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CONTENTS

PART I: PLANT SCIENCES

PART II: AGRICULTURAL ENGINEERING

PART III: COMMUNITY SCIENCE

PART IV: SOCIAL SCIENCES

PART V: RESEARCH NOTES

J. Res. ANGRAU 48 (3) 1-16, 2020

INFLUENCE OF ESTABLISHMENT METHODS AND NITROGEN LEVELS ON YIELD ATTRIBUTES, YIELD, NUTRIENTS UPTAKE AND ECONOMICS OF *KHARIF* RICE IN INCEPTISOLS OF WARANGAL DISTRICT

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ABSTRACT

The field experiment was conducted during *Kharif* 2015, 2016 and 2017 at Regional Agricultural Research Station, Warangal to study the effect of establishment methods (machine transplanting, conventional transplanting, drum seeding and broad casting) and nitrogen levels (120 kg ha^{-1},160 kg ha^{-1} and 200 kg ha^{-1}) in a strip plot design. Number of panicles m^{-2}, grains $panicle^{-1}$, grain and straw yields (317 kg ha^{-1}, 277 kg ha^{-1}, 5345 kg ha^{-1} and 6305 kg ha^{-1}, respectively) were significantly high under machine transplanting over other establishment methods.Significantly higher number of panicles m^{-2}, grains $panicle^{-1}$, grain and straw yields (263 kg ha^{-1}, 276 kg ha^{-1}, 4838 kg ha^{-1} and 6109 kg ha^{-1}, respectively) were recorded with the application of 160 kg N ha^{-1} over 120 kg N ha^{-1} but at par with 200 kg N ha^{-1}.The interaction effect between establishment methods and nitrogen levels was non-significant during all the years of study. The net income (Rs.64,587/-) as well as return per rupee invested (1:3.1) was maximum with machine transplanting followed by broadcasting (1:3.0).

Key Words: Establishment methods, Yield attributes, Yield, Nitrogen Levels, Rice, Kharif

INTRODUCTION

Rice is the most important staple food for more than half of the world's population. In Asia, more than two billion people are getting 60-70 percent of their energy requirement from rice and its derived products, a major source of dietary carbohydrate for most people in tropical Asia (Juliano, 1993). In India, rice (*Oryza sativa L.*) is the staple food crop for more than two-third of the population. Millions of rural households depends on rice crop for their livelyhood andit plays a vital role in national food security. In India, it is grown in an area of 44.10 mha with 106.70 mt production and productivity of 2.42 t ha^{-1}. In Telangana state, rice is the principal food crop cultivated throughout the state. The crop is grown in an area of about 2.01 mha with an annual production of 7.71 mt and productivity of 3.99 t ha^{-1} (Directorate of Economics and Statistics, 2018). In all the rice growing areas there is an acute shortage of human labour during transplanting stage due to migration of labour to non-agricultural sectors leading to delayed transplantation with aged seedlings, causing yield and lesser profit. To overcome these difficulties, conventional transplanting can be substituted by sprouted seeding with drum, broadcasting and machine transplanting. Under different establishment methods (drum seeding, broadcasting,

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Table 1. Influence of establishment methods and nitrogen levels on number of effective tillersm^{-2}(panicles) in *kharif* rice

Establishment methods Factor-(A)	*Kharif-2015*				*Kharif-2016*				*Kharif-2017*				*Pooled*			
	N-levels (Factor-B) (kg ha^{-1})				N-levels(B) (kg ha^{-1})				N-levels(B) (kg ha^{-1})				N-levels(B) (kg ha^{-1})			
	120	**160**	**200**	**Mean**	**120**	**160**	**200**	**Mean**	**120**	**160**	**200**	**Mean**	**120**	**160**	**200**	**Mean**
MT	305	336	314	**318**	309	329	321	**320**	300	313	322	**312**	305	329	316	**317**
CT	266	279	274	**273**	271	279	275	**275**	252	297	280	**276**	263	280	282	**275**
DS	267	275	271	**271**	259	271	265	**265**	239	270	262	**257**	255	269	269	**264**
BC	254	262	257	**258**	264	274	284	**274**	262	287	279	**276**	260	272	276	**269**
Mean	**273**	**288**	**278**		**276**	**288**	**286**		**263**	**292**	**286**		**271**	**288**	**286**	
Factors	**CD (P=0.05)**		**SEm±**		**CD (P=0.05)**		**SEm±**		**CD (P=0.05)**		**SEm±**		**CD (P=0.05)**		**SEm±**	
A	28.00		8.11		32.10		9.11		29.01		8.33		23.00		7.21	
B	3.00		1.21		6.12		2.12		8.12		2.60		4.00		1.21	
A X B	NS		14.10		NS		16.00		NS		14.00		NS		12.00	
B X A	NS		8.12		NS		10.01		NS		9.01		NS		7.12	

MT : Machine Transplanting, CT:ConventionalTransplanting,DS: Drum Seeding, BC: Broadcasting

machine and conventional transplanting) nitrogen is the major yield influencing nutrient in rice cultivation. Hence, precise need based N application helps in improving the yield and reduces the N losses. The optimum requirement of N can be achieved by supplying matching quantity of nitrogen with crop demands as expected to be varied with different establishment methods.

MATERIAL AND METHODS

The experiment was conducted during *kharif*-2015, 2016 and 2017 at Regional Agricultural Research Station, Warangal (Telangana), to investigate the influence of establishment methods and nitrogen levels in inceptisols on yield attributes, yield, nutrients uptake and economics. Initial soil analysis (0-20 cm depth) of the study area was done following the standard methods for pH and electrical conductivity(EC) (Jackson, 1973); organic carbon (Walkley and Black, 1934); available nitrogen (Subbiah and Asija, 1956); available phosphorus(Olsen *et al.,*1954); available potassium(Jackson, 1973); available zinc, copper, iron and manganese (Lindsay and Norvell, 1978); The experiment was laid out in strip-plot design with 12 treatments and replicated thrice.

Rice (RNR-15048 variety) seed was sown in third week of July and first week of August under conventional and machine transplanting, respectively; under drum seeding and broadcastingseed was sown in third week of August and all establishment methods (machine, conventional transplanting, drumseeding and broad casting) were sown in main field in the third week of August.The crop was maintained weed free, pest free and harvested at 125 days after sowing (DAS). At harvest, grain and straw samples were collected, processed and analysed for total NPK content following standard procedures.

RESULTS AND DISCUSSION

The soil in experimental site was clay in texture with moderately alkaline in reaction (pH - 8.15), non-saline in nature (EC 0.44 dSm^{-1}), medium in organic carbon content (OC-0.68%), medium in available nitrogen (339 kg ha^{-1}), higher in available phosphorus (68 kg ha^{-1}), lower in available potassium (235 kg ha^{-1}) and marginal in available Zn, Cu, Fe and Mn(0.66mg kg^{-1}, 1.38 mg kg^{-1}, 11.48 mg kg^{-1} and 3.56 mg kg^{-1}).

Number of effective tillers (panicles)

Number of panicles (318m^{-2}, 320m^{-2}, 312m^{-2} and 317m^{-2} during *kharif* - 2015, 2016, 2017, respectively) was significant under machine transplanting over other establishment method which can be attributed to optimum plant population, plant geometry (30 cm x 12 cm) coupled with transplanting young seedlings (17 days) facilitating even distribution of light, moisture and nutrients among rice plants leading to better growth and yield attributes. This was also reported by Revathi *et al.* (2016) and Latheef Pasha *et al.* (2014). Significantly higher number of panicles *viz.,*288, 288, 292 and 288 were recorded with the application of 160 kg N ha^{-1} in all the seasons of 2015, 2016, 2017 and in pooled mean, respectively over 120 kg N ha^{-1}but at par with 200 kg N ha^{-1}. The increased number of panicles m^{-2} observed in this treatment might be due to favourable root growth and higher mobility of nitrogen in soil

Table 2. Influence of establishment methods and nitrogen levels on panicle length in *kharif rice*

Establishment methods Factor- (A)	Kharif-2015				Kharif-2016				Kharif-2017				Pooled Mean			
	N-levels (Factor-B) (kg ha^{-1})				N-levels (B) (kg ha^{-1})				N-levels (B) (kg ha^{-1})				N-levels (B) (kg ha^{-1})			
	120	160	200	Mean	120	160	200	Mean	120	160	200	Mean	120	160	200	Mean
MT	23.31	23.89	23.45	**23.55**	23.31	24.19	23.82	**23.77**	26.63	27.97	27.48	**27.36**	24.42	25.35	24.92	**24.90**
CT	22.72	23.48	23.15	**23.12**	22.95	23.67	23.31	**23.31**	25.99	26.90	26.47	**26.45**	23.89	24.68	24.31	**24.29**
DS	22.25	23.16	22.90	**22.77**	22.21	23.15	22.86	**22.74**	25.22	25.75	25.49	**25.48**	23.23	24.02	23.75	**23.67**
BC	21.80	22.70	22.34	**22.28**	21.90	22.73	22.07	**22.23**	24.17	25.07	24.64	**24.62**	22.62	23.50	23.02	**23.04**
Mean	**22.52**	**23.31**	**22.96**		**22.59**	**23.43**	**23.01**		**25.50**	**26.42**	**26.02**		**23.54**	**24.39**	**24.00**	
Factors	**CD (P≤0.05)**		**SEm±**		**CD (P≤0.05)**		**SEm±**		**CD (P≤0.05)**		**SEm±**		**CD (P≤0.05)**		**SEm±**	
A	0.52		0.15		0.54		0.16		1.37		0.40		0.27		0.08	
B	0.17		0.06		0.12		0.04		0.19		0.06		0.10		0.03	
A X B	NS		0.26		NS		0.27		NS		0.69		NS		0.14	
B X A	NS		0.18		NS		0.17		NS		0.41		NS		0.09	

MT : Machine Transplanting, CT : Conventional Transplanting, DS : Drum Seeding, BC : Broadcasting

solution and its absorption by plant root. Similar trend of results were reported by Pramanik and Bera (2013). The interaction effect among establishment methods and nitrogen levels on number of panicles m^{-2} were not significant in all the years of study and in pooled mean (Table 1).

Panicle length

Significantly higher panicle length of 24cm, 24cm, 27cm and 25 cm were recorded in *kharif*-2015, 2016, 2017 and in pooled mean, respectively by machine transplanting over other establishment methods. It might be due to lower competition for space, sunlight and nutrients in machine transplanted rice than direct seeding.Similar type of results was also reported earlier by Mukesh Kumar Pandey *et al.* (2018). However, higher panicle length of 23 cm, 23, 26 and 24cm were found with the application of 160 kg Nha^{-1} in *kharif* 2015, 2016, 2017 and in pooled mean, respectively over 120 kg N ha^{-1} and 200 kg N ha^{-1}. As nitrogen plays a role in panicleformation aswell as panicle elongation, the application of N up to 160 kg ha^{-1}resulted in increased panicle length. This was also reported by Pramanik and Bera (2013). No interaction effect was found between establishment methods and nitrogen levelsin all the years and in pooled means (Table 2).

Number of filled grains

Significantly higher filled grains per panicle 270, 287, 274 and 277 were recorded in *kharif*-2015, 2016, 2017 and in pooled mean, respectively under machine transplanting over other establishment methods. This might be due to more light interception because of wider spacing (30 cm x 12 cm), that resulted in more dry matter production and partitioning into sink (panicles). This was also reported by Revathi *et al.* (2016) and Latheef Pasha *et al.* (2014). Significantly higher filled grains per panicle *i.e.* 263, 276, 279 and 273 were observed with the application of 160 kg N ha^{-1} in *kharif*-2015, 2016, 2017 and in pooled mean, respectively compared to 120 kg N ha^{-1} and 200 kg N ha^{-1}. The results inferred that lower dose of fertilizer application did not mitigate the nutrient need by the crop particularly at the time of grain filling stage and resulted in lower number of filled grains $panicle^{-1}$. The results are in confirmity with the findings of Pramanikand Bera (2013). Similarly, application of 200 kg N ha^{-1} reduced the number of filled grains $panicle^{-1}$, which might be due to increase in competition for metabolic supply between tillers causing heavy drain of soluble carbohydrates, thus, reduced availability for spikelet formation possibly due to vigorous vegetative growth and thereby affecting the fertile spikelets production. Similar trend of resultswere reported by Hasegawa *et al*. (1994) and Wu *et al*. (1998). Interaction effect between establishment methods and levels of nitrogen on filled grains per panicle were non- significant in all the three years (Table 3).

Test weight (1000 grain weight)

Test weight was not influenced significantly by establishment methods which ranged between 11.43g and 12.33g in different crop establishment methods. Similar results were also reported by Latheef Pasha *et al.* (2014); Sreenivasulu and Bala Hussain Reddy (2014). Also different nitrogen levels did not influence test weight significantly (Table 4). However

Table 3. Influence of establishment methods and nitrogen levels on filled grains in *kharif* rice

Establish-ment methods Factor-(A)	Kharif-2015				Kharif-2016				Kharif-2017				Pooled mean			
	N-levels (Factor-B) (kg ha^{-1})				N-levels (B) (kg ha^{-1})				N-levels (B) (kg ha^{-1})				N-levels (B) (kg ha^{-1})			
	120	**160**	**200**	**Mean**	**120**	**160**	**200**	**Mean**	**120**	**160**	**200**	**Mean**	**120**	**160**	**200**	**Mean**
MT	259	280	270	**270**	275	298	288	**287**	257	291	275	**274**	264	290	278	**277**
CT	236	266	249	**250**	256	278	262	**266**	257	286	273	**272**	250	277	261	**263**
DS	234	258	247	**247**	246	271	262	**260**	249	276	265	**263**	243	269	258	**256**
BC	226	246	233	**235**	233	258	250	**247**	243	262	260	**255**	234	256	248	**246**
Mean	**239**	**263**	**250**		**252**	**276**	**265**		**252**	**279**	**268**		**248**	**273**	**261**	
Factors	**CD (P≤0.05)**		**SEm±**		**CD (P≤0.05)**		**SEm±**		**CD (P≤0.05)**		**SEm±**		**CD (P≤0.05)**		**SEm±**	
A	9.11		3.10		20.22		6.21		11.10		3.06		8.12		2.11	
B	4.12		1.12		5.11		2.21		5.10		1.53		2.12		1.11	
AXB	NS		5.01		NS		10.12		NS		5.31		NS		4.12	
BXA	NS		3.01		NS		6.11		NS		3.95		NS		3.11	

MT : Machine Transplanting, CT : Conventional Transplanting, DS : Drum Seeding, BC : Broadcasting

vigorous growth and increased number of spikelets with increased dose of N application might have reduced the 1000-grain weight slightly (non-significant) due to insufficient supply of carbohydrates to individual spikelets and there by poor dry matter production in the spikelets of rice Pramanik and Bera (2013).

Grain yield

Significantly higher grain yields of 5721 kg ha^{-1}, 5741 kg ha^{-1}, 4573 kg ha^{-1} and 5345 kg ha^{-1}, were recorded during *kharif*-2015, 2016, 2017 and thereby in pooled mean, respectively under machine transplanting over other establishment methods. This might be due to the cumulative effect of better vegetative growth, drymatter accumulation, effective partitioning to the panicles and grains.The increase in grain yield in machine transplanting was supported by the study of Revathi *et al.*(2016).Under different nitrogen levels, 160 kg N ha^{-1} recorded significantly higher grain yields *i.e.* 5175 kg ha^{-1}, 5184 kg ha^{-1}, 4190 kg ha^{-1} and 4850 kg ha^{-1} over 120 kg N ha^{-1}*i.e.*4984 kg ha^{-1}, 4793 kg ha^{-1}, 3459 kg $ha^{-1}$and 4412 kg ha^{-1}, but, it is at par with 200 kg N ha^{-1}*i.e.*5101 kg ha^{-1}, 4973 kg ha^{-1}, 4031 kg ha^{-1} and 4702 kg ha^{-1}, in *kharif* 2015, 2016, 2017 and in pooled mean, respectively (Table 5). This can be attributed to increase in number of panicles m^{-2}, total number of filled grains $panicle^{-1}$ and test weight. Similar results were also reported by Payman *et al.* (2015)and Pramanik and Bera (2013). Increase in yield attributes are associated with better nutrition, plant growth and increased nutrient uptake (Kumar and Rao, 1992; Thakur, 1993).The interaction effect between different methods of establishment and nitrogen levels on grain yield was non- significant in all the years of study.

Straw yield

Significantly higher straw yields of 6454 kg ha^{-1}, 6072 kg ha^{-1}, 6388 kg ha^{-1} and 6305 kg ha^{-1} were recorded in *kharif*-2015, 2016, 2017 and in pooled mean, respectively under machine transplanting over other systems. It can be attributed to better establishment of seedlings and more tillers m^{-2}. Similar trend of results were also reported by Sathish *et al.* (2016).Under different nitrogen levels, 200 kg N ha^{-1} recorded significantly higher straw yield *i.e.* 6174kg ha^{-1}, 6184, 5985 and 6114 in *kharif* 2015, 2016, 2017 and therebyin pooled mean, respectively over 120 kg N ha^{-1} and 160 kg N ha^{-1} (Table 6). Similar results were also reported by Payman *et al.* (2015) and Pramanik and Bera (2013). Drymatter production was non-significantly influenced by the interaction effect between establishment methods and different levels of nitrogen.

Total nitrogen, phosphorus and potassium uptake

Total nitrogen uptake under machine transplanting was significantly higher *i.e.*134 kg ha^{-1}, 118 kg ha^{-1}, 111 kg ha^{-1} and 121 kg ha^{-1} in *kharif*-2015, 2016, 2017 and in pooled mean, respectively under machine transplanting over other establishment methods (Table 7). Phosphorus uptake was significantly higher (21.40 kg ha^{-1}, 22.84 kg ha^{-1}, 19.07 kg $ha^{-1}$and 21.10 kg ha^{-1}) in *kharif*-2015, 2016, 2017 and as seen in pooled mean, respectively under machine transplanting over drum seeding and broadcasting methods and at par with

Table 4. Influence of establishment methods and nitrogen levels on test weight of grains

Establishment methods Factor-(A)	*Kharif-2015*				*Kharif-2016*				*Kharif-2017*				*Pooled mean*			
	N-levels (Factor-B) (kg ha^{-1})				N-levels (B) (kg ha^{-1})				N-levels (B) (kg ha^{-1})				N-levels (B) (kg ha^{-1})			
	120	160	200	Mean	120	160	200	Mean	120	160	200	Mean	120	160	200	Mean
MT	12.15	12.50	12.34	**12.33**	11.61	12.49	12.37	**12.16**	11.45	12.45	11.95	**11.95**	11.68	12.50	12.07	**12.08**
CT	11.42	12.47	12.28	**12.06**	11.35	12.17	12.01	**11.84**	11.35	12.50	11.68	**11.84**	11.37	12.38	11.99	**11.91**
DS	11.33	11.89	11.53	**11.58**	11.31	11.59	11.45	**11.45**	11.31	12.26	12.12	**11.89**	11.31	11.91	11.70	**11.64**
BC	11.11	11.73	11.44	**11.43**	11.45	12.12	11.95	**11.84**	11.27	12.49	11.50	**11.76**	11.34	12.10	11.78	**11.74**
Mean	**11.50**	**12.15**	**11.90**		**11.43**	**12.09**	**11.95**		**11.35**	**12.43**	**11.81**		**11.43**	**12.22**	**11.88**	
Factors	**CD (P≤0.05)**		**SEm±**		**CD (P≤0.05)**		**SEm±**		**CD (P≤0.05)**		**SEm±**		**CD (P≤0.05)**		**SEm±**	
A	NS		0.15		NS		0.13		NS		0.17		NS		0.12	
B	NS		0.06		NS		.08		NS		0.09		NS		0.05	
A X B	NS		0.26		NS		0.23		NS		0.30		NS		0.22	
B X A	NS		0.18		NS		0.19		NS		0.23		NS		0.16	

MT : Machine Transplanting, CT : Conventional Transplanting, DS : Drum Seeding, BC : Broadcasting

Table 5. Influence of establishment methods and nitrogen levels on grain yield in *kharif*

Establishment methods Factor- (A)	Kharif-2015				Kharif-2016				Kharif-2017				Pooled			
	N-levels (Factor-B) (kg ha^{-1})				N-levels (B) (kg ha^{-1})				N-levels (B) (kg ha^{-1})				N-levels (B) (kg ha^{-1})			
	120	160	200	Mean	120	160	200	Mean	120	160	200	Mean	120	160	200	Mean
MT	5690	5759	5715	**5721**	5481	5936	5805	**5741**	4006	5041	4672	**4573**	5059	5579	5397	**5345**
CT	5102	5406	5394	**5301**	5115	5536	5321	**5324**	3685	4229	4165	**4026**	4634	5057	4960	**4884**
DS	4659	4939	4706	**4768**	4343	4653	4518	**4505**	3629	4099	3974	**3901**	4210	4564	4399	**4391**
BC	4486	4595	4589	**4557**	4231	4611	4248	**4363**	2514	3390	3312	**3072**	3744	4199	4050	**3998**
Mean	**4984**	**5175**	**5101**		**4793**	**5184**	**4973**		**3459**	**4190**	**4031**		**4412**	**4850**	**4702**	
Factors	**CD (P≤0.05)**		**SE m±**		**CD (P≤0.05)**		**SE m±**		**CD (P≤0.05)**		**SE m±**		**CD (P≤0.05)**		**SE m±**	
A	78		23		198		58		529		153		176		51	
B	151		50		88		29		189		63		91		30	
AXB	NS		39		NS		100		NS		266		NS		88	
BXA	NS		85		NS		75		NS		185		NS		71	

MT : Machine Transplanting, CT : Conventional Transplanting, DS : Drum Seeding, BC: Broadcasting

Table 6. Influence of establishment methods and nitrogen levels on straw yield in *kharif* rice

Establishment methods Factor-(A)	Kharif-2015				Kharif-2016				Kharif-2017				Pooled			
	N-levels (Factor-B) (kg ha^{-1})				N-levels (B) (kg ha^{-1})				N-levels (B) (kg ha^{-1})				N-levels (B) (kg ha^{-1})			
	120	**160**	**200**	**Mean**	**120**	**160**	**200**	**Mean**	**120**	**160**	**200**	**Mean**	**120**	**160**	**200**	**Mean**
MT	6210	6580	6573	**6454**	5716	6196	6304	**6072**	5887	6279	6999	**6388**	5938	6352	6625	**6305**
CT	5754	6210	6604	**6189**	5589	5768	6603	**5987**	5037	5625	5691	**5451**	5460	5868	6299	**5876**
DS	5116	5630	5803	**5516**	4972	5235	5403	**5203**	4448	5560	5821	**5276**	4845	5475	5676	**5332**
BC	5027	5259	5716	**5334**	5142	5765	6425	**5777**	4513	5233	5429	**5058**	4894	5419	5857	**5390**
Mean	**5527**	**5920**	**6174**		**5355**	**5741**	**6184**		**4971**	**5674**	**5985**		**5284**	**5778**	**6114**	
Factors	**CD (P≤0.05)**		**SEm±**		**CD (P≤0.05)**		**SEm±**		**CD (P≤0.05)**		**SEm±**		**CD (P≤0.05)**		**SEm±**	
A	253		73		438		127		797		231		373		108	
B	124		41		250		83		355		118		155		52	
A X B	NS		127		NS		220		NS		400		NS		187	
B X A	NS		100		NS		186		NS		301		NS		137	

MT : Machine Transplanting, CT : Conventional Transplanting, DS : Drum Seeding, BC : Broadcasting

Table 7. Influence of establishment methods and nitrogen levels on total nitrogen uptake in *kharif* rice

Establishment methods Factor-(A)	*Kharif-2015*				*Kharif-2016*				*Kharif-2017*				Pooled			
	N-levels (Factor-B) (kg ha^{-1})				N-levels (B) (kg ha^{-1})				N-levels (B) (kg ha^{-1})				N-levels (B) (kg ha^{-1})			
	120	**160**	**200**	**Mean**	**120**	**160**	**200**	**Mean**	**120**	**160**	**200**	**Mean**	**120**	**160**	**200**	**Mean**
MT	113	154	134	**134**	104	132	118	**118**	89	130	113	**111**	102	139	122	**121**
CT	115	152	129	**132**	102	121	117	**113**	72	99	94	**88**	96	124	113	**111**
DS	99	134	115	**116**	95	125	117	**112**	82	90	92	**88**	92	116	108	**105**
BC	98	128	111	**112**	91	111	105	**102**	65	78	80	**74**	85	106	99	**97**
Mean	**106**	**142**	**122**		**98**	**122**	**114**		**77**	**99**	**95**		**94**	**121**	**111**	
Factors	**CD (P≤0.05)**		**SEm±**		**CD (P≤0.05)**		**SEm±**		**CD (P≤0.05)**		**SEm±**		**CD (P≤0.05)**		**SEm±**	
A	12		3.5		6		1.75		14		3.98		9		3	
B	5		1.75		4		1.32		10		3.24		5		2	
A X B	NS		6.00		NS		3.03		NS		6.90		NS		5	
B X A	NS		4.49		NS		2.78		NS		6.62		NS		4	

MT : Machine Transplanting, CT : Conventional Transplanting, DS : Drum Seeding, BC : Broadcasting

Table 8. Influence of establishment methods and nitrogen levels on total phosphorus uptake in *kharif* rice

Establishment methods Factor-(A)	Kharif-2015				Kharif-2016				Kharif-2017				Pooled			
	N-levels (Factor-B) (kg ha^{-1})				N-levels (B) (kg ha^{-1})				N-levels (B) (kg ha^{-1})				N-levels (B) (kg ha^{-1})			
	120	160	200	Mean	120	160	200	Mean	120	160	200	Mean	120	160	200	Mean
MT	20.16	23.23	20.81	**21.40**	21.58	23.87	23.08	**22.84**	18.74	21.30	17.17	**19.07**	20.16	22.80	20.35	**21.10**
CT	19.74	21.28	20.90	**20.64**	20.90	22.25	22.64	**21.93**	16.97	19.95	16.35	**17.76**	19.20	21.16	19.96	**20.11**
DS	17.96	19.17	18.83	**18.65**	17.30	18.96	18.12	**18.13**	15.30	17.00	16.32	**16.21**	16.85	18.38	17.76	**17.66**
BC	16.36	16.77	16.38	**16.50**	16.55	18.66	18.40	**17.87**	10.54	15.67	13.02	**13.08**	14.48	17.03	15.93	**15.81**
Mean	**18.56**	**20.11**	**19.23**		**19.08**	**20.94**	**20.56**		**15.39**	**18.48**	**15.72**		**17.67**	**19.84**	**18.50**	
Factors	**CD (P≤0.05)**		**SEm±**		**CD (P≤0.05)**		**SEm±**		**CD (P≤0.05)**		**SEm±**		**CD (P≤0.05)**		**SEm±**	
A	2.75		0.80		1.25		0.36		3.40		0.99		1.10		0.32	
B	NS		0.53		0.71		0.27		2.20		0.73		0.98		0.33	
A X B	NS		1.38		NS		0.63		NS		1.71		NS		0.55	
B X A	NS		1.20		NS		0.53		NS		1.55		NS		0.62	

MT : Machine Transplanting, CT : Conventional Transplanting, DS : Drum Seeding, BC : Broadcasting

Table 9. Influence of establishment methods and nitrogen levels on total potassium uptake in *kharif*rice

Establishment methods Factor-(A)	*Kharif-2015*				*Kharif-2016*				*Kharif-2017*				Pooled			
	N-levels (Factor-B) (kg ha^{-1})				N-levels (B) (kg ha^{-1})				N-levels (B) (kg ha^{-1})				N-levels (B) (kg ha^{-1})			
	120	160	200	Mean	120	160	200	Mean	120	160	200	Mean	120	160	200	Mean
MT	93	101	100	**98**	78	87	83	**83**	123	137	130	**130**	98	108	104	**103**
CT	85	92	90	**89**	78	85	80	**81**	105	122	116	**114**	89	100	95	**95**
DS	74	82	77	**78**	66	77	71	**71**	89	117	109	**105**	76	92	86	**85**
BC	72	83	79	**78**	64	84	75	**74**	84	106	100	**97**	73	91	85	**83**
Mean	**81**	**90**	**87**		**72**	**83**	**77**		**100**	**121**	**114**		**84**	**98**	**93**	
Factors	**CD (P≤0.05)**		**SEm±**		**CD (P≤0.05)**		**SEm±**		**CD (P≤0.05)**		**SEm±**		**CD (P≤0.05)**		**SEm±**	
A	9		2.61		NS		3.24		18		5		9		2.64	
B	NS		2.59		5.1		1.70		8		3		4		1.42	
A X B	NS		4.52		NS		5.60		NS		9		NS		4.58	
B X A	NS		4.96		NS		4.27		NS		7		NS		3.52	

MT : Machine Transplanting, CT : Conventional Transplanting, DS : Drum Seeding, BC : Broadcasting

Table10. Influence of establishment methods and nitrogen levels on cost of cultivation in *kharif* rice

Establishment methods	Grain Yield (kg ha^{-1})	Cost of cultivation (Rs.ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs.ha^{-1})	Benefit: Cost ratio
MT	6305	29988	94575	64587	1:3.1
CT	5876	32338	88140	55802	1:2.7
DS	5332	26950	79980	53030	1:2.9
BC	5390	26450	80850	54400	1:3.0

MT : Machine Transplanting, CT : Conventional Transplanting, DS : Drum Seeding, BC : Broadcasting

conventional transplanting method (Table 8). Significantly higher total potassium uptake *i.e.* 98 kg ha^{-1}, 83 kg ha^{-1},130 kg ha^{-1} and 103 kg ha^{-1}, was observed in *kharif*-2015, 2016, 2017 and in pooled mean, respectively under machine transplanting over drum seeding and broadcasting and found on par with conventional method of transplanting (Table 9).This might be due to large and functional root system and also higher production of dry matter per unit area in machine transplanting as observed by Revathi *et al.* (2016) and Sathish *et al.* (2016). Significantly higher total nitrogen uptake *i.e.*142 kg ha^{-1}, 122 kg ha^{-1}, 99 kg ha^{-1} and 121 kg ha^{-1} was recorded in *kharif*-2015, 2016, 2017 and in pooled mean, respectively by the application of 160 kg N ha^{-1} over 120 and 200 kg N ha^{-1}, since the grain and straw yield were recorded higher in this treatment. These results were in contrast to the findings of Payman *et al.* (2015) where highertotal nitrogen uptake was recorded by 200 kg N ha^{-1} followed by 160 kg N ha^{-1}. Under different nitrogen levels, application of 160 kg N ha^{-1} recorded significantly higher P-uptake *i.e.* 20.94 kg ha^{-1}, 18.48 kg ha^{-1} during 2016 and 2017 and in pooled, respectively over the 120 kg N ha^{-1} and it was at par with 200 kg N ha^{-1}(Table 8). Potassium uptake was significantly higher *i.e*. 90 kg ha^{-1}, 83 kg ha^{-1}, 121 kg ha^{-1} and 98 in *kharif*-2015, 2016, 2017and in pooled mean, respectively with 160 kg N application over 120 kg N ha^{-1} and it was at par with 200 kg N ha^{-1}. The higher phosphorus and potassium uptake with application of 160 kg N ha^{-1} might be directly related to higher drymatter yield (Table 8 & Table 9). Similar results were also reported by Payman *et al*. (2015). However, there was no interaction effect between different establishment methods and different levels of nitrogen on the uptake of N, P & K in all the years.

Economics

Lowest cost of cultivation (Rs.26,450/-) was found in broadcasting and slightly higher cost (Rs.26,950/-) was recorded with drum seeding method. The cost of cultivation is higher in conventional transplanting and machine

transplanting due to more requirement of human labour for nursery raising. The net income (Rs.64,587/-) and return per rupee invested (1:3.1) was maximum with machine transplanting closely followed by broadcasting (1:3.0). The higher yield recorded with machine transplanting resulted in higher benefit-cost ratio though the cost of cultivation was on a little higher side than the drum seeding and broadcasting methods (Table 10).

CONCLUSION

Rice under machine transplanting gave higher grain yield (6305 kg ha^{-1}) over other establishment methods and also responded to the application of nitrogen upto 160 kg ha^{-1} by giving the higher grain yield, straw yields and net returns. Overall, rice under machine transplanting with 160 kg N ha^{-1} proved better than the other methods.

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ASSESSMENT OF GENETIC VARIABILITY IN TEST CROSS HYBRIDS OF MAIZE (*Zea mays L.*)

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ABSTRACT

Estimation of genetic parameters *viz.,* genetic variability, heritability and genetic advance as percent of mean of a character helps in the selection of the breeding programme for the development of the particular trait. Analysis of variance recorded highly significant differences for twelve characters among 54 test cross hybrids of maize except for protein content. The magnitude of PCV was higher than the GCV for all the characters studied indicating the role of environment in the expression of these traits. Higher estimates of PCV and GCV were recorded by the trait grain yield (kg ha^{-1}). The character grain yield (kg ha^{-1}) also recorded high heritability associated with high genetic advance as per cent of mean indicating the role of additive gene action, and hence, selection of this trait may be effective. Alternatively, the traits days to anthesis, days to silking, ear length, ear girth, kernel rows per ear, and shelling percentage showed medium heritability with lower genetic gain indicating the predominance of non-additive gene action.

Key Words: Genetic variability, Heritability, Genetic advance, Maize

INTRODUCTION

Maize is a cereal grain of Southern American origin. Maize belongs to family Poaceae and is a versatile crop with wider genetic variability. It is one of the most important cereal crops grown next to rice and wheat in area and production across the world. Maize is primarily used for feed (60%) followed by human food (24%), industrial (starch) products (14%) and beverages and seed (1% each) (Kuselan *et al*., 2017). Maize is cultivated across the globe because of its high genetic yield potential among the cereals.In India, it is cultivated over an area of 9.03 Mha, with a production and productivity of 27.71 million metric tonnes and 3070 kg ha^{-1}, respectively. In Andhra Pradesh, it is cultivated in an area of 2.66 lakh ha, with a production and productivity of 15.63 lakh tonnes and 6992 kg ha^{-1}, respectively (Source: www.indiaagristat.com). Maize acreage and production have an increasing tendency with the introduction of hybrids due to its high yield potential (Uday Kumar *et al*., 2013).The success of any crop breeding programme depends on the selection of elite genotypes. Thorough knowledge of genetic variation among the lines is a requirement for any crop breeding programme. The magnitude of variability present in a character can be known through phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV). To know whether the accumulated genetic variability is due to a

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heritable character or a non-heritable character heritability is estimated. Hence, heritability represents the amount of variability that is transmitted from one generation to next generation. Selection is effective when the desirable characters have high heritability coupled with high genetic advance as it indicates the multitude of additive gene action. High heritability coupled with high genetic advance as percent of mean estimates offer the most suitable condition for selection and breeding in maize (Patil *et al*., 2016; Bisen *et al*., 2018). Keeping this in view, the experiment was conducted to study PCV, GCV, heritability and genetic advance.

MATERIAL AND METHODS

In the study, 81 genotypes were sown in Simple Lattice Design and replicated twice during *kharif*, 2019 at Agricultural Research Station, Peddapuram, East Godavari District, Andhra Pradesh situated at 17.07^{0}N Latitude 82.14^{0}E Longitude at an altitude of 46.2m above MSL. The experimental material used consisted of 50 hybrids obtained by crossing of 25 inbred lines of maize with two testers in Line × Tester design along with four checks. Each genotype was planted in two rows each of 4 m in length in each replication with the spacing of 70 cm × 20 cm. Analysis was carried out among the 50 test cross hybrids along with four checks to study genetic variability, heritability and genetic advance. The observations were recorded for 13 traits *viz*., days to 50% tasseling, days to 50% silking, days to maturity, plant height (cm), ear placement height (cm), ear length (cm), ear girth (cm), kernel rows per ear, kernels perrow, test weight (g), shelling percentage, protein content (%) and kernel yield (kg ha^{-1}). The mean values were computed and used for statistical analysis using TNAU statistics software package 9.2 version.

RESULTS AND DISCUSSION

The analysis of variance was carried out to partition the total variance into variance due to genotype and phenotype for all characters. The results of analysis of variance for 13 characters among fifty-four test cross hybrids of maize revealed significant mean sum of squares for 12 characters *viz*., days to anthesis, days to silking, plant height, ear placement height, days to maturity, ear length, ear girth, kernel rows per ear, kernels per row, test weight, shelling percentage and grain yield (kg ha^{-1}) and non significant for protein content (Table 1).

Phenotypic and genotypic coefficient of variation

The magnitude of PCV was higher than the GCV for all the characters studied indicating that the variation is not only due to the genotype but also due to the influence of environment. Similar findings were observed by Adhikari *et al*. (2018) and Sharma *et al*. (2018). High PCV and GCV was observed for grain yield (kg ha^{-1}). Low PCV and GCV was observed for days to anthesis, days to silking, days to maturity, plant height, ear girth, kernel rows per ear, kernels per row and shelling percentage. Similar results for days to 50% tasseling and days to 50% silking were reported earlier by Ram Reddy *et al*. (2012) and Dar *et al*. (2018). Also, lower PCV and GCV values for kernel rows per cob were reported earlier by Supraja *et al*. (2019), Wali (2019) and Dar *et al*. (2018). Moderate PCV and GCV were

Table 1. Analysis of variance for thirteen characters among fifty four test cross hybrids of maize

ANOVA	df	DTA	DTS	PHT	EHT	DM	EL	EG	KRE	NKR	TW	SP	PC	GY(kg ha^{-1})
		1	2	3	4	5	6	7	8	9	10	11	12	13
Treatments	53	1.69**	2.24**	425.09**	241.85**	2.68**	2.35**	0.87**	1.81**	9.94*	29.76**	16.66**	6.04	3013728.64**
Blocks	1	0.23	2.68	1337.04	700.23	1.33	3.82	1.87	0.14	17.44	37.57	0.06	47.59	12404011.12
Residuals	53	0.78	1.02	95.06	67.21	0.50	1.17	0.35	0.92	5.85	11.60	7.78	3.82	448735.74
Mean		43.14	44.73	165.65	63.84	102.00	12.58	13.87	14.44	28.46	29.94	81.29	9.61	5648.18
CV		2.05	2.25	5.89	12.84	0.70	8.59	4.26	6.65	8.50	11.38	3.43	20.35	11.86
MSerror		0.78	1.02	95.06	67.21	0.50	1.17	0.35	0.92	5.85	11.60	7.78	3.82	448735.74
LSD		1.77	2.02	19.56	16.44	1.42	2.17	1.19	1.93	4.85	6.83	5.59	3.92	1343.60

DTA: Days to Anthesis; DTS: Days to Silking; PHT: Plant Height; EHT: Ear Placement Height; DM: Days To Maturity; EL: Ear Length; EG: Ear Girth; KRE: Kernel Rows per Ear; NKR: Number of Kernels per Row; TW: Test Weight; SP: Shelling Percentage; PC: Protein Content; GY: Grain Yield

Table 2. Estimates of genetic variability parameters for thirteen characters

S.No.	Character	Mean	GCV %	PCV %	Hb (%)	GAM %
1	Days to anthesis	43.14	1.56	2.57	36.84	1.95
2	Days to silking	44.73	1.75	2.85	37.61	2.21
3	Plant height (cm)	165.65	7.75	9.74	63.45	12.73
4	Ear placement height (cm)	63.84	14.64	19.47	56.50	22.66
5	Days to maturity	102.00	1.02	1.24	68.38	1.74
6	Ear length (cm)	12.58	6.11	10.54	33.61	7.30
7	Ear girth (cm)	13.87	3.69	5.64	42.80	4.97
8	Kernel rows per ear	14.44	4.62	8.10	32.60	5.44
9	Kernels per row	28.46	5.03	9.87	25.93	5.27
10	Test weight (g)	29.94	10.07	15.19	43.90	13.74
11	Shelling %	81.29	2.59	4.30	36.36	3.22
12	Protein content %	9.61	10.96	23.11	22.48	10.70
13	Grain yield (kg ha^{-1})	5648	20.05	23.30	74.08	35.55

observed for ear placement height and test weight. High PCV and moderate GCV were recorded for protein content. Moderate PCV with low GCV was recorded for ear length (Table 2).

Heritability and genetic advance

High to moderate estimates of heritability were recorded for the characters plant height, days to maturity and grain yield, days to anthesis, days to silking, ear placement height, ear length, ear girth, kernel rows per ear, test weight and shelling percentage. Low estimates of heritability were observed for kernels per row and protein content. High to moderate estimates of genetic advance were recorded for ear placement height and grain yield (kg ha^{-1}), plant height, test weight and protein content. Whereas, low estimates of genetic advance were recorded for days to anthesis, days to silking, days to maturity, ear length, ear girth, kernel rows per ear, kernels per row and shelling percentage.

High heritability associated with high genetic advance as per cent of mean wasobserved for grain yield (kg ha^{-1}). Similar reports were given by Wali(2019) and Supraja *et al*. (2019). High heritability with moderate to low genetic advance as per cent of mean was observed for plant height and days to maturity. These findings were found in agreement with the results of Reddy *et al*. (2013) and Nzuve *et al*. (2014) for plant height. Moderate heritability associated with moderate genetic advance as per cent of mean was observed for test weight. Whereas, moderate heritability associated with low genetic advance as percent of mean was observed for days to anthesis, days to silking, ear length, ear girth, kernel rows per ear, and shelling percentage. Low heritability with moderate to low genetic advance as per cent of mean was recorded for kernels per row and protein content.

CONCLUSION

High PCV and GCV were observed for grain yield (kg ha^{-1}) which provides considerable variability and offers scope for genetic improvement. High heritability coupled with high genetic advance as percent of mean was recorded for grain yield (kg ha^{-1}) indicating the importance of selection of this character for further improvement of breeding program. On the contrary, the traits days to anthesis, days to silking, ear length, ear girth, kernel rows per ear, and shelling percentage showed medium heritability with lower genetic gain indicating the predominance of non-additive gene action and thus employing of breeding methods such as heterosis breeding, and progeny testing methods for improvement on such traits.

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J. Res. ANGRAU 48 (3) 22-32, 2020

EFFECT OF MOLE DRAINAGE ON SOIL SALINITY AND OXIDATION REDUCTION POTENTIAL OF WATERLOGGED VERTISOLS IN ANDHRA PRADESH

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ABSTRACT

The effect of mole drainage at various spacings (2m, 3m, 4m and 5m) placed at different depths (0.4m b.g.l and 0.5m b.g.l) on salinity and oxidation reduction potential of the waterlogged vertisols in Kapileswarapuram village was studied from 2016-17 to 2017-18. It was found that the soil salinity (EC_e (1:2.5) got reduced from 1.73 dS m^{-1} to 0.41dS m^{-1} and 0.58 dS m^{-1} in 0.4 m mole drain depth drains at 2m and 3m mole drain spacing, whereas, it got reduced to 0.46dS$m^{-1}$and 0.62 dSm^{-1} in 0.5m mole drain depth drains with 2m and 3 m drain spacing respectively after 2 years of leaching and drainage. The positive net effect of mole drainage systems on improving ORP in sugarcane vertisols was significant as the recorded ORP was found to be 680mV, 603mV, 283mV and 166mV and -567 mV in 2m, 3m, 4m, 5m and check mole drainage spacing plots with 0.4m mole drain depth. Similarly, in 0.5m mole drain depth plots, the net effect of mole drainage systems on improving ORP in sugarcane vertisols was significant as the recorded ORP was found to be 567mV, 492mV, 242mV, 121mV and -532 mV in 2m, 3m, 4m, 5m and check mole drainage spacing plots. It was recorded that the response of vertisols oxidation reduction potential to mole drainage systems was found to be following the 2^{nd} order polynomial relationship with the highest coefficient of determination.

Key Words: Mole drainage, Sugarcane, Waterlogging, Oxidation Reduction Potential (ORP), Mole Drain Depth (MDD), Mole drain spacing (MDS)

INTRODUCTION

Land degradation has numerous environmental, economic, social and ecological consequences. Waterlogging and salinity are twin problems found complementarily to each other in canal command areas. Soils saturated with water for a long time presents uniquegley horizons resulting from oxidation-reduction processes. A profile of waterlogged soil contains (a) free surface water, (b) a partially oxidized layer with oxidation reduction potential (ORP) of 400 mV or more, and (c) a permanently reduced layer with bluish green mottling (Robinson, 1949).Across the globe, Reliable time series data are available only for salt affected land, which has increased from 7.18 M ha in 1987 to over 10 M ha in 1993 (National Remote Sensing Centre, 2016). Similarly, the waterlogged area increased from 3.082 M ha in 1982 to 14.30 m ha in 20 years. Thus, there is a pressing need for enlarging area

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under arable lands, by the way of reclaiming degraded lands for sustainable intensification of agriculture with yield enhancement without compromising environment and forest area.

India has approximately 11.6 M ha *i.e*., 8.3% of its net sown area under waterlogged condition (Planning Commission, 2011). The nature of the waterlogging problem in India is of two types, *i.e.* 1) surface ponding (1.66 M ha) and 2) sub-surface waterlogging (4.75 M ha) and also with waterlogging and salt affected soils account for 7.89 m ha. Similarly, in Andhra Pradesh, the waterlogged area is estimated as 36,000 ha and in East Godavari district, it is 12,000 ha, which is 33% of the newly formed Andhra Pradesh state waterlogged area. The waterlogging intensity in different districts is in the order of Krishna district (15,000 ha) >East Godavari district (12,000 ha) > Nellore district (3,000 ha) > Srikakulam district (2,000 ha) > Kurnool = West Godavari = Prakasam = Visakhapatnam (1,000 ha) (Sambaiah *et al.,* 2018).

Agricultural drainage is the removal and disposal of excess water from the surface and subsurface matrix of the agricultural lands. The seasonal waterlogging results from heavy rainfall or splash runoff, frequently supersaturating the soils. It is reported that in India,96.4 mha (29.32%) of land is undergoing the process of degradation out of which 14.30 m ha is under waterlogging (PIB, 2020). Out of this waterlogged area, 1.66 mha has become wasteland (Maji *et al*., 2010).The excess soluble salts present in saline soils-characterized by EC_e values above 4 dS m^{-1} at 25^0Crender them unsuitable to grow the majority of the food crops.

In India, with a considerable decrease of waterlogging through implementing drainage systems in 3% of the cultivated area (Mohammad Valipour, 2014), and thereby the importance of agricultural drainage is increasing day by day. Similarly,in Andhra Pradesh also, waterlogged and salt affected soils can be reclaimed using surface, subsurface and mole drainssuccessfully.

The study was conducted for facilitating mole drainage systems in sugarcane grown on vertisols of Andhra Pradesh. Radha *et al.* (2017) reported that waterlogging is one of the serious environmental constraints for optimum sugarcane crop growth, yield and juice quality. Gomathi *et al*. (2014) reported that waterlogging is a widespread phenomenon that affects the growth and survival of sugarcane, which leads to a 15–45% reduction in cane yield. Under such conditions, subsurface drainage is considered as the most suitable approach for controlling these waterlogging conditions, especially in vertisols. This drainage also facilitates water and salt balancing in the root zone to facilitate a favourable environment for the crop growth and contains the water table at a suitable level (Luthin, 1978; Gates and Grismer, 1989). The sugarcane crop is very sensitive to waterlogging conditions, especially, when it crosses 1400 cm-days sum of excess water index.

MATERIAL AND METHODS

The study area, Kapileswarapuram village is located in the Kapileswarapuram mandal of East Godavari district of Andhra Pradesh

(Fig. 1). The study was conducted from 2016-17 to 2017-18 (2 years) in Kapileswarapuram fields of M/s. Sri Sarvaraya Sugars, Chellore. The normal rainfall of the district is 1218 mm out of which 62% (758 mm) of the rainfall is received during south-west monsoon (June-September). During north-east monsoon also, the district (October-December) receives a good amount of rainfall accounting to 28% (344

Fig. 1. Location of the study area, Kapileswarapuram

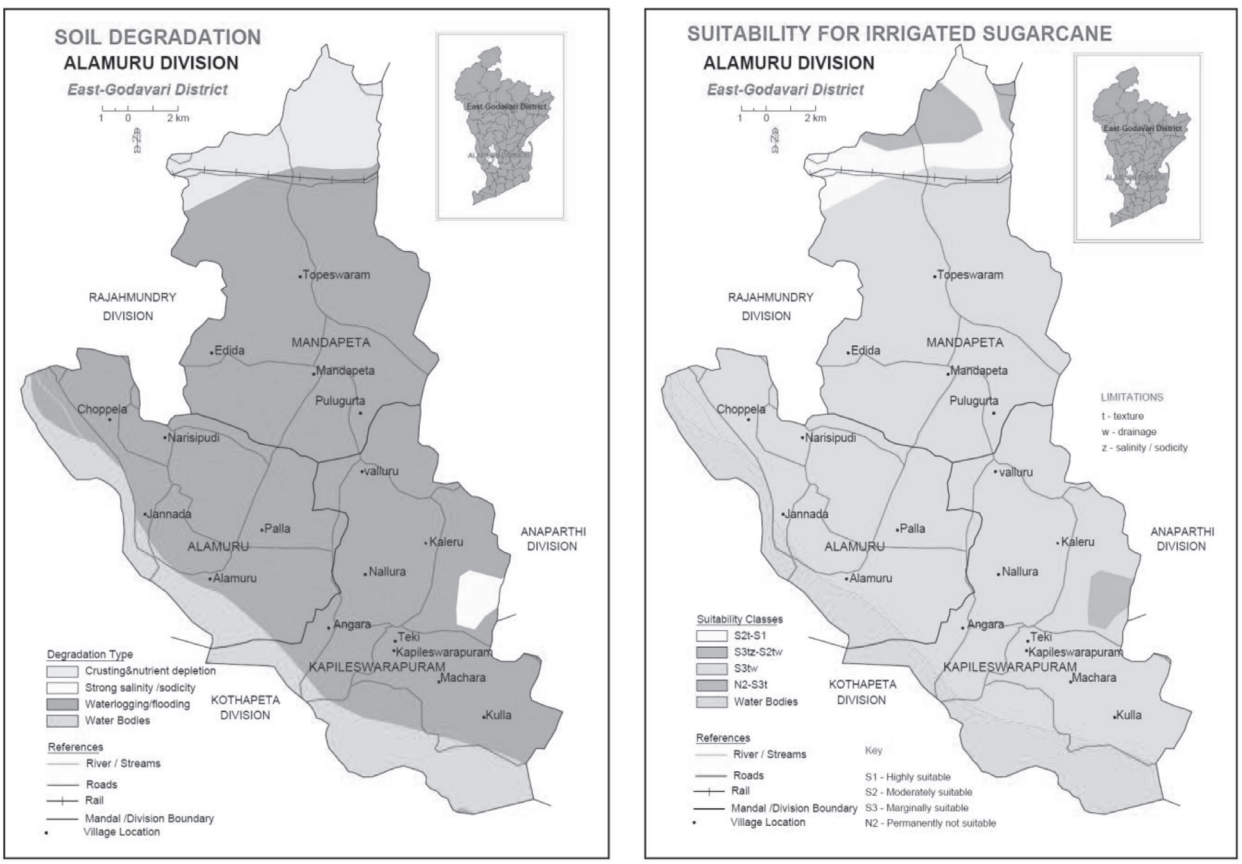
mm) and remaining amount is received during the remaining months of the year.

The soils of the study area are very fine (Smectitic, EnticHaplusterts, fine, Smectitic and vertic Haplusteps), deltaic black cracking clay soils, very deep and imperfectly drained with a very high available water capacity (AWC-Available Water Capacity or Available Water Content), shallow water table (<0.9m WTD, b.g.l), slightly flooded associated with very deep, imperfectly drained, deltaic black cracking clay soils (Vertisols) and sometimes calcareous. The study area suffers from waterlogging and flooding (Fig. 2(a)) and the area suitability for sugarcane is marginally suitable (Fig. 2(b)) for sugarcane with textural and drainage limitations as characterised by NBSS&LUP maps.

The design of the mole drainage system was carried out after thoroughly conducting the pre-drainage investigations and hydrological analysis and the input parameters presented in Table 1 are considered for the design.

Designed parameters of mole drains

Mole drains are designed by considering various input factors responsible for causing waterlogging *i.e.,* hydrological, terrain, climatic, soil (physical and chemical) and crop factors.



(a) (b)

(Source: Pub.No. 870, NBSSLUP)

Fig.2. Soil degradation and sugarcane suitability in Kapileswarapuram

Table 1. Design input and output parameters of the mole drainage system

Input Parameters	
Parameter/Variable	**Value**
Hydrological Parameters	
1. Normal 1-day maximum rainfall	**119.6 mm**
2. 1-day maximum rainfall	248.0 mm
3. 5 Year return period 1-day maximum rainfall	157.0 mm
4. Direct Runoff from 157.0 mm rainfall event	101.4 mm
5. Depth to relatively impervious layer	2.10 m
6. Average minimum water table depth (pre-drainage and post-monsoon)	0.30 m
7. Average hydraulic conductivity	0.30 m d^{-1}
8. Groundwater table depth	0.1-0.3 m
9. Sum of Excess Water Index (SEW_{30})	2891 cm-days
10. Optimum Sum of Excess Water Index (SEW30) for sugarcane crop	1400 cm-days (Carter and Camp, 1994)
Topographic Parameters	
1. Longitude	81.941845^0 E
2. Latitude	16.736382^0 N
3. Altitude	10.1 m, MSL
4. Land slope (Before levelling)	0.36%
5. Land slope (After levelling)	0.28%
6. Maximum slope length of the field	82.50 m
7. Maximum width of the field	120.0 m
8. Area	2.0 ac
Soil Parameters	
1. Clay content	52.87%
2. Silt content	33.25%
3. Sand content	13.88%
4. Total porosity	56.60%
5. Bulk density	1.06 -1.22 g cc^{-1}
6. Field capacity	41.00%
7. Effective porosity	15.70%
8. Permanent wilting point	25.60%
9. Available soil water capacity (ASWC), mm	153.75%
10. Water easily available in the soil (WEAS), mm	76.875 mm m^{-1}
11. Available soil water reserve (ASWR), mm	76.875 mm m^{-1}
12. Average initial $EC_{e(1:2.5)}$	1.73 dS m^{-1}

Table 1 contd... 27

13. Average pH	7.89
14. Oxygen Reduction Potential (Before mole drainage)	-500 mV
15. Plastic limit of the soil	31%
16. Soil moisture at the time of moling	33%
Output Parameters	
1. Lateral mole slope	0.30%
2. Collector line slope	0.50%
3. Drainage Co-efficient (5 year return period)	55.6
4. Mole drain spacing (MDS) - (Designed)	2
5. Mole drain spacing (for Sensitivity Analysis)	3.0, 4.0 & 5.0 m
6. Mole drain depth (MDD)	0.4 & 0.5 M
7. Diameter of the mole hole	75
8. Mole plough leg dimensions	1250 × 250 × 25 mm
9. Mole plough shank foot of 63 mm and a 75 mm diameter bullet	63 mm
10. Mole plough Bullet/expander diameter	75 mm
11. Tractor H.P. needed	45-60H. P
Crop Parameters	
1. Crop	Sugarcane (High yielding, High Sucrose mid-late variety but a poor performer in Waterlogging. Tropical zone variety. Drought resistant.)
2. Sugarcane Variety	Co 86032 (Nayana)
3. Duration of the crop	10-12 months (Multiple Ratooning)

Determination of Soil Oxidation Reduction Potential

Soil oxidation reduction potential (ORP) which is also called redox potential is very important for characterizing the ability of soils to exchange the oxygen to facilitate anaerobic and aerobic processes in the soil matrix under waterlogged conditions a measure of voltage over a period of time.

Hydric soils require a period of reduction and these measures can provide the length of time that the reduction process is occurring. In soils that have fluctuating wet and dry conditions, wide fluctuations in Eh occur. Redox conditions are of basic importance to agriculture. Most of our agriculture systems are based on non-saturated conditions. Anaerobiosis impairs the growth of most crops (Light, 1972).

RESULTS AND DISCUSSION

Effect of mole drains on soil salinity

Operation of mole drainage systems in waterlogged and salinized vertisols has resulted in reducing the salinity and improved the oxidation reduction potential of the soil for facilitating favourable conditions in the root zone for nutrients leaching reduction and making them available to the plant systems in a regulated mode.

The soil salinity (ECe (1:2.5)of the study area got reduced to the normal range of 0.41 to 0.58 dSm^{-1} in 0.4 m MDD drains, whereas, it got reduced to 0.46 and 0.62 dSm^{-1} in 0.5 m MDD drains in 2 and 3 m MDS treatment respectively after 2 years of leaching from the initial soil salinity of 1.73 dS m^{-1}. Whereas, the reduction in the soil salinity with respect to initial soil salinity of 1.73 dS m^{-1}under 4 and 5 m in 0.4 m mole drain depth (MDD) treatment is much slower and the salinity after 2 years remained at 0.83 and 0.94 dS m^{-1} and in 0.5 m drain, it remained at 0.91 and 1.11 dSm^{-1}(Table 2), respectively.

The soil salinity of check plot got increased from average salinity of 1.73 dSm^{-1} to 2.49 - 2.67 dS m^{-1}, which means that the surface drainage is insufficient to remove the salts out of the rootzone. To sustain good sugarcane

Table 2. Final soil salinity and pH under mole drainage system in different layers

Mole Drainage System	2017		2018	
	EC_e (1:2.5) dS m^{-1}	pH (1:2.5)	EC_e (1:2.5) dSm^{-1}	pH (1:2.5)
	0.4m MDD (Mole Drain Depth)			
2 m	0.61	7.67	0.41	7.24
3 m	0.86	7.89	0.58	7.18
4 m	1.22	7.77	0.83	7.27
5 m	1.38	7.74	0.94	7.49
Check	1.81	7.98	2.49	7.98
	0.5m MDD (Mole Drain Depth)			
2 m	0.68	7.65	0.46	7.15
3 m	0.91	7.85	0.62	7.26
4 m	1.34	7.99	0.91	7.00
5 m	1.63	8.02	1.11	8.02
Check	1.99	8.10	2.67	8.10

crop, the intervention of subsurface drainage technology is essential and the mole drains did the job of reducing the soil salinity as well. The mathematical models developed for the relationship between reduction in soil salinity and mole drain spacings are presented through Fig. 3.

The mathematical models are developed to predict the reduction in soil salinity using the responses of the various mole drain spacings on soil salinity. It is found that the spacing and reduction in soil salinity are negatively regressed (Fig. 4) with the increase in mole drain spacing.

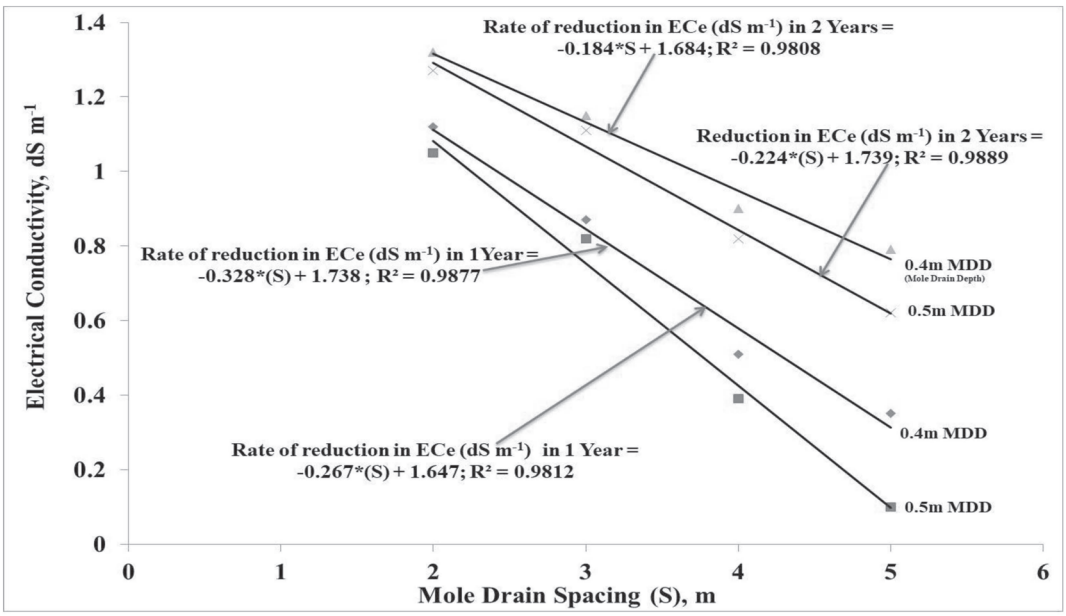


Fig.3. Reduction of soil salinity in mole drained fields of the study area

Effect of mole drains on oxidation reduction potential (ORP)

The soil oxygen reduction potential (ORP) variations with respect to mole drainage and soil oxygenation treatments render the soil adequate oxidising zones as shown in Table 3. Generally, the reduction potential of -300 mV occurs in highly reduced soils, where accelerated denitrification, reduction of iron etc. takes place. In the case of the study area, it was found that the initial ORP ranged from -567 mV to -532 mV. This is one of the reasons as to why the low yields and significant difference in plant growth was observed in sugarcane cultivated under reduced soil conditions.

The positive net effect of mole drainage systems on improving ORP in sugarcane vertisols is significant as the average recorded ORP was found to be 680, 603, 283 and 166 and -567 mV in 2m, 3m, 4m, 5m and check mole drainage spacing plots respectively with 0.4m mole drain depth (Table 3).

Similarly, in 0.5m mole drain depth plots (Table 3), the net effect of mole drainage systems on improving ORP in sugarcane vertisols is significant as the average recorded ORP was found to be 567 mV, 492, 242 and 121 and -532 mV in 2m, 3m, 4m, 5m and check mole drainage spacing plots respectively.

Table 3. Oxidation reduction potential (ORP, mV) of the waterlogged soil under mole drainage

Mole drain spacing (MDS)	2017	2018	Average
0.4 m MDD (Mole Drain Depth)			
2 m	655	704	680
3 m	599	627	603
4 m	304	318	283
5 m	142	189	166
Check	-521	-612	-567
0.5 m MDD (Mole Drain Depth)			
2 m	531	604	567
3 m	485	498	492
4 m	227	258	242
5 m	115	126	121
Check	-526	-638	-532

Among the field plots with 0.4and 0.5m MDD spaced at 2m and 3m presented good aerated conditions whose ORP is found to be more than +350 mV and poor aerated conditions were registered with 4 and 5m mole drain spacingswhose ORP is found to be less than +350 mV, which represents highly reduced and chronic waterlogged soil conditions.

Among all, check plots exhibited lowest ORP values to the extent in the range of -521 mV to -638 mV during 1st and 2nd year (Fig. 4.) respectively during the 1-day maximum rainfall event, which means that the situation of high water table is rendering the soil slabs the high reduced conditions, which hampers the biochemical reactions of the soil and microorganisms, thus affecting the nutrient fixation, instead of storing the applied nutrients in an unavailable form. Thus, it may lead to leaching of the nutrients causing non-point source pollution from the waterlogged soils.

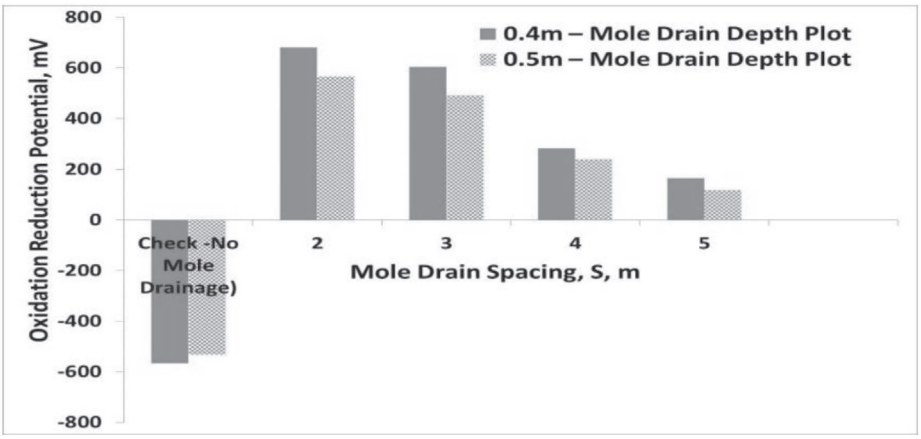


Fig. 4. Comparative performance of mole drains in different spacings and depths

The relationship between the mole drain spacing and the oxidation reduction potential of the study area was found best fitted through the 2nd order polynomial equations (Fig.5).

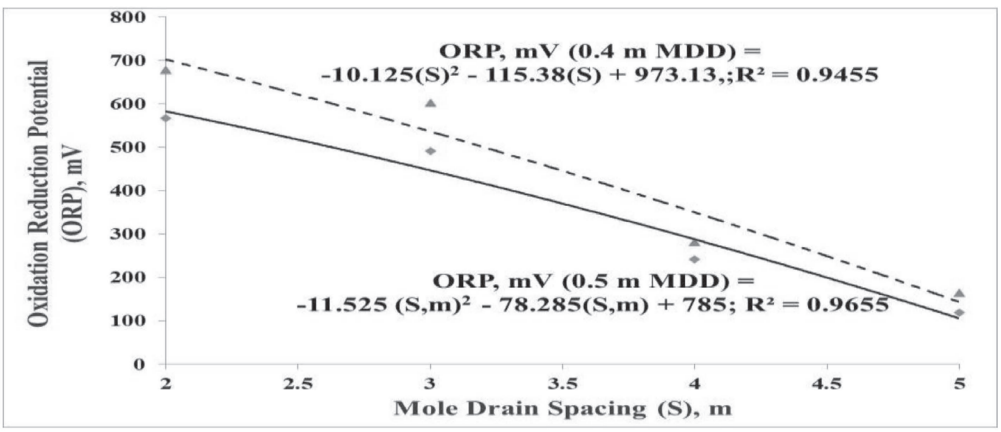


Fig. 5. Models of ORP under mole drainage conditions

CONCLUSION

Operation of mole drainage systems in waterlogged and salinized vertisols has resulted in reducing the salinity and improved the oxidation reduction potential of the soil. Among the field plots with 0.4 m and 0.5 m MDD spaced at 2m and 3m, presented good aerated conditions whose ORP is found to be more than +350 mV and mole drains with 4m and 5 m mole drain spacings created poor aerated, highly reduced and chronic waterlogged conditions with ORP less than +350 mV. The potential of mole drainage systems for control of waterlogging and salinity in vertisols is clearly brought out.

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DEVELOPMENT OF A MANUALLY OPERATED RICE TRANSPLANTER USING FOUR-BAR LINKAGE MECHANISM

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ABSTRACT

The manually operated two-row rice transplanter was developed to transplant root washed type seedlings using four bar linkage transplanting mechanism during 2016. Effective field capacity of the transplanter was 0.012 ha h^{-1} at an operating speed of 0.36 km h^{-1}. The average height of the seedlings were 162.2 mm, 190.35 mm and 220.55 mm for 20, 25 and 30 days old seedlings, respectively.Average hill-to-hill spacing, number of seedlings per hill and depth of planting were 200.22 mm, 4.06 mm and 61.66 mm, respectively. Average missing hills, floating hills and visible damage of the transplanter were10.33%, 6.17% and 2.83%, respectively.Cost of transplanting by the transplanter was Rs.6500 ha^{-1}, whereas, by manual transplanting it was Rs.11400 ha^{-1}, thus,there is a saving of Rs.4900 ha^{-1}.

Keywords: Rice Transplanter, Four Bar Linkage Mechanism, Root Washed Type Seedlings, Transplanting Mechanism

INTRODUCTION

Rice is an important staple food crop of India. Rice crop yields contributed 39.87 % to the total food grain production (275.11 million tones) in the year 2016-17. The gross cropped area under cultivation of rice was 43.70 mha with an average cropping intensity of 137.65% (GoI, 2018). At global level, India ranks second in overall production of rice, China being the first. However, India ranks first in the area of production. Rice is cultivated in almost all the states of India. Uttar Pradesh, West Bengal, Andhra Pradesh, Chattisgarh, Odisha and Bihar are leading states area-wise while, West Bengal, Punjab and Uttar Pradesh lead in production (ICAR, 2019).

Before the introduction of machines, transplanting of rice, a widely followed practice was carried out manually. Manual transplanting can be completed either in well-defined rows or at random. Row planting takes more time, however, facilitates mechanical weeding. Manual transplanting requires about 250-300 man-h ha^{-1} which accounts for one-fourth (25%) of the total labour requirement of the crop (Kumar and Thomas, 2019). It is observed that the person has to maintain a stooping posture during the transplanting operation which is a labour intensive and a tiresome process.

Mechanical transplanting, is an alternative to manual transplanting, in terms of timeliness

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of operation, reduction of drudgery and low cost of operation. When mechanical transplanters were introduced, root washed seedlings were used. It was recorded that separation of seedlings by the transplanting finger from the seedling tray was difficult. Distribution of number of seedlings in individual hills was uneven (Biswas *et al.*, 2019; Kumar and Thomas, 2019). With the popularity of machine transplanting, mat type seedlings were adopted to overcome this problem. Gradually mat type seedlings are increasingly used due to their superior performance in terms of less number of floating hills, less number of missing hills, establishing the required number of seedlings in the hills and reducing the labour requirement (Dixit *et al.*, 2007).

Transplanting carried out using manually operated tranplanter requires 33-66 man-h ha^{-1} as reported by different researchers from different locations using different methodologies (Kumar and Thomas, 2019). Considering an average time requirement of 50 man-h ha^{-1}, 80 % of the labour requirement in transplanting can be saved compared to the manual method. Similarly, power operated self-propelled rice transplanters require 10-42 man-h ha^{-1} with different models of machine (Manjunatha *et al.*, 2009). Accordingly, 90% of labour requirement for transplanting is saved. Thus, there would be less dependence on labour which is scarce and uncertain during the peak transplanting season (Dixit *et al.,* 2007).

Main well-designed part of the transplanter is the picking-cum-planting unit. Planting finger is the critical part in the planting unit. It meters the number of seedlings planted per hill. Different types of transplanting fingers are used in the transplanters. Fixed fork type finger is the simplest and most popular. During operation, seedlings are picked up from the tray and held in the fork. When the fork enters the puddled soil, the seedlings are pushed into the soil and the fork is withdrawn. Most transplanters used planar four bar linkage mechanisms with the planting finger forming a coupler point (Thomas and Kumar, 2017).

In India, about 85% of the operational holdings are in the size group of less than 2 ha and this covers only 44% of the area (ICAR, 2019). Fragmentation of land into smaller plots further limits free movement of the machines.

Popularity of mechanical rice tranplanter is low as raising of mat type seedling is the main constraint. Raising of seedling and transplanting with transplanter requires lot of skill and management of the raised nursery is also a difficult task(Kumar and Thomas, 2019). Farmers use root wash type seedlings for transplanting. Adoption of mechanical transplanting technique leaving the traditional method requires high initial investment cost in the transplanter, precision leveling of the land and expenditures on plastic sheets and mat frame.

Hence, a transplanter suitable for the cropping practices prevalent in India was required to overcome the problems in the mechanization of rice cultivation. Utility of power operated transplanter machines is less due to undulating topography of land and difficult in operation during turning in small plots. In an effort, a manually operated rice transplanter for root washed type seedlings have been developed by Kavitkar (2016) and Biswas *et al.*

(2019). However, there is a problem during operation as well as in terms of missing hills. A commercially available Chinese hand crank rice transplanter has also been tested by various researchers and reported number of problems associated (movement of the crank, and time setting of picking finger and transplanting finger for seedlings falling) with the machine (Budiman *et al.*, 2016; Mehta, 2017).No mechanism has been successful for continuous planting of conventional root-washed seedlings. Therefore, an attempt was made to develop a manually operated two-row rice transplanter using four-bar linkage mechanism for root washed type seedlings suitable for Indian conditions.

MATERIAL AND METHODS

Analytical calculation of position of transplanting finger and its path of motion

A number of trials have been conducted with different kinematic link length to satisfy the Grashof condition so that at least one link can be capable of making a full revolution with respect to the ground plane. A four bar linkage mechanism has been developed with link lengths and link angles (Table 1).Vector loop equation can be formulated and solved for determining the location of links in a four-bar linkage mechanism (Thomas and Kumar, 2017). Link dimensions are used to layout the mechanism as shown in Fig. 1.

Table 1. Developed kinematic links dimensions of the transplanting mechanism

Parameters	Dimensions
Length of crank	100 mm
Length of coupler link	198 mm
Length of follower link	300 mm
Length of fixed link	320 mm
Distance from coupler link centre to tip of finger	400 mm
Angle of the Fixed link	300°
Angle of the coupler link with the tip of the finger	170°

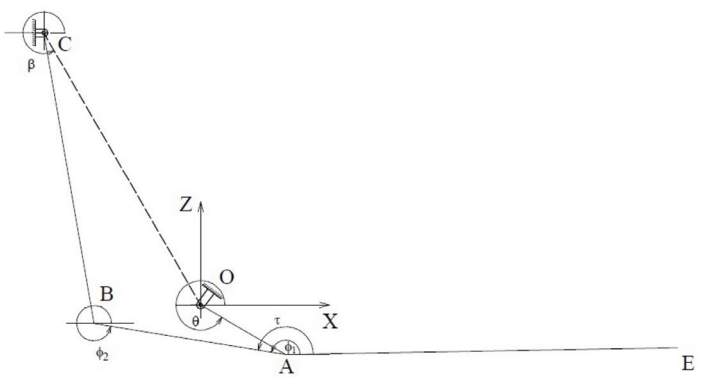

Fig. 1. Developed transplanting mechanism drawn with link angles for analysis

Link OA represent the crank, AB the coupler and BC the follower. OC is the fixed link which is part of the frame of the machine. Point E represents position of finger. Orientation of finger is shown by line EF. AE is coupler extension.

Using complex variable notations of the link vectors shown in Fig. 1,

$$r.\, e^{j\theta} + d.e^{j\phi 1} + b.\, e^{j\phi 2} + c.\, e^{j\beta} = 0 \qquad \ldots (1)$$

In which,

r = OA = length of crank
d = AB = length of coupler
b = BC = length of follower
c = OC = length of fixed link
e = AE = length of coupler extension
θ = crank angle
ϕ_1 = coupler angle
ϕ_2 = follower angle
β = angle of fixed link

Eq. (1) can be written as

$(r\cos\theta + j.r\sin\theta) + (d\cos\phi_1 + j.\, d\sin\phi_1) + (b\cos\phi_2 + j.\, b\sin\phi_2) + (c\cos\beta + j.\, c\sin\beta) = 0 \qquad \ldots (2)$

Separating the components in X and Z- directions.

$$r\cos\theta + d\cos\phi_1 + b\cos\phi_2 + c\cos\beta = 0 \qquad \ldots (3)$$

$$r\sin\theta + d\sin\phi_1 + b\sin\phi_2 + c\sin\beta = 0 \qquad \ldots (4)$$

Using vector loop method and the above Eq.(3) and (4) the following relation is obtained.

$$K_1 + K_2\cos(\phi_2 - \beta) + K_3\cos(\theta - \phi_2) + \cos(\theta - \beta) = 0 \qquad \ldots (5)$$

Where assuming, $K_1 = (r^2 + b^2 + c^2 - d^2)/(2rc)$, $K_2 = b/r$; and $K_3 = b/c$

Using further substitution for $\sin\phi_2$ and $\cos\phi_2$

$$\sin\phi_2 = \frac{2\tan(\frac{\phi_2}{2})}{1+\tan^2(\frac{\phi_2}{2})}$$

$$\cos\phi_2 = \frac{1-\tan^2(\frac{\phi_2}{2})}{1+\tan^2(\frac{\phi_2}{2})}$$

the above Eq. (5) can be solved using the following expression

$$\tan(\frac{\phi_2}{2}) = