915/- and Rs.3,22,256/-, respectively. The total production cost ranged from Rs.1.2 Lakhs to Rs.3.8 Lakhs. The production cost per kg ranged from Rs.60 in large units to Rs.63 in medium and Rs.74 in small units. This clearly implies existence of economies of scale in chilli processing. Among the various items of variable costs, raw material cost (*i.e.*the dry chillies) accounted for the highest percentage. However, for large size units the raw material cost was found to be the lowest (13.39%), while, it was18.46% and18.82% for small and medium units, respectively. This is understandable because large units tended to avoid wastage of raw material by adopting mechanization at different stages of processing. GST accounted for the next highest part of the variable cost, the percentage of which being 13.44 %, 14.69% and 20.60%, respectively for small, medium and large processing units. The GST paid by larger units formed the highest proportion (20.60%) and it was greater than the raw material cost

Table 2. Cost of production of chilli powder in different sized processing units

(Average monthly value in Rs)

S. No.	Cost	Small	Medium	Large
I. Fixed costs				
	Depreciation on building @5%	2836(2.54)	3543(1.49)	12523(3.22)
	Equipment @ 5%	1132(1.01)	2456(1.03)	8876(2.29)
	Insurance	--	2143(0.90)	9987(2.57)
	Interest on fixed capital @10%	7563(6.77)	13255(5.56)	16523(4.26)
	Wages to permanent labour	6250(5.61)	10000(4.20)	18000(4.64)
	Total fixed cost (A)	**17781(15.93)**	**31397(13.17)**	**65909** (16.98)
II. Variable costs				
	Raw material	21000(18.82)	44000(18.46)	52000(13.39)
	Electricity Charges	7324(6.56)	10645(9.54)	17356(4.47)
	Wages to labour	8000(7.17)	25000(10.49)	38000(9.79)
	Administrative charges	3500(3.14)	5500(2.31)	10000(2.58)
	Repair and maintenance charges	6500(5.82)	7500(3.15)	12000(3.09)
	License charges	2500(2.24)	3500(1.47)	7500(1.93)
	Interest on working capital @10%	10000(8.96)	13250(5.56)	15500(3.99)
	GST @ 1.6%	15000(13.44)	35000(14.69)	80000(20.60)
	Charges for Agmarking of powder	10000(8.96)	17500(7.34)	40000(10.30)
	Packing and labeling charges	10000(8.96)	30000(12.59)	40000(10.30)
	Branding and advertising charges	0(00.00)	15000(6.29)	10000(2.58)
	Total Variable cost (B)	**93824(84.07)**	**206915(86.83)**	**322356(83.02)**
	Total cost (A + B)	**111605(100.00)**	**238312(100.00)**	**388265(100.00)**
	Total quantity processed	**1500**	**3800**	**6500**
	Total cost of processing per Kg	**74**	**63**	**60**

Figures in brackets are percentages to the total cost

(13.39%). A plausible explanation for high percentage of GST in respect of larger units was that most of them are registered units, and hence, it is mandatory for them to register for GST ID number, thus, making it impossible for them to evade GST. On the contrary, small units were mostly unregistered household enterprises without GST ID number and hence does not pay GST.

Value addition costs in different value chains

It was observed during the field study that there were three major value chains for dry chillies (Table 3).

It can be inferred that among the different players in chillies market, the main player was farmer himself who harvested, packed and transported the produce to the market (Table 3). Apart from these tasks he also added value

Table 3. Value addition cost (VAC) across different actors for dry chillies

(Rs./q)

S. No.	Particulars	VAC 1	VAC 2	VAC 3
1. Farmer				
	Drying	132.55	144.56	137.24
	Grading	81.34	52.34	71.92
	Sorting	66.93	69.32	62.47
	Packing	98.3	--	80.43
	Total	**379.12**	**266.22**	**352.06**
2. Village trader				
	Assembly	---	98.32	----
	Packing	---	137.45	---
	Total	---	**235.77**	---
3. Commission agent				
	Handling	171.65	---	---
	Total	**171.65**	---	---
4. Wholesaler				
	Assembly	87.65	77.54	80.43
	Drying	98.45	87.43	85.57
	Grading	67.25	45.25	58.82
	Packaging	86.34	80.43	100.02
	Total	**339.69**	**290.65**	**324.84**
5. Retailer				
	Packing	78.63	82.64	96.35
	Total	**78.63**	**82.64**	**96.35**
	Total cost	**969.09**	**639.51**	**773.25**

Source: Primary Data October and November 2019.

to the fresh chillies by drying, grading, sorting and packing of the produce. In each value chain channel, the farmer's role is different. In the case of Value Addition Cost (VAC)-1 an amount of Rs.379 was spent per quintal of these activities, of which drying cost was high in each value chain *i.e.* Rs.133, Rs.145 and Rs.137, respectively.

At the village level, the trader's task is to gather chillies, packing them in the gunny bag and taking them to the market. It was found that in the case of VAC-1 and VAC-3, village traders were not participating, and they existed only when small and marginal farmers are involved. In VAC- 2 the costs incurred for assembling and packing per quintal are Rs.98 and Rs.138, respectively. The commission agents, who acted only as the transitional handler of the produce, added Rs.172 to the total cost.The other major participant was wholesaler, who handled the tasks of assembling, drying, grading and packaging. Cost incurred per

Table 4. Value addition cost for chilli powder production

(Rs./quintal)

S.No.	Stage	Amount of value addition cost	% to the total
1. Farmer			
	Production	312.42	51.27
	Drying	82.63	13.56
	Grading	73.45	12.05
	Sorting	58.29	9.56
	Packing	82.63	13.56
	Total	**609.42**	**100.0**
2. Processing firm			
	Drying	62.36	8.27
	Grinding	546.32	72.43
	Grading	30.25	4.01
	Packaging and labeling	115.36	15.29
	Total	**754.29**	**100.0**

quintal were Rs.340, Rs.291 and Rs.325 in the value chain. Finally, for the retailer who performed the tasks such as buying the produce, packing and sellingthe costs incurred by him were Rs.79, Rs.83 and Rs.97, respectively in VAC 1, VAC 2 and VAC 3. Thus, the total value addition to the produce was found to be Rs.970 under the first value chain, Rs.640 in the case of the second value chain and Rs.774 in the case of third value chain.

Table 4 shows the processing of dry chillies and the participants involved in moving produce from one point to another point. It also shows the value addition cost for chilli powder. In this process mainly two players were involved, one of whom was farmer himself, in converting chilli to chilli powder. The process included production, drying, grading, sorting and packing. The total cost incurred at the farmer's level was found to be Rs.609 while costs incurred by the processing firm was Rs.754. Thus, it can be inferred that in the both cases the value addition costs for production of the chilli powder remained almost the same with a difference of only Rs.145 per quintal.

CONCLUSION

Most of the fresh chillies were sold in the open market by the famers and traders. However, in the major chilli-growing areas served by well-established regulated chilli markets and or having access convenient to the processing units, fresh chillies were processed into dry chillies and sold either in the regulated markets or directly to the processing firms.

In all the three value chains identified in the study, the value addition cost in Chain 1 (VAC1) was the highest with Rs.969 and the lowest in VAC 2 with Rs. 640. Among the various players involved in the value chain, the wholesaler and processor played an important role; the former being important in grading, packing and transportation; and the latter being crucial in converting raw chillies into value-added products. The retailer was only involved in the task of moving the produce (raw or processed) to the consumer.

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PERCEPTION OF VEGETABLE GROWERS TOWARDS EXCESSIVE USE OF PESTICIDES IN BANKURA DISTRICT OF WEST BENGAL

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ABSTRACT

Pesticides are an essential input for maximizing the agricultural production through controlling the vegetable disease, pest, weed and others. The study was conducted during 2018 to know the perception of vegetablegrowers towards excessive use of pesticidesin *Bankura* District of West Bengal. The results revealed that the majority of the respondents fall under medium level of perception. Among the eleven independent variables, five variables were having positive and highly significant relationship with dependent variable. Regression analysis had shown that all the 11 independent variables put together have influenced significant variation in perception to the extent of R^2 45.5 percent and out of eleven, only one variable was positive and significant at one percent level of confidence. Path analysis showed that independent variables had direct and indirect effect on perception of vegetable growers towards excessive use of pesticides.For sustainable vegetable production, plant protection activity holds a significant importance in increasing the profit of vegetable cultivation in the study area.

Keywords: Gravity of Perception,Vegetable Production, Vegetable Growers, Use of Pesticide and Path analysis.

INTRODUCTION

The Green Revolution in 1965 focused on developing new technologies for irrigation, chemical fertilizers, herbicides and high yielding varieties. Farmers obviously did not obey safety measures regarding the use of fertilizers, pesticides and the necessary pre-harvest interims, *i.e.* the period between the last application of pesticides and the harvest of treated crops (Latif *et al*., 2011). Accordingly, controllingtheapplication of fertilizers and pesticides in crops by the competent authorities and imposing procedures on approved regulations were found to be necessary (Syed *et al*., 2014). Dhital (2015) found that pesticides were used for increasing the agricultural productivity without hampering the public health. Excessive use of chemicals endangered quality of soil, air and water with a high risk to environmental safety (Mehdizadeh *et al*., 2017). Damalas and Khan (2017) revealed that only 6.4% of vegetable farmers had high rates of awareness and 12.9% were able to obtain details of pesticide usage, whereas, approximately only 60% of vegetable farmers

*Corresponding Author E-mail i.d: anindita_psb@rediffmail.com; M.Sc thesis submitted to Visva- Bharati University,Santiniketan had sufficient knowledge regarding pesticides usage. Less awareness on pesticides usage had led farmers to misuse pesticides, to accumulate the risk of adverse health effects on themselves, the environment and consumers, and even to threaten the sustainability of pest control measures. Application of chemicals in the field resulted faster growth of weed which further resulted in insect, pest and disease infestation thereby reducing the possible yields of crops (Dnyaneshwar *et al*., 2018).

In the overall crop development systems, plant protection practices hold tremendous significance for sustainable agriculture. Excessive use of pesticides leads to destruction of biodiversity and severe health hazards in humans globally.Nowadays, farmers are using pesticides excessively to reduce the chances of borer infestations in tender vegetablesfor fetching higher returns. Unsafe use of pesticides is harmful to the health of farmers and the Indian population.

The word 'pesticides' includes a broad variety of compounds including insecticide, fungicide, herbicide, rodenticide, nematicideand other chemical compound. Ideally a pesticide must be lethal to the target pests but not to non-target species, including human being. The study was undertaken to assess the perception of vegetable growers regarding excessive use of pesticides in vegetable cultivation and to find out the relationship between profiles and perception of vegetable growers regarding excessive use of pesticides in vegetable cultivation.

MATERIAL AND METHODS

The study was mainly concerned with identifying some selective characteristics of farmer that influence their perception on excessive use of pesticides in vegetable cultivation and confined to *expost facto* research design as the independent variables were already occurred in the study area of *Bankura* district of West Bengal stateduring 2018.Purposive sampling procedure was followed for selection of district, block, and villages. Purposive sampling was used for identification and selection of information rich vegetable growers for most effective use of limited vegetable cultivation. This sampling procedure also ensured availability and willingness of respondents to participate, and the ability to communicate experiences and opinions in an articulate, expressive and reflective manner. Four villages namely-*Maklara, Dakai, Bansi, Menjua* were selected from two blocks *Khatra* and *Indpur.* Cultivation of vegetables was the predominant cropping pattern in the selected blocks and villages as per the existing data base.The vegetable growers (sample size 120) were selected randomly from the selected four villages. The selection and measurement of the variables for the study were framed based on the objectives of the study, from the literature and opinion of

Table 1. Distribution of the respondents according to gravity of perception of vegetable growers towards excessive use of pesticides

n = 120

S. No.	Category	Frequency	Percentage
1	Low (<8)	17	14.2
2	Medium (8-21)	78	65.0
3	High (>21)	25	20.8
$\tilde{x}$ = 14.52			**S.D. = 6.13**

Table 2. Correlation and regression analysis of perception of vegetable growers towards excessive use of pesticides with the independent variables

n = 120

S. No.	Characteristics	Correlation Co-efficient 'r' value	Significant 'P'value	Regression Co-efficient	P value
x^1	Age	-0.012	0.893	-0.042	0.586
x^2	Education	0.642**	0.000	3.836**	0.000
x^3	Farming Experience	-0.035	0.708	0.056	0.493
x^4	Social participation	-0.074	0.420	0.674	0.813
x^5	Size of land holding	0.361**	0.000	0.228	0.162
x^6	Annual income	0.287**	0.001	0.000	0.487
x^7	Extension Contact	0.079	0.389	-0.223	0.754
x^8	Mass media exposure	0.331**	0.000	0.751	0.146
x^9	Economic motivation	-0.085	0.358	-0.365	0.136
x^{10}	Risk orientation	0.147	0.110	-0.165	0.306
x^{11}	Scientific orientation	0.301**	0.001	0.068	0.596
****Significant at 0.01 level**					
R^2=0.455					

experts involved in the field. SPSS software version 16.0 and OPSTATE website were utilized for various statistical calculations.

It is evident from the results (Table1 and Fig.1)that majority of the farmers (65%)had medium gravity of perception (8-21) towards excessive use of pesticides. Only 20.8% of farmers belonged to high gravity of perception towards excessive use of pesticides having score >21 and 14.2% of vegetable farmers were having low gravity of perceptionregarding excessive use of pesticide with score <8.

Table 3. Path analysis of perception of vegetable growers towards excessive use of pesticides with independent variables

n = 120

S. No.	Characteristics	Total Indirect Effect	Direct Effect	Total Effect
x_1	Age	0.06041	-0.072	-0.012
x_2	Education	0.06801	**0.574** first	**0.642** first
x_3	Farming Experience	-0.1267	0.092	-0.035
x_4	Social participation	-0.09235	0.018	-0.074
x_5	Size of land holding	0.19616	**0.165** second	**0.361** second
x_6	Annual income	**0.35743** first	-0.07	0.287
x_7	Extension Contact	0.1067	-0.028	0.079
x_8	Mass media exposure	0.20451	0.126	**0.331** third
x_9	Economic motivation	0.04578	**-0.131** third	-0.085
x_{10}	Risk orientation	**0.24562** third	-0.099	0.147
x_{11}	Scientific orientation	**0.25126** second	0.05	0.301

Correlation and regression analysis of gravity of perception of vegetable growers towards excessive use of pesticides with the independent variables

The results revealed that education, extension participation, annual income, extension contact, mass media exposure, economic motivation, risk orientation, scientific orientation were significantly correlated at one percent level of confidence with gravity of perception of vegetable growers towards excessive use of pesticides (Table 2).The multiple regression analysis of gravity of perceptionof vegetables growers with the independent variables is presented (Table2).All the 11 independent variables were put together to calculate the influence.Significant variation of these independent variablesover gravity of perception of vegetable growers towards excessive use of pesticides was to the extent of R^2 45.5 percent. Out of eleven, only 'education' was having positive significant relationship at one percent level of confidence.

Path analysis of perception of vegetable growers towards excessive use of pesticide with independent variables

Path analysis was selected to show the indirect interrelationship of independent variables toward the gravity of perception of vegetable growers regarding excessiveuse of pesticides. Out of the 11 variables,five were found significant in correlation analysis viz.,education, size of land holding, annual income, mass media exposure and scientificorientation.Sequential multiple regressions were calculated to analyse the actual interrelationship among these variables. Hence, the model was restructured based on the values of multiple regressions (Table3).It shows the direct and indirect effects among the interrelated independent variables with the gravity of perception of vegetable growers towards excessive use of pesticides. The maximum total indirect effect on perception of vegetable growers towards excessive use of pesticides was exhibited by the variable annual income (0.35743) variable which was followedby risk orientation (0.24562) in the second position and scientific orientation (0.25126) in the third. The maximum total direct effect on perception of vegetable growers towards excessive use of pesticides was exhibited by the variable education (0.574) followed by the other variables *viz.*, size of land holding (0.165)and economic motivation (-0.131). The maximum total effect on perception of vegetable growers towards excessive use of pesticides was shown by the education (0.574) followed by size of land holding (0.165) and mass media exposure (0.331) in that order.

Distribution of the respondents according to gravity of perception of vegetable growers.

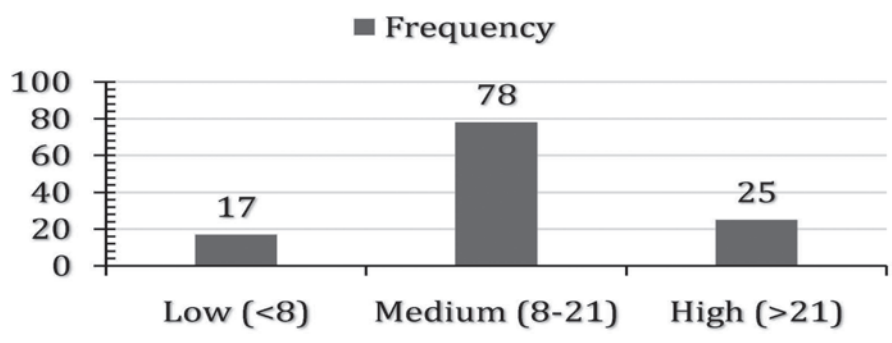

Fig. 1. Distribution of the respondents according to gravity of perception of vegetable growers towards excessive use of pesticide

CONCLUSION

Majority of the respondents were under medium gravity of perception towards excessive use of pesticides in the study area. Among the 11 independent variables, five variables *viz.,*education, size of land holding, annual income, mass media exposure and scientific orientation were having positive and highly significant relationship with perception of vegetable growers towards excessive use of pesticides. In the regression analysis, all the 11 independent variables put together showed and significant variation in perception of vegetable growers towards excessive use of pesticides to the extent of R^2 45.5 percent. Out of the eleven variables, only one variable was positively significant at 1% level of confidence. Path analysis showed that independent variables had effect (direct and indirect effect) on perception of vegetable growers towards excessive use of pesticides.The maximum total indirect effect on perception of vegetable growers towards excessive use of pesticide was exhibited by annual income (0.35743). The path coefficient analysis revealed that education(0.574) exerted highest positive direct effect on gravity of perception of vegetable growers.

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Research Note

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EFFECT OF DIFFERENT DATES OF SOWING ON STIGMA RECEPTIVITY AND POLLEN VIABILITY IN PARENTAL LINES OF SORGHUM HYBRIDS

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Sorghum is the 5th major cereal crop in the agriculture scenario of the globe and also one of the world's most important sources of food, animal feed and biofuel. Sorghum has tolerance to drought, heat and salt conditions. Improper nicking of male sterile lines and restorer of hybrids is one of the reason for low seed yield of released hybrids during hybrid seed production. Synchronized flowering of male sterile (A) lines and restorer (R) is essential for better seed production of hybrids. Delayed or early flowering of any parent adversely affects the seed setting. Among the released hybrids, serious synchronization problem is often observed with the hybrid seed production of CSH-5 and CSH-9 (Singh and Nayeem,1980). Male sterile lines show differential flowering behaviour in different sowing dates because prevailing of environmental factors during primordial initiation to seed maturity. The stigma receptivity studies of male sterile lines will help in predicting proper planting time of male and female lines for maximum seed set. It also helps to find out the male sterile lines with longer stigma receptivity period. Longer period of stigma receptivity will help whenever the pollen parental line crossed blooms later than male sterile parent (Ross, 1957). Synchronization, stigma receptivity and pollen viability are the bottle necks in the hybrid seed production of sorghum.Pollen viability studies are important for understanding the pollen sterility problems in crop plants and hybridization programme studies on pollen viability helps to determine proper time for pollination during hybridization programme. Hence, the studies were under-taken with the parents of newly evolved sorghum hybrids *viz.,*CSH-14, CSH-16, SPH-840 and SPH-388 during *Kharif* to see performance of these hybrids for determining the pollen viability of 'R' lines.

The experiment was laid out during *Kharif,* 2017-18. Eight genotypes were studied at three planting dates in factorial randomized block design and replicated thrice. Sorghum hybrids *viz.*, CSH-14, CSH-16, SPH-840 and SPH-388 are sown at three different dates D_1(25th June), D_2(1st July) and D_3 (7th July). All the cultural practices were followed as per the recommended package of practices. Results were analysed for RBD (factorial) by adopting standard statistical procedures (Panse and Sukhatme, 1981). Five plants were randomly selected from the middle of rows of each

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genotype in all the sowing dates for recording observations.

Stigma receptivity studies

Four male sterile 'A' lines AKMS-14A, MS-27A, MS-70A and MS-296A were undertaken by growing the genotypes during *Kharif* season. After stigma protrudence, pollens from respective restorer (R) lines were collected and male sterile 'A' lines were pollinated in D_1, D_2 and D_3 sowing dates respectively each day from 0 to 6 Day between 8 AM to 10 AM by giving one day as a starvation period to the stigma of male sterile (A) lines.

Pollen viability studies

Four restorer 'R' lines AKR-150, C-43, ICSR-89058 and AKR-73 were used by sowing the genotypes. By giving one hour storage period interval to the pollens of restorers (R) lines, the male sterile (A) lines were pollinated from 8.00 AM to 1.00 PM. Pollen viability studies was conducted on restorer(R) lines was judged by seed setting percentage on their respective seed parents after complete flowering and judged at 8.00 AM through sowing starvation period in D_1, D_2 and D_3 sowing date.

Stigma receptivity and pollen viability studies in parental lines of newly evolved sorghum hybrids were conducted by planting parental lines of CSH-14 (AKMS-14A x AKR150), CSH-16 (MS-27A x C-43), SPH-840 (MS-70A x ICSR-89058) and SPH-388 (MS-296A x AKR-73). Three rows of four male sterile lines and three rows of restorer lines were planted in replicated trials on three different sowing dates and observations were recorded on stigma receptivity of male sterile lines and pollen viability of restorer lines.

Stigma Receptivity

It is observed from the data (Table1, 2&3)that on average stigma receptivity was significantly highest at '0' day starvation period in D_1, D_2, D_3 and subsequently reduced due to delayed pollination. Seed setting percentage in seed parents was significantly better up to three days of starvation period after complete flowering in all sowing dates. Stigma of seed parent MS-27A remained receptive upto five days starvation period in D_1,D_2 and D_3 sowing dates with highest receptivity on 0 day and lowest on 6 days of starvation period; whereas, stigma of other seed parents AKMS-14A, MS-296A remained receptive up to 5 days starvation period and subsequently reduced due to delay in pollination in male sterile lines in all sowing dates. On an average, seed setting percentage in these male sterile (A) lines was better up to 2 to 3 day's starvation period in all sowing dates. These observations corroborates with the findings of Shellar and Patil(1991).

Stigma receptivity was evaluated in the female parents AKMS-14 A, MS-27 A, MS-70 A and MS-296 A. Variation for stigma receptivity was significantly affected by starvation period, genotypes and interaction in D_1, D_2& D_3 sowing dates.Stigma receptivity was studied after

Table 1. Performance of male sterile 'A' lines for stigma receptivity studies in D_1 sowing date

Genotypes (F2)	Starvation Period in days (F1)							Mean
	0	1	2	3	4	5	6	
AKMS-14A	88.21	78.26	60.26	53.25	20.10	0.00	0.00	42.86
MS-27A	93.21	84.24	76.01	64.79	33.41	21.90	0.00	53.36
MS-70A	90.83	88.13	69.87	49.95	15.55	0.00	0.00	44.19
MS-296A	84.05	75.20	61.91	45.02	25.25	0.00	0.00	41.63
Mean	89.07	80.20	67.01	53.25	23.57	5.47	0.00	
	F test	SE (m)±	CD at 5 %					
Sowing date(F1)	Sign.	0.77	1.55					
Genotype (F2)	Sign.	0.58	1.17					
Interaction (F1x F2)	Sign.	1.55	3.11					

Table2. Performance of male sterile 'A' lines for stigma receptivity studies in D_2 sowing date

Genotypes (F2)	Starvation Period in days (F1)							Mean
	0	1	2	3	4	5	6	
AKMS-14A	85.92	77.30	56.22	48.18	18.34	0.00	0.00	40.85
MS-27A	89.24	81.31	68.12	58.28	28.39	18.56	0.00	49.12
MS-70A	87.56	75.10	65.75	42.16	12.48	0.00	0.00	40.43
MS-296A	87.43	76.17	67.72	40.23	20.41	0.00	0.00	41.75
Mean	87.53	77.47	64.45	47.28	19.90	4.64	0.00	
	F test	SE (m) ±	CD at 5 %					
Sowing date(F1)	Sign.	0.62	1.25					
Genotype (F2)	Sign.	0.47	0.94					
Interaction (F1x F2)	Sign.	1.24	2.50					

Table3. Performance of male sterile 'A' lines for stigma receptivity studies in D_3 sowing date

Genotypes (F2)	Starvation Period in days (F1)							Mean
	0	1	2	3	4	5	6	
AKMS-14A	86.21	80.45	60.13	45.28	15.27	0.00	0.00	41.04
MS-27A	84.21	78.00	64.18	54.46	27.26	15.19	0.00	46.24
MS-70A	85.34	71.15	66.78	41.41	10.36	0.00	0.00	39.29
MS-296A	81.27	75.88	58.19	38.33	17.27	0.00	0.00	38.70
Mean	84.35	76.37	62.32	44.87	17.54	3.79	0.00	
	F test	SE (m) ±	CD at 5 %					
Sowing date(F1)	Sign.	0.80	1.60					
Genotype (F2)	Sign.	0.60	1.21					
Interaction (F1x F2)	Sign.	1060	3.20					

Table 4. Performance of Restorer(R) lines for pollen viability in D_1 sowing date

Genotypes (F2)	Starvation Period in hours(F1)						Mean
	8.00	9.00	10.00	11.00	12.00	1.00	
AKR-150	86.98	82.80	70.25	52.12	18.70	6.36	52.86
C-43	60.00	91.65	80.70	46.00	25.27	0.00	50.60
ICSR-89058	85.57	73.36	67.30	55.53	30.35	0.00	52.36
AKR-73	84.29	71.63	61.21	46.46	24.50	0.00	48.01
Mean	87.53	77.47	64.45	47.28	19.90	4.64	
	F test	SE (m) ±	CD at 5 %				
Sowing date(F1)	Sign.	0.88	1.77				
Genotype (F2)	Sign.	0.71	1.44				
Interaction (F1x F2)	Sign.	1.76	3.84				

Table 5. Performance of Restorer(R) lines for pollen viability in D_2 sowing date

Genotypes (F2)	Starvation Period in hours(F1)						Mean
	8.00	9.00	10.00	11.00	12.00	1.00	
AKR-150	87.18	76.29	62.21	41.46	21.23	0.00	48.06
C-43	43.30	88.35	72.58	47.36	30.04	0.00	46.93
ICSR-89058	82.48	77.30	69.19	50.56	25.40	0.00	50.82
AKR-73	83.30	65.16	65.80	52.43	28.19	0.00	49.14
Mean	74.06	76.77	67.44	47.95	26.21	0.00	
	F test	SE (m) ±	CD at 5 %				
Sowing date(F1)	Sign.	0.71	1.43				
Genotype (F2)	Sign.	0.58	1.17				
Interaction (F1x F2)	Sign.	1.42	2.87				

Table 6. Performance of Restorer(R) lines for pollen viability in D_3 sowing date

Genotypes (F2)	Starvation Period in hours(F1)						Mean
	8.00	**9.00**	**10.00**	**11.00**	**12.00**	**1.00**	
AKR-150	89.47	80.50	65.13	48.40	16.56	0.00	50.01
C-43	37.66	88.14	81.56	50.30	21.29	0.00	46.49
ICSR-89058	82.28	70.14	62.30	41.31	25.10	0.00	46.85
AKR-73	85.40	78.28	65.73	45.56	23.26	0.00	49.70
Mean	73.70	79.26	68.68	46.39	21.55	0.00	
	F test	SE (m) ±	CD at5 %				
Sowing date(F1)	Sign.	1.01	2.03				
Genotype (F2)	Sign.	0.82	1.66				
Interaction (F1x F2)	Sign.	2.02	4.07				

complete flowering and was counted as 0,1,2,3,4,5,6 days of starvation period in D_1, D_2 and D_3 sowing dates.Stigma receptivity was highest at '0' days of starvation period in D_1, D_2 and D_3 and subsequently reduced due to delayed pollination. D_1 sowing date (89.07%) exhibited highest stigma receptivity followed by D_2 (87.53%) and D_3 (84.35%) at '0' days starvation period. Seed setting percentage was significantly better upto 2 days of starvation period after complete flowering in all sowing dates. Seed parent MS-27A exhibited highest (53.36%) stigma receptivity in D_1, D_2 and D_3 sowing date followed by seed parent MS-70 A (44.19%) and AKMS-14 A (42.86%). Seed parent MS-296 A exhibited lowest (38.70%) stigmareceptivity in D_3 sowing date.

Pollen viability

Pollen viability studies in parental lines of newly evolved Sorghum hybrids were conducted by planting parental lines of CSH-14, CSH-16, SPH-840 and SPH-388. Three rows of restorer lines were planted in replicated trial on three different sowing dates and observations were recorded on pollen viability of restore lines. It was observed that in D_1 sowing date, pollen of seed parent AKR-150 was viable upto six hours.Viability was highest at 8.00 AM, whereas, in D_2 and D_3 viability was up to 5 hours for seed parents AKR-150, C-43, ICSR-8905 & AKR-73.Seed setting was highest at 8.00 AM for seed parents AKR-150, ICSR-8905 and AKR-73 except C-43. Seed parent C-43 showed highest seed setting at 9.00 AM. In general, pollen viability was satisfactory up to 11.00 AM (3h storage) under field condition in *Kharif*. These results corroborates with the findings of Singh *et al*. (1985). Early planting of seed crop and staggered sowing of early parent in *Kharif*season under Vidharbha condition should be adopted to reduce synchronization problems.Variation due to storage of pollens, genotypes and interaction was statistically significant in D_1, $D_2$and D_3 sowing dates. Pollen viability studies were conducted on restorer (R) lines and judged by seed setting percentage on their respective seed parent in D_1, D_2& D_3 sowing date.Pollen viability was maximum in D_1 (52.86%) and minimum in D_3(46.49%). Pollen parent AKR-150 exhibited highest (52.86%) pollen viability followed by ICSR-8958 (52.36%) in $D_1$and C-43 exhibited best pollen viability(46.49%) in D_3 sowing date (Table 4, 5 and Table 6).

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Research Note
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ANALYSIS OF RAINFALL DATA AT AMF UNIT - LAM, GUNTUR DISTRICT OF ANDHRA PRADESH

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Rainfall is the important and unique hydrological phenomenon with temporal and spatial variations and an important factor in deciding agricultural crops cultivation and strategic planning of crops for an area. Fluctuations in the quantity of rainfall and its distribution is a varying phenomenon, such comprehensive knowledge about the total rainfall and its distribution pattern round the year of a area is very important for better crop planning, determining irrigation scheduling and drainage requirement of crops, design and construction of soil and water conservation structures, etc. In rainfed agriculture, the total amount of rainfall and it's distribution in a particular area affects the plant growth and its yield and yield parameters, respectively.

Drought is a normal recurring climatic phenomenon that varies in space, time, and intensity. Drought is one of the most serious problems for human societies and ecosystems. It gradually establishes with the negative anomaly of rainfall for a required period and it is one of the most damaging types of natural disasters over long periods. It is necessary to know about the time, locations, severity, and pattern of droughts for effective planning and decision making.

Information about drought occurence helps officials and farmers to be more proactive in managing drought risks. Impacts of drought can be reduced through better understanding and identifying the appropriate drought indicators for an early warning system. It is being monitored by computing indices based on rainfall and many other parameters. In the last few decades, several drought indices have been developed based on several parameters, the details of which can be found in Venkatesh *et al.* (2016), Mishra and Singh (2010), Dai (2011) and Pandey *et al.* (2014). Keeping this in view, an attempt was made to evaluate drought occurrence patterns of weekly, seasonal, monthly, and annual rainfall according to the severity, based on 45 years (1975-2018) data recorded at Regional Agricultural Research Station, Lam, Guntur district of Andhra Pradesh.

Daily rainfall data recorded at RARS, Lam Guntur was used for this study. Rainfall data from 1975 to 2018 was analysed on a yearly and monthly basis for 45 years. This analysis was carried out during March-June, 2019, and results were classified as a drought, normal and wet events depending upon the following criteria (Sharma *et al.,* 1979).

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Table1. Annual rainfall analysis to access the deviations in rainfall distribution pattern of AMFU, RARS, Lam

S.No.	Year	Rainfall received (mm)	Deviation from long period average Rainfall (%)	Class	Time interval between the years	Chances for occurrence the events (%)
1	1979	471.0	-47.0	Moderate Drought	--	11.1
2	1984	612.9	-31.5		4	
3	1992	671.5	-25.1		8	
4	2002	618.8	-30.9		10	
5	2009	650.8	-27.3		7	
6	1991	695.9	-22.3	Deficit Rainfall	---	6.6
7	2017	678.8	-24.2		26	
8	2018	694.6	-22.4		0	
9	1998	1220.8	+36.3	Excess Rainfall	--	13.3
10	2000	1116.3	+24.6		1	
11	2003	1174.8	+31.1		2	
12	2010	1515.9	+69.2		7	
13	2012	1194.3	+33.3		2	
14	2013	1210.3	+35.1		0	

Table 2. Seasonal rainfall data analysis for Wet, Normal and Dry Seasons

Month	Mean (N)	N/2	2N	WS	PWS	NS	PNS	DS	PDS
Monsoon	591.0	295.5	1182.0	0.0	0.0	44.0	97.8	1.0	2.2
Post-Monsoon	200.0	100.0	400.0	6.0	13.3	29.0	64.4	10.0	22.2
Winter	29.8	14.9	60	9.0	20.0	7.0	15.6	29.0	64.4
Summer	72.8	36.4	146	6.0	13.3	29.0	64.4	10.0	22.2

*WS –Wet Season, NS- Normal Season, DS- Dry Season, PWS- Probability of Wet Season, PNS- Probability of Normal Season, PDS- Probability of Dry Season

Yearly Drought Analysis

Meteorological Drought is defined usually based on the degree of the dryness. According to IMD, meteorological drought is defined as occurring when the seasonal rainfall received over an area is less than 75% of a Long Period average value. It is further classified as a moderate drought, if the rainfall deficit is within a range of 25% to 50%, severe drought if departure exceeds 50% (Pandey *et al*., 2014).

Percentage Occurrence of Drought

It is defined as the number of drought events occurred divided with the total number of record and multiplied with a hundred.

Seasonal/ Monthly/ Weekly Drought Analysis

N is the Normal Seasonal/ Monthly/ Weekly Rainfall, a Season / Month / Week receiving rainfall less than half N is termed as Drought Season / Month / Week and on another hand, a Season / Month / Week that receive rainfall more

Table 3. Seasonal rainfall data analysis for wet, normal and dry seasons

Month	Mean (N)	N/2	2N	WM	PWM	NM	PNM	DM	PDM
January	5.9	2.9	11.8	6.0	13.3	2.0	4.4	37.0	82.2
February	10.3	5.1	20.6	6.0	13.3	4.0	8.9	35.0	77.8
March	8.1	4.0	16.1	7.0	15.6	5.0	11.1	33.0	73.3
April	13.3	6.7	26.6	9.0	20.0	11.0	24.4	25.0	55.6
May	51.5	25.7	102.9	3.0	6.7	26.0	57.8	16.0	35.6
June	103.8	51.9	207.6	2.0	4.4	33.0	73.3	10.0	22.2
July	169.0	84.5	338.0	1.0	2.2	39.0	86.7	5.0	11.1
August	176.2	88.1	352.4	1.0	2.2	33.0	73.3	11.0	24.4
September	142.5	71.2	284.9	2.0	4.4	30.0	66.7	13.0	28.9
October	144.8	72.4	289.6	3.0	6.7	30.0	66.7	12.0	26.7
November	55.2	27.6	110.4	6.0	13.3	19.0	42.2	20.0	44.4
December	15.2	7.6	30.5	7.0	15.6	6.0	13.3	32.0	71.1

*WM –Wet Month, NM- Normal Month, DM- Dry Month, PWM- Probability of Wet Month, PNM- Probability of Normal Month, PDM- Probability of Dry Month

than double the normal(N) is termed as wet Season / Month / Week.

Forty-five years rainfall was analysed to find out the drought years, deficit rainfall years and excess rainfall years (Table1). Among the years of study *i.e.* 1975 to 2018 the annual rainfall of five years was moderately drought, and 11.1% occurrence of moderate drought condition was noticed. Besides, analysis for deficit rainfall was carried out and the results indicated that 1991, 2017, 2018 were showing deficit rainfall status with percent deviation of rainfall from long-period average rainfall of -22.3, -24.2 and -22.4 (Table1).

Year-wise rainfall investigation for the past 45 years (1975-2018) was carried out to record the years with above-normal and excess rainfall.Among the period under study,six years (13.3%) noticed excess rainfall among the six years 2010 with highest rainfall 1515.9 mm with +69.2 % deviation from the long period average rainfall (Table 1).

Agricultural season-wise rainfall analysis was carried out to find out the probability of dry normal and wet seasons. The results denoted that monsoon season being normal is indicated with 97.8% probability. Out of 45 years under the study, 44 monsoon seasons received normal rainfall and only one season received below the normal rainfall. Post-monsoon season probability being normal is 64.4%.Winter season probability being normal is less probable than probability of dry season and wet season.Summer season probability being normal season is 64.4% (Table 2).

The results of the month-wise rainfall indicated that out of 12 months, the probability of being wet month ranges from 2.2%-20%.

Probability of months being normal is low from January to April. Probability of being normal is high from May to November months and the probability of dry months is higher from January to April and December (Table 3).

Overall, it is indicated that pre-monsoon and post-monsoon months are most probably normal and in case of annual rainfall analysis none of the years experienced severe drought for the last 45 years and there was only 11% probability for experiencing moderate drought.

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Research Note
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AN OVERVIEW OF STATISTICS OF SUGARCANE CROP IN INDIA

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Sugarcane is an important commercial crop in India and important raw material for the sugar industry(ShabanaAnjum and Madhulika, 2018). India is the second-largest producer of centrifugal sugar in the world after Brazil. For sugarcane cultivation, India is divided into tropical and sub-tropical regions. The subtropical region covers Uttar Pradesh, Bihar, Punjab and Haryana states, whereas, the tropical region covers Maharashtra, Gujarat, Tamil Nadu, Andhra Pradesh and Karnataka states. It is spread over an area of 4.73 million hectares (2017-18) (Source:agricoop.nic.in) and the states having highest sugarcane acreage are Uttar Pradesh(47%), Maharashtra(19%), Karnataka(8%), Bihar (5%), Tamilnadu (4%) and Gujarat (4%). The major countries to which sugar is exported are Sudan(24.3%), Somalia (15.89 %) and UAE (11.45 %) (2017-18) (CACP, 2020). As a risk aversion measure against price variations of sugarcane crop, GoI introduced Fair and Remunerative Price (FRP)(Source: Indian Sugar Journal, 2020)replacing the concept of Statutory Minimum Price (SMP) for sugarcane. The Fair and Remunerative prices when plotted against time (Fig.1) showed an increasing trend. Realising the growing demand for sugarcane, this paper is aimed at analysing the statistics of sugarcane area, production, and yield.

The study is based on the time series data collected from various sources such as the Indian Sugar Journal, websites such as *http://www.indiastat.com, http://agricoop.nic.in*, and Sugarcane Price Policy 2019-20 (CACP, 2020). The data was collected on area, production,

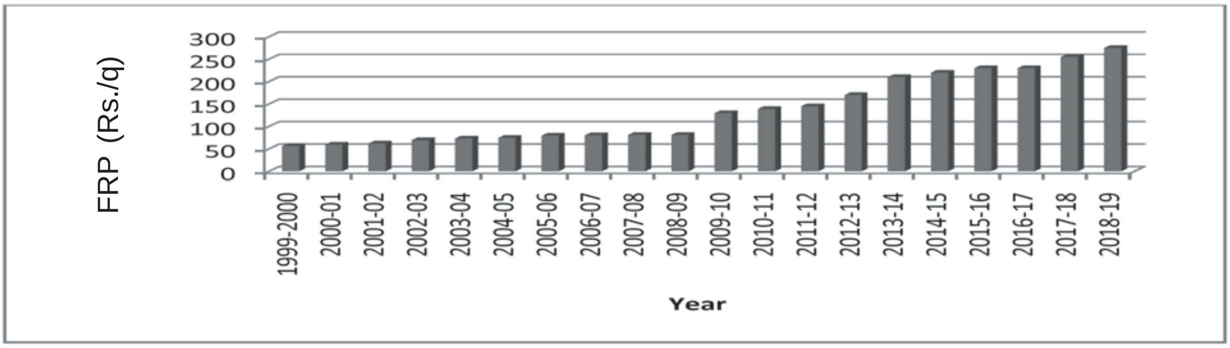

Fig. 1. Fair and Remunerative prices of sugarcane

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Table 1. Growth rates, instability, and correlation of sugarcane area, production and yield of India during (1999-2000 to 2017-18)

State	Mean		SD		CGR(%)		CV(%)		CORRELATION	
	Period-I	Period-II	Period-I	Period-II	Period-I	Period-II	Period -I	Period-II	Period-I	Period-II
AREA ('000 ha)										
Uttarpradesh	2078.34	2277.22	101.64	163.21	0.98**	1.20**	4.89	7.17	0.60	0.42
Maharashtra	651.40	933.33	249.09	111.74	5.54**	0.30**	38.24	11.97	0.52	0.06
Karnataka	311.11	431.59	83.68	56.93	-5.01**	1.29**	26.88	13.19	-0.60	0.26
Bihar	107.12	243.98	10.16	63.56	1.74**	7.81**	9.49	26.05	0.55	0.64
Gujarat	191.38	183.89	29.77	13.34	3.66**	0.53**	15.56	7.25	0.63	0.16
Tamilnadu	304.57	279.44	60.15	42.25	1.62**	-4.73**	19.75	15.12	0.26	-0.83
All India	4388.86	5006.57	452.77	378.46	1.22**	1.03**	10.32	7.56	0.38	0.34
PRODUCTION ('000 tonnes)										
Uttarpradesh	118501.84	134292.26	8286.43	18419.87	0.86**	3.43**	6.99	13.72	0.38	0.72
Maharashtra	50313.79	75729.33	21297.12	14510.62	4.65**	-0.64**	42.33	19.16	0.42	-0.02
Karnataka	28020.30	36689.02	9368.97	6769.46	-4.64**	-1.78**	33.44	18.45	-0.48	-0.21
Bihar	4531.52	12346.62	658.13	3385.87	1.22**	9.82**	14.52	27.42	0.28	0.73
Gujarat	14144.55	13013.12	1185.45	1090.64	2.15**	-1.42**	8.38	8.38	0.77	-0.44
Tamilnadu	31241.60	27223.0	7248.26	8524.19	1.91**	-11.39**	23.20	31.31	0.26	-0.96
All India	292071.80	341739.66	39257.83	28122.55	0.94**	1.05**	13.44	8.23	0.24	0.35
YIELD (tonnes ha^{-1})										
Uttarpradesh	56.99	59.02	2.43	8.10	-0.12**	2.17**	4.26	13.73	-0.07	0.50
Maharashtra	75.93	80.69	9.35	9.89	-0.84**	-0.95**	12.31	12.26	-0.23	-0.15
Karnataka	85.55	85.11	10.47	10.60	-1.49**	-2.96**	12.24	12.45	-0.41	-0.60
Bihar	42.25	50.44	3.03	3.99	-0.45**	1.94**	7.16	7.90	-0.16	0.67
Gujarat	71.66	70.69	1.66	5.64	0.29**	-1.93**	2.32	7.97	0.37	-0.66
Tamilnadu	101.74	91.76	5.77	14.71	0.02**	-5.16**	5.67	16.03	0.01	-0.83
All-India	66.40	68.45	3.37	5.42	-0.26**	0.02**	5.08	7.91	-0.16	0.05

** indicates 1% level of significance

PERIOD-I : 1999-2000 to 2008-09
PERIOD-II: 2009-10 to 2017-18

SD: Standard Deviation
CV: Coefficient of Variation (%)

CGR:Compound Growth Rate(%)

and yield of sugarcane in India and the major sugarcane growing states of India. The data was divided into Period-I (1999-2000 to 2008-09) and Period-II(2009-10 to 2017-18) representing before and after implementation of FRP. The arithmetic mean, compound annual growth rates, correlation coefficient and coefficient of variation were computed for the data collected to analyse the changes in area, production, and yield of sugarcane for the selectedtime periods.

Statistical Analysis of sugarcane area

At the All- India level, growth in the area has declined in Period-II and among the states, the growth rate analysis for the two periods revealed that Uttar Pradesh (1.20%), Karnataka (1.29%) and Bihar (7.81%) had shown an increased growth (Table 1). Alternatively, states such as Maharashtra (0.30%) and Gujarat (0.53%) experienced a decreasing growth in Period-II as compared with Period-I (Fig 2). Apart from this, the Tamilnadu state has registered a negative growth (-4.73 %) in period-II, the shrinkage in the cultivation area can be attributed to drought and poor rainfall. The higher sugarcane area in the states such as Bihar is attributed to the intervention of state policies in sugarcane cultivation (Patil Ganesh Gouda *et al.,*2016). The decreased growth rate in Maharashtra was due to drought in that area and many districts had faced water scarcity, thus, making the farmers unwilling to go for sugarcane cultivation. In Karnataka, Period-I experienced a negative trend in the area and the growth in the area was negatively correlated (-0.60) with time during this period while in Tamilnadu the negative correlation (-0.83) was observed in Period-II. States such as Gujarat (0.16) and Maharashtra (0.06) exhibited weak positive collinearity during Period-II. The instability in the growth of the area has decreased at all India level and among the states except for Bihar (26.05%) from Period-I to Period-II.

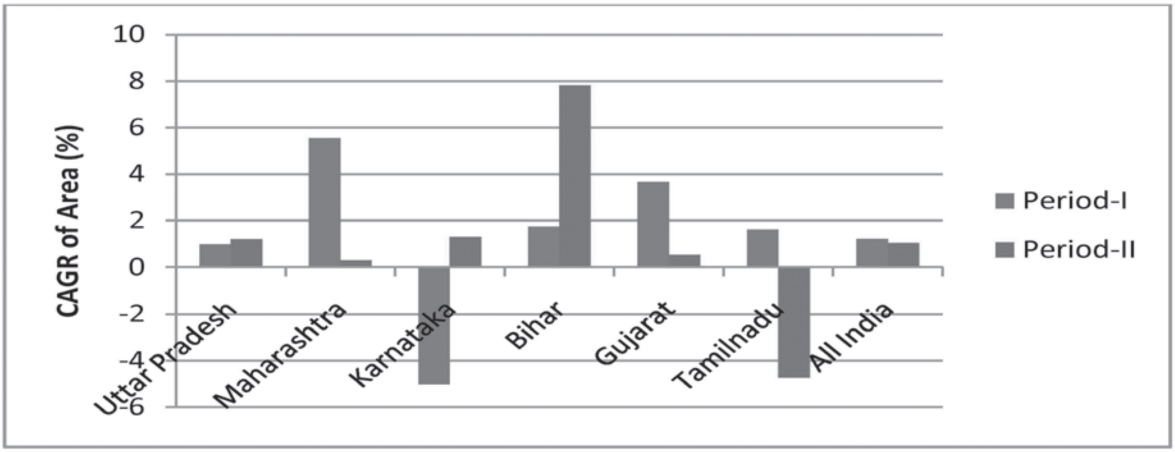


Fig 2. CAGR of area in major sugarcane growing states and All India

Statistical Analysis of sugarcane production

Growth rate analysis of sugarcane production revealed that Bihar registered the highest positive significant growth rate of 9.82% followed by Uttar Pradesh (3.43%) (Fig. 3). The climatic conditions and Government intervention in the introduction of new varieties of sugarcane favored for the growth of sugarcane production in these states. Besides FRP, Uttar Pradesh state government announces SAP (State Advised Price). On the other hand, Maharashtra (-0.64%), Karnataka (-1.74%), Gujarat (-1.42 %) and Tamilnadu (-11.39 %) states recorded a negative trend in production in Period-II. The variation in the production has decreased from period-I to Period-II indicating the stable sugarcane production except in the states such as Uttar Pradesh and Tamilnadu, wherein, the variability has increased.

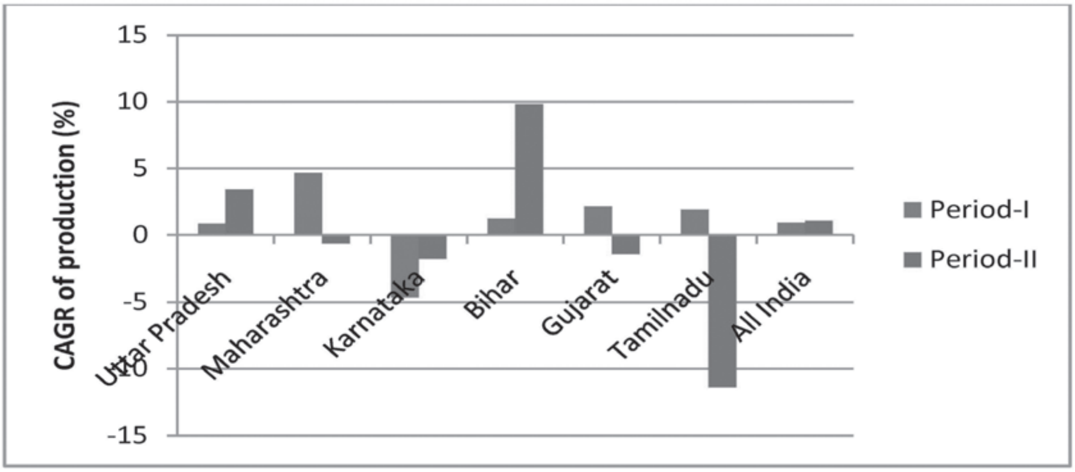


Fig 3. CAGR of Production in major sugarcane growing states and All India

Statistical Analysis of sugarcane yield

The growth rate analysis of sugarcane yield revealed that Uttar Pradesh (2.17%) and Bihar (1.94%) recorded the positive growth and were also higher than the all India yield growth (0.02%). The positive trend in the yield for Period-II in these states was mainly attributed to the adoption of high yielding variety Co-0238. The states such asTamilnadu (-5.16 %), Maharashtra (-0.95%), Karnataka (-2.96 %) and Gujarat (-1.93 %) recorded negative growth (Fig. 4) which might be attributed to the frequent droughts and water scarcity in Maharashtra and Karnataka, largely because of continuous irrigation and the practice of ratoon or stubble cropping. In the case of Tamilnadu, the majority of the farmers continue to use only the CO86032 variety of sugarcane leading to a decrease in the yield. In these states, growth in yield with time was negatively correlated. The instability in productivity was recorded highest in Tamilnadu (16.03 %) and Uttar Pradesh (13.73%), representing more variation in yield levels during period-II.

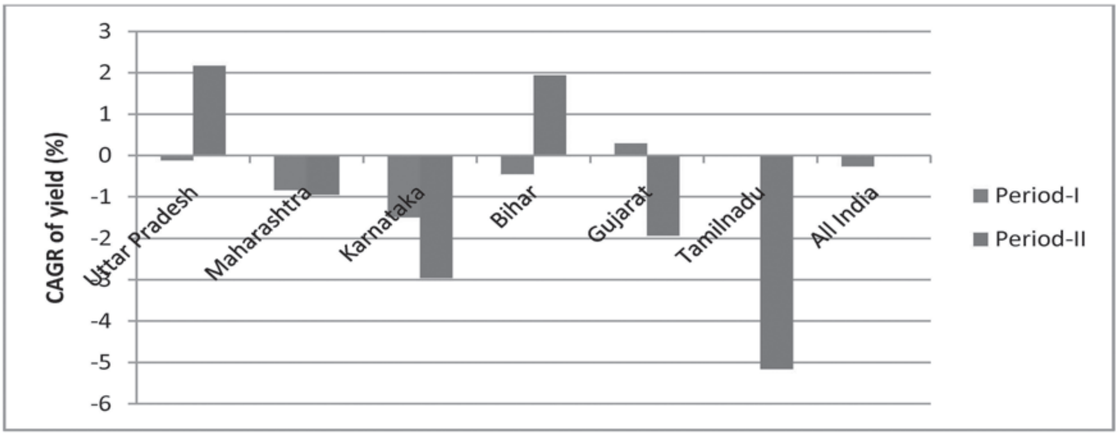
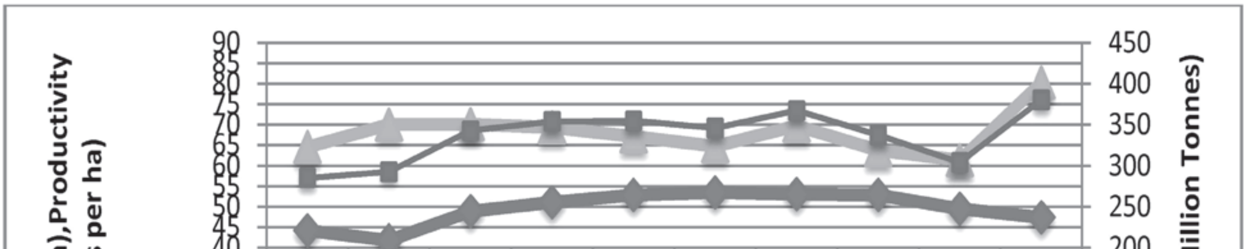


Fig 4. CAGR of yield in major sugarcane growing states and All India

Sugarcane statistics at All India Level

Fig. 5 shows All-India level trends in area, production, and productivity of sugarcane during the last 10 years.The area under sugarcane witnessed a steady increase from 2009-10 to 2014-15 and declined from 2015-16 (Price Policy of Sugarcane, 2020).



	2008 -09	2009 -10	2010 -11	2011 -12	2012 -13	2013 -14	2014 -15	2015 -16	2016 -17	2017 -18
area	44.15	41.75	48.85	51.06	52.79	53.41	53.07	52.84	49.45	47.37
productivity	64.5	70	70.1	69.3	67.1	64.7	69.7	63.7	61.3	80.19
production	285.0	292.3	342.3	353.7	354.4	345.6	366.8	336.9	303.6	379.9

Fig 5. Area, Production, and yield of Sugarcane at All- India level (2008-09 to 2017-18)

Sugarcane yield had not recorded any significant improvement. The average yield was 68.05 tonnes per ha. However, in 2017-18 yield had increased to 80.19 tonnes per ha. The highest production of 366.8 million tonnes was recorded during 2014-15. However, production decreased significantly during the years of deficit rainfall in 2008-09, 2009-10, 2015-16 and 2016-17, however, increased again in 2017-18 with 379.9 million tonnes.

Among the major sugarcane growing states, Uttar Pradesh registered a positive growth in the area, production and yield, while,Tamilnadu, Gujarat, and Maharashtra had negative growth at a significant level. In Karnataka, there was growth in area and production, but, productivity was showing a negative trend. There was remarkable progress in the growth of area (7.81%), production (9.82%), and yield (1.94%) for Period-II in Bihar. As far as the yield is concerned, Uttar Pradesh state registered higher growth from -0.12 per cent to 2.17 percent which was greater than All India level productivity growth from -0.26 per cent to 0.02 percent. Estimates of Coefficient of Variation showed that Uttar Pradesh has witnessed an increased variability in area, production and productivity from Period-I, whereas, states such as Maharashtra, Karnataka showed a decreased variability in terms of area and production (Table 1).

Maharashtra and Karnataka though recorded negative growth in sugarcane yield,however,contributed to the highest yield of over 92 tonnes ha^{-1} and 84.8 tonnes ha^{-1}, respectively which was higher than the All-India average yield of 80.19 tonnes ha^{-1}. It can be concluded that despite GoI's interventions towards protecting the farmer's interest in sugarcane cultivation, there was a decline in the sugarcane area from 2015-16 onwards at All-India level indicating the crop shift in some of the regions.

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Research Note
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COMMUNITY PRACTICES IN MANAGEMENT OF CROP STUBBLE AND ASSESSING IMPACT ON HUMAN HEALTH IN SONIPAT AND JHAJJAR DISTRICTS OF HARYANA

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Stubble management during both *Kharif* and *Rabi* seasons in India has recently emerged as a major issue of environmental health and also affecting the health of the human life. Rice-Wheat Cropping cycle and high yielding varieties on an average produced 500 Mt of residue every year. In the months of October and November every year,stubble burning caused atmospheric pollution (brown haze) with several noticeable health problems, which necessitated invoking the pollution control regulations of India against the stubble burning practice on farm lands. Smoke and hanging particulate matter was identified as source of respiratory distress and disorders in children below the age of five years as well as in elderly population as indicated in media reports, and scientific studies by Yadav *et al*. (2017); Devi, 2017; Sindhu *et al*. (2015); Long *et al*. (1998); Gupta *et al*. (2004) and Auffhammer *et al*. (2006).

Stubble burning is found to adversely affect soil health of agricultural land and influences soil temperature, pH, moisture retaining capacity, micronutrients and organic matter, which in turn influence the microbial population in the soil.With an objective of reducing burning of farm residue for keeping the air pollution level to permissible limits, sustained awareness campaigns were organized.Campaigns achieved partial success despite strict rules of monitoring and monetary fines. Instead of adopting harsh measures, farmers were encouraged to adopt innovative technological intervention such as using 'Happy Seeder' for chopping the stubble and mixing it again in the soil to achieve '*in situ*' management. The Department of Agriculture, Govt. of Haryana with the aid and assistance of other departments and various agencies also introduced schemes for funding the procurement of equipment relevant to the management of stubble and residue operations at an affordable price.

In addition to this, the farmers were made aware as how they could have used various other healthy and environment friendly practices such as use of crop residues as animal fodder, generating electricity in bio-thermal power plants, bedding for mushroom cultivation, making biogas and in paper manufacture industry besides packaging from the crop residue.

The Government of Haryana along with a few non-government organizations (NGOs) regularly organized awareness campaigns

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Table 1. End use of crop as detailed by the respondents (n=240)

End use of crops	Frequency	Percentage	*P*-value
Burnt	26	10.83	NS
As Fodder	33	13.75	NS
Biothermal power plant	141	58.75	0.001
Bedding material for cattles	123	51.25	NS
Mushroom cultivation	39	16.25	0.0001
Paper production	12	5.00	NS
Biogas preparation	24	10.00	0.0001
Incorporation in Soil	54	22.50	NS

*NS: non- significant ; **Note:** Multi-response Table

tosusta in interest among the farmers for the management of crop residue such as setting up of farm machinery depots or Custom Hiring Centers and helping individuals to open enterprises in rural zones that help in managing residues and stubbles. Hence, the study was designed to investigate if the practices and alternative approaches introduced as a result of massive and sustained awareness generation campaigns were sustainable or otherwise and what type of measureable or visible impact on health of the population could be seen in the past couple of years in the selected villages of Sonipat and Jhajjar districts of Haryana during the year 2018.

The survey was conducted during June to December, 2018 in six randomly selected villages in Sonipat and Jhajjar districts. In case of Sonipat district, Murthal, Thana Kalan and Sehri Khanda were selected, whereas,Badli, Kharar and Khungai villages in Jhajjar district were selected. Data was collected from 240 respondents from the selected villages, which were further clustered at random into six small groups of 40 each that followed wheat-rice cycle every year for over two decades. A pre-set template of questionnaire was completed during the survey from each of the respondents that either had the title of cultivable land in own name or leased-in cultivable land. Data collected was statistically analysed by using SPSS 16.0 Version.

Socio-demographic characteristics of respondents

Overall, 240 respondents were surveyed falling inthe age group 30-60 years.Only 24 respondents(10 percent) had acquired higher education *i.e.* graduation or post-graduation. Only 66 percent of the farmers cultivated wheat and 56 percent rice, followed by sugarcane (14.16%), vegetables (16.45%) and other crops (17.91%). About 94.16% of the respondents reported annual income below three lakhs.Whereas, 63.33% of the farmers possessed 1-5 hectares of land under cultivation.

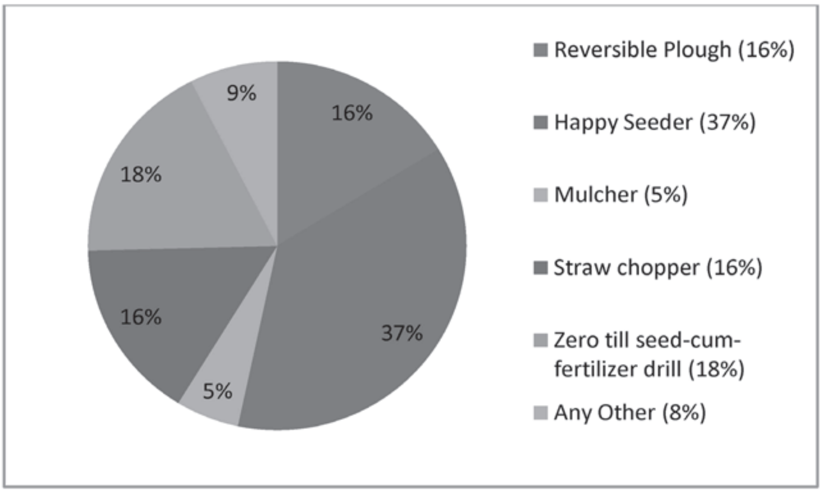

Fig. 1. Stubble management machinery used by respondents(n=240)

It is observed that respondents with gross agricultural income below rupees three lacs, nuclear family size, and low level of education largely preferred usage of combine-harvester machine for rice and wheat crops. Thus, stubble leftover in the fields was seen as the next management problem, which was hitherto been disposed of by burning since neither the domestic animals could fed on stubbles nor it was known for any industrial use. However, in the past couple of year's pollution control measures were tightened and monitored. Respondents with high annual income in these selected villages of both the districts could adopt certain good practices and found to be aware about various alternative methods and schemes of the government for the management of crop residues.

End use of crop by the respondents

It is revealed that with respect to the end-use of stubble, only 26 farmers (10.83%) agreed to have burnt crop residues in their own fields after harvesting (Table 1). It was further observed that the end-use of crop residues in production of biogas, generation of electricity and beds for mushroom cultivation was significantly correlated to the educational status of the respondents *i.e.* $P<0.05$ in all the selected villages of both the Sonipat and Jhajjar districts. In case of usage of stubble management machinery, less than 37.4 % of respondents incorporated crop residue into the soil by use of Happy-Seeder (a new tiller) because intense tillage operations were needed if crop residue was burnt (fig.1). However, the respondents opined that in the starting years it might affect the yield of wheat, but later things may improve as soil health will be maintained due to the presence of micro-flora and microorganisms. These results were corroborated with the findings of Beri *et al*. (1995).

Respiratory disorders due to stubble burning

Respiratory disorders such as irritation in eyes and dry eyes, triggering asthma and frequent coughing due to burning of crop

(n=240)

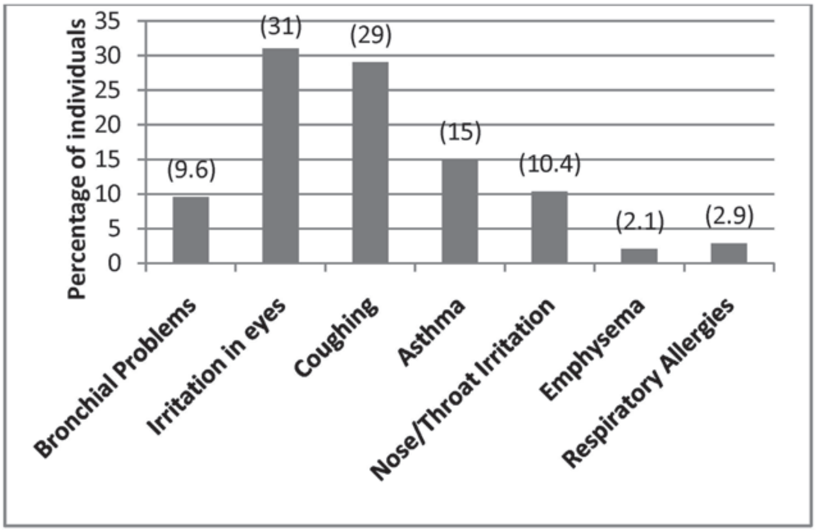

Fig 2. Percentage of household members suffering from diseases due to stubble burning

residue were mentioned by the respondents (Fig.2). The results were found to be in concurrence with other studies (Long *et al*., 1998; Chakrabarti *et al*., 2019). However, other health complications such as irritation in nose and throat, emphysema, bronchitis, other allergieswere not found to be associated with the health of the respondents in the absence of sufficient clinical data.

Machinery usage for Stubble Management

It was noticed that about 66 per cent of the respondents in Sonipat and 71.6 per cent of the respondents in Jhajjar district had acquired awareness about various government awareness schemes for stubble management. The most preferred stubble management machinery wasHappy Seeder, Zero Till seed-cum-fertilizer drill (Fig.1), which was significantly correlated with the economic status, family size and level of education ($P < 0.05$). It was also reported that the usage of the farm machinery improved the soil environment,thereby, increasing crop yield, profitability and also conserving time and energy on the farming operations. The findings coincided with the study of the researchers (Sidhu *et al*. (2007); Singh *et al*. (2012); Singh *et al*. (2014). Besides, a small number of respondents (16%) stated that they were using combine-harvester machines preferred wheat straw-chopper, which saved chaff and increased profits. The findings were supported by few other studies (Mahmood *et al*., 2016; Mangaraj and Kulkarni, 2011). On the contrary, the use of mulcher machine was not popular among the farmers due to high cost and scarcity of labour.

The study revealed that only 10.83% of the respondents were involved in on-farm burning of the crop residues, while, 66-71% preferred modern stubble management practices.

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OPTIMIZING PLANT GEOMETRY AND NUTRIENT MANAGEMENT FOR YIELD ENHANCEMENT OF GREENGRAM UNDER SYSTEM OF PULSE INTENSIFICATION (SPI)

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India is the largest producer and consumer of pulses in the world. Pulses are grown on 22-23 mha of area with an annual production of 20 million tonnes. India accounts for 33 percent of the world area and 22 percent of the world production of pulses (GoI, 2017). The climate change and global warming has deleterious effects on crop production in terms of period of maturity and yield. Although, the production of pulses has increased to some extent since independence the per capita availability has declined substantially. It implies that the increase in production has not kept pace with the growing population, which led to a sharp decline in the per capita availability of pulses from 60 gm/day/ person in 1951 to 36 gm/day/person (Indian Coun-cil of Medical Research, New Delhi recommends 65 gm/day/capita) in 2017 (Puja Sinha *et al.*, 2019). In this grim scenario of demand, supply, and consumption, the pulse production needs to be doubled by 2020 in order to meet the requirement of increasing population.

Plant spatial arrangement, or planting pattern is an important factor determining individual crop plant performance. Spatial arrangement has been quantified as the mean rectangularity, or the ratio of distance between rows to the distance between plants within a row. The influence of rectangularity has been quantified by measuring mean population yield rather than individual plant yield within the population. This method ignores the possibility of non-regular planting patterns, such as occurs in broadcast or solid seeded plantings, or in natural plant populations. Foliar application of growth regulators reduces the flower drop and improves the pod formation and seed setting percentage. Increased drought tolerance and reduced flower drop can be achieved in pulses by foliar spray of nutrient such as TNAU Pulse Wonder. Spraying Pink-pigmented facultative methylotrophs (PPFM) is also known to influence the crop growth by producing plant growth regulators such as zeatin and related cytokinins and auxins (Omer *et al*., 2004). Keeping this in view, an experiment was

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designed to improve the greengram productivity to achieve higher utilization efficiency of all inputs and to arrive at the nutrient package under System of Pulse Intensification.

The field experiment was conducted during summer season of 2015 and 2016 at Agricultural College and Research Institute, Madurai which comes under semi-arid tropics with mean annual rainfall of 840 mm received in 48 rainy days. The soil of experimental site was sandy clay loam in texture (23.67 % clay, 13.65 % silt, 36.52 % fine sand and 25.99 % coarse sand), low in available nitrogen, medium in available phosphorus and high in available potassium. Experiment was laid out in randomized block design with nine treatments and replicated thrice. Green gram (*Vigna radiata* L.) variety CO 6 maturing in 65-70 days was sown at the rate of 20 kg ha^{-1}.

The treatment consisted of T_1 - 25 cm × 25 cm spacing + STCR based fertilizer application; T_2 - T_1 + $ZnSO_4$ + Pulse Wonder; T_3 - T_1 + $ZnSO_4$ + Pulse Wonder + PPFM spray; T_4 - 25 cm × 25 cm spacing + RDF + ZnSO4; T_5 - 30 cm × 30 cm spacing + STCR based fertilizer application; T_6 - T_5 + $ZnSO_4$ + Pulse Wonder, T_7 -T_5 + ZnSO4 + Pulse Wonder + PPFM spray; T_8-30 cm × 30 cm spacing + RDF + $ZnSO_4$ and T_9 -30 cm × 10 cm spacing + RDF + $ZnSO_4$. As per the treatment schedule, recommended dose of fertilizers (25:50:25 kg NPK $ha^{"1}$), Soil Test Crop Response (STCR) based fertilizer application (33:25:13 kg NPK ha^{-1}) and Zinc Sulphate (25 kg ha^{-1}) were applied as basal. Foliar spraying of Pulse Wonder @ 5 kg ha^{-1} at 50% flowering followed by 15 days after first spray and spraying of Pink-Pigmented Facultative Methylotrophs (PPFM) @ 500 ml ha^{-1} at one week after flowering was completed.

Growth characters

The results of the experiments on different crop geometry and nutrient management revealed that wider spacing 30 cm × 30 cm recorded increased plant height as compared to 25 cm × 25 cm spacing for the same set of treatments. Among the different nutrient treatments, highest plant height was observed with application of STCR based fertilizer dose and 25 kg of $ZnSO_4$ as basal and foliar spraying of pulse wonder and PPFM at 50 percent flowering irrespective of spacing. Irrespective of nutritional treatments, wider plant spacing (30 cm × 30 cm) produced taller plants as compared to conventional plant spacing of 30 cm × 10 cm. This might be due to less competition between inter and intra plants for sun light, water, nutrients as well as space. Similar findings were also reported by Mathur *et al*. (2007) in greengram.

The observation on the dry matter production of greengram showed that closer spacing registered comparatively higher dry

Table 1. Effect of crop geometry and nutrient management on growth parameters of green gram

Treatment	Plant height (cm)			DMP (kg ha^{-1})			Pods $Plant^{-1}$			No. of seeds Pod^{-1}		
	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean
T_1: 25 cm x 25cm + STCR based FA	41.6	36.1	38.8	1925	1703	1814	18	25	22	8.2	7.0	7.6
T_2: T_1 + $ZnSo_4$ + Pulse wonder	40.1	39.4	39.8	2074	1985	2030	28	34	31	10.0	8.5	9.3
T_3: T_2 + PPFM	46.0	43.4	44.7	2176	2183	2180	31	40	36	10.5	9.0	9.8
T_4: 25 cm x 25 cm + RDF + $ZnSo_4$	42.7	37.2	39.9	2319	1942	2131	24	29	27	9.5	8.1	8.8
T_5 : 30 cm x 30 cm + STCR based FA	39.2	35.9	37.5	1845	1664	1755	17	27	22	8.3	7.1	7.7
T_6: T_5 + $ZnSo_4$ + Pulse wonder	49.5	44.5	47.0	2521	2181	2351	22	36	29	8.8	7.5	8.2
T_7: T_6 + PPFM	53.5	47.9	50.7	2683	2275	2479	28	41	34	9.8	8.4	9.1
T_8: 30 cm x 30 cm + RDF + $ZnSo_4$	41.0	37.6	39.3	2225	2055	2140	20	31	26	8.5	7.2	7.8
T_9 : 30 cm x10 cm + RDF	37.5	34.9	36.2	2824	2232	2528	16	30	23	7.9	6.8	7.4
S.Ed	1.87	2.01		144.3	163.2		1.3	1.5	1.4	0.5	0.3	0.4
CD (P=0.05)	3.42	4.58		298.7	303.4		2.5	2.6	2.5	1.2	1.1	1.1

matter production than wider spacing. The control plot having 30 cm x 10 cm spacing is observed with higher dry matter production of 2528 kg ha^{-1} due to accommodation of more number of plants per unit area. Among the nutrient management treatments, adoption of square planting (30 cm x 30 cm) with application of fertilizer based on STCR approach and 25 kg of $ZnSO_4$ as basal and foliar spraying of pulse wonder and PPFM at 50 per cent flowering produced higher dry matter of 2779 kg ha^{-1}.

Yield attributes

Number of pods $plant^{-1}$ and number of seeds pod^{-1} were higher when crop was planted at wider spacing (square planting) than closer spacing (30cm x10cm). The increase in yield attributes at wider planting geometry (square planting) might be due to better crop growth, resulted by utilization of more sunlight, soil nutrients and water. This is in conformity with the findings of Kumar *et al*. (2011) in mungbean.

Application of fertilizer based on STCR approach, $ZnSO_4$ and spraying of pulse wonder and PPFM produced the highest number of pods $plant^{-1}$ and number of seeds pod^{-1} in both the square planting spacing of 25cm x 25cm and 30cm x 30cm. Soil application of fertilizer based soil test based crop response could have provided the ideal soil health by supplying all plant essential nutrients for plants for increased photosynthesis and enhanced the translocation of the photosynthates which accumulated more dry matter in plants. The better translocation of the accumulated photosynthates might have resulted in improvement of yield contributing characters. Addition of $ZnSO_4$ could have increased its availability. Further, spraying of the Pulse Wonder and PPFM might have supplemented the plant nutrients at the critical stages and reduced the moisture stress in plants. Similar findings were reported earlier by Thalooth *et al*. (2006).

Seed yield

Adoption of crop geometry of 25 cm × 25 cm spacing with application of fertilizer based on STCR, 25 kg of $ZnSO_4$ as basal and foliar spraying of Pulse Wonder and PPFM at 50 per cent flowering recorded higher grain yield of 852 kg ha^{-1}. However, it was comparable with same nutrient management with crop geometry of 30 x 30 cm spacing which produced a seed yield of 795 kg ha^{-1}. When compared to conventional method of 30 cm x 10 cm spacing, wider spacing of 25 cm x 25 cm and 30 cm x 30 cm produced 39% and 27% more seed yield, respectively. Further, comparing the geometrical arrangements, the closer spacing registered higher haulm yield than wider spacing. The higher haulm yield of 2432 kg ha^{-1} was observed under conventional recommended sowing at 30 cm x10 cm spacing.

Table 2. Effect of crop geometry and nutrient management on yield and economics of green gram

Treatment	Seed yield (kg ha^{-1})			Haulm yield (kg ha^{-1})			Cost of cultivation (Rs. ha^{-1})	Net income (Rs. ha^{-1})			B:C Ratio		
	2015	2016	Mean	2015	2016	Mean		2015	2016	Mean	2015	2016	Mean
T_1: 25 cm x 25cm + STCR based FA	576	515	546	1743	1515	1629	21772	22736	17990	20363	2.04	1.83	1.94
T_2: T_1 + $ZnSo_4$ + Pulse wonder	786	717	752	2062	1792	1927	22788	37708	32331	35019	2.65	2.42	2.54
T_3: T_2 + PPFM	846	858	852	2235	1943	2089	25106	40020	40701	40360	2.59	2.62	2.61
T_4: 25 cm x 25 cm + RDF + $ZnSo_4$	692	575	634	1927	1675	1801	24086	29259	20295	24777	2.21	1.84	2.03
T_5 : 30 cm x 30 cm + STCR based FA	549	519	534	1764	1534	1649	20137	22361	19939	21150	2.11	1.99	2.05
T_6: T_5 + $ZnSo_4$ + Pulse wonder	630	645	638	2335	2029	2182	21750	27251	28146	27699	2.25	2.29	2.27
T_7: T_6 + PPFM	756	834	795	2565	2177	2371	24316	34608	40167	37387	2.42	2.65	2.54
T_8: 30 cm x 30 cm + RDF + $ZnSo_4$	604	558	581	1937	1683	1810	23611	23142	19501	21321	1.98	1.83	1.90
T_9 : 30 cm x10 cm + RDF	513	491	502	2574	2290	2432	23737	16368	14505	15437	1.69	1.61	1.65
S.Ed	48.5	16.3	32.4	78.5	66.3	63.4							
CD (P=0.05)	92.3	58.5	73.9	185.6	138.2	138.3							

Hussain *et al.* (2008) reported that increase in yield at wider planting geometry might be due to better crop growth rate and lesser competition for resources between plants (for water and soil nutrients) that led to produce more pods in greengram. The application of fertilizers based on STCR approach might have increased the soil fertility and favoured for better nutrient supply during early establishment stages, thus, resulted in better plant growth, DMP and nutrient uptake and positive influence on the yield attributes of the greengram and eventually in the yield. Positive influence of wider spacing and nutrient application methods on various plant growth characters *viz.*, plant height and total dry matter production eventually resulted in higher seed yield. This finding is also in accordance with Geetha and Velayutham (2009) in blackgram.

Economic analysis

The economic indicators of various treatments were worked out (Table 2). The cost of cultivation of different treatments ranged between Rs. 20,137 ha^{-1} and Rs. 25,106 ha^{-1}. Among the different treatment combinations, 25 cm × 25 cm spacing with application of STCR based fertilizer and 25 kg of $ZnSO_4$ as basal and foliar spraying of pulse wonder and PPFM at 50 percent flowering recorded highest, net return (Rs. 40360 ha^{-1}) and Benefit-Cost ratio (2.61) when compared to other treatments. Adopting a closer planting spacing of 30 cm × 10 cm recorded the lowest net return (Rs.15,437 ha^{-1}) and Benefit-Cost ratio (1.65).

Total cost of cultivation (Rs. 25106 ha^{-1}) was found higher in 25 cm × 25 cm spacing with STCR based fertilizer application and $ZnSO_4$ and foliar spraying of pulse wonder and PPFM. The reason might be due to the additional use of inputs and labour requirement for spraying as compared to the conventional practice. Further, the cost of seed would have been more when compared to wider spacing of 30 cm × 30 cm.

Square planting of greengram (25 cm x 25 cm) with application of fertilizer based on STCR approach (33: 30: 25 kg NPK ha^{-1}) along with basal application of $ZnSo_4$ (25 kg ha^{-1}) and foliar spray of pulse wonder (5 kg ha^{-1}) and PPFM (500 ml ha^{-1}) at 50 percent flowering is a good management option for getting better seed yield and economic returns.

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Research Note
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EFFECT OF BIOSOLARIZATION ON THE GROWTH ATTRIBUTES OF CLUSTER ONION (*Allium cepa* L. var. Aggregatum Don)

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Onion is one of the most important bulb vegetable crops grown in India and around the globe. Organic vegetables fetch 20-30% higher price than the vegetables from conventional farming. Soil solarization involves covering moist soil with transparent polyethylene sheet during hot months for 30 days to 45 days to raise the soil temperature to the levels lethal for soil borne pests such as insects, disease pathogen, nematodes and weeds. Artificial soil heating or soil solarization is the only non-chemical soil disinfestation method which has been tested on a large scale under farming conditions. Combining organic amendments with soil solarization is a development approach for the control of soil borne plant diseases (Srivastava and Abhijeet Ghatak, 2017). Higher soil temperatures may be obtained with dark-coloured nature of organic amended soils since they absorb more solar radiation than light-coloured. Although, the major benefit of solarization is reduction of soil borne pathogens, there are many other possible additional beneficial effects that can result in an increased growth response (IGR) of plants. Such additional effects include control of weeds and insect pests and release of plant nutrients (Lombardo, 2012). Hence, the experiment was conducted to find out the biosolarization practices for augmenting the growth attributes of cluster onion by adopting organic practice.

The experiment was laid out during *Kharif*, 2018 in a randomized block design with 14 treatments and replicated thrice. It was conducted in the farmer's field at Sandapadugai – a village located 10 km away from Chidambaram. Nutrient status of soil was 181 kg ha^{-1} of Nitrogen, 22 kg ha^{-1} of phosphorus and 238 kg ha^{-1} of potassium. The experiment was carried out by practicing solarization with various amendments and nutrient management through various bulky organic manures, concentrated oil cakes, biofertilizers and foliar organic nutrition. The treatments included a combination of solarization for four weeks with three different amendments *viz.*, Vermicompost, Farm Yard Manure (FYM), and neem cake along with non-solarized control and solarization without amendment. At the end of treatment period, inoculation with Consortium Bio Fertilizers (CBF) was completed for specific treatments. Analysis of Variance (ANOVA) as described by Panse and Sukhatme (1967) was

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used to test for significance in the data generated.

The results revealed that the growth attributes of cluster onion were superior in treatment combination T_{14} that involved solarization for four weeks with vermicompost @ 5 t ha^{-1}, neem cake @1 t ha^{-1}, CBF@ 2 kg ha^{-1} and foliar application of *panchagavya* @ 4 % sprayed four times. This was closely followed by T_{12} that had the solarization with FYM @ 12.5 t ha^{-1}, neem cake @ 1 t ha^{-1}, CBF @ 2 kg ha^{-1}, foliar application of *panchagavya* @ 4 % sprayed four times (Table 1).

In this study, the possible reason for the variations under different treatments in plant height might be due to differential amount of nutrients made available in the treated plots because of solarization and also differential level of uptake of nutrients, which reflected in differences in growth. Increased plant height might be due to increased uptake of nitrogen which is the constituent of protein and protoplasm and vigorously induced the vegetative development of the plants as reported by Joshi and Pal Vig (2010). The increased plant height might be due to the supplementation of nutrients through organic sources besides the growth promotary effect of vermicompost as suggested by Goutam Kumar *et al*. (2011) in tomato. Application of vermicompost increases the activity of N fixing bacteria and the rate of humification. Humic acid in vermicompost enhances the availability of both native and added micronutrients in the soil as reported by Deepamala *et al*. (2017). Application of organic manures would have helped in the plant metabolism through the supply of important micronutrients such as zinc, iron, copper, manganese in an optimum level, in the early growth phase which might have encouraged the vigorous growth. The favourable response in plant height obtained in the study could be attributed to the catalytic action of vermicompost in the soil which might have improved the soil physical conditions facilitating better aeration leading to deeper penetration of roots and higher nutrient extraction. Regarding the highest number of tillers per plant in the same treatment (T_{14}), more availability and uptake of nutrients, particularly N, P, K, micronutrients, water and production of growth promoting substances through the integration of vermicompost and the ready availability of nutrients from the groundnut cake might have contributed for the highest number of branches.

The next best result was obtained with the treatment T_{12} which received FYM, Neem cake, CBF and *panchagavya* along with solarization. This might be due to the nutrient content of neem cake and beneficial effect of *Azospirillum* and Phosphobacteria combined with the growth promoting effect of *panchagavya* in increasing the growth characters. In line with the findings of Ghosh *et al*. (2014), stimulatory effect of neem products might have attributed to the improvement in growth characters. Phosphobacteria solubilise and increase the availability of organic phosphorus to the plants and its uptake by the way of production of organic acids. Another mechanism by which

Table 1. Effect of solarization in bio amended soil on growth and yield attributes of cluster onion

Treatment	Plant height (cm)	Number of tillers	Number of leaves $Plant^{-1}$	Leaf area (cm^2) at peak flowering	Chlorophyll content ($mg\ g^{-1}$)	Bulb yield ($t\ ha^{-1}$)
T_1 - Conventional farming practices (60: 60: 30 kg NPK ha^{-1}) + No solarization	38.51	1.93	10.61	117.61	0.27	4.22
T_2- Conventional farming practices (60: 60: 30 kg NPK ha^{-1}) + Solarization	39.67	2.08	11.12	119.76	0.33	5.47
T_3 -FYM (12.5 t ha^{-1}) + Consortium Bio Fertilizers (2 kg ha^{-1}) + No solarization	40.84	2.23	11.62	121.90	0.38	6.72
T_4- FYM (12.5 t ha^{-1}) + Consortium Bio Fertilizers (2 kg ha^{-1}) + Solarization	43.15	2.57	12.64	126.15	0.49	9.23
T_5 -Vermicompost (5 t ha^{-1}) + CBF (2 kg ha^{-1}) + No solarization	42.00	2.41	12.12	124.02	0.44	7.98
T_6 -Vermicompost (5 t ha^{-1}) + CBF (2 kg ha^{-1})+ Solarization	44.30	2.74	13.16	128.29	0.55	10.48
T_7- FYM+ CBF + Neemcake (1 t ha^{-1}) + No solarization	45.46	2.89	13.67	130.43	0.60	11.74
T_8- FYM+ CBF + Neemcake (1 t ha^{-1}) + Solarization	50.10	3.52	15.71	138.96	0.82	16.77
T_9- Vermicompost + CBF+ Neemcake (1 t ha^{-1}) + No solarization	46.62	3.05	14.19	132.56	0.66	13.00
T_{10}- Vermicompost + CBF+ Neemcake (1 t ha^{-1}) + Solarization	51.26	3.69	16.22	141.10	0.89	18.03
T_{11}-FYM + CBF + Neemcake + Panchagavya (4%) + No solarization	47.77	3.20	14.69	134.69	0.71	14.26
T_{12}- FYM+ CBF + Neemcake +Panchagavya (4%) + Solarization	52.44	3.86	16.74	143.24	0.94	19.30
T_{13}-Vermicompost + CBF + Neemcake + Panchagavya (4 %) + No solarization	48.93	3.37	15.20	136.83	0.76	15.51
T_{14} -Vermicompost + CBF + Neemcake + Panchagavya (4 %) + Solarization	53.89	4.02	17.25	145.36	0.99	22.48
S.Ed.	0.58	0.08	0.25	1.06	0.03	0.63
CD @5%	1.15	0.15	0.50	2.12	0.05	1.25

Note: CBF- Consortium Bio Fertilizers phosphobacteria augment the plant growth is due to the biosynthesis of growth promoting substances like B_{12} vitamin and auxin (Javier Barra *et al*., 2019).

Panchagavya acts as a growth promoter and immunity booster. The stock solution of *panchagavya* creates a depression, which facilitates a cosmic ray link which is the basic element for refreshing the growth process. Besides, *panchagavya* also carries considerable amount of nitrogen which helps in protein synthesis essential for the formation of protoplasm leading to cell division and cell enlargement. This also would have stimulated plant growth. Further, nitrogen is an important component of amino acids and co-enzymes which have considerable biological importance. Beneficial and proven biofertilizers such as azotobacter, *Azospirillum* and phosphobacteria and plant protection substances *viz., Pseudomonas* and saprophytic yeasts detected in *panchagavya* can be attributed to its efficacy as organic foliar nutrient that might have in turn, stimulated the growth, resulting in increased plant height and number of branches as reported by Sundarraman *et al*. (2001).

The induction of early flower bud formation might have been influenced by triggering of such metabolic processes and narrowing of carbon: nitrogen ratio by the significant accumulation of carbohydrates. Furthermore, foliar spray of *panchagavya* facilitates greater uptake of nutrients which leads to the effective conversion of vegetative phase to flowering phase. The findings on improved growth parameters in onion due to application of *panchagavya* are in line with Archana (2008) in bitter gourd. The better physiological status of the plants was also identified by the higher level of chlorophyll content and the number of leaves in the plants.

Highest bulb yield of onion (22.48 t ha^{-1}) was recorded with T_{14} (Vermicompost + CBF+ neem cake +*panchagavya* (4 %) +solarization) followed by T_{12} (FYM+ CBF+ neem cake +*panchagavya* (4 %) +solarization).

The treatment combination of solarization for four weeks with vermicompost @ 5 t ha^{-1}, neem cake 1 t ha^{-1}, CBF 2 kg ha^{-1} and foliar application of *panchagavya* @ 4 % sprayed four times(T_{14}) showed the best performance in improving the growth attributes such as plant height, number of tillers, number of leaves, leaf area chlorophyll content and also bulb yield of cluster onion.

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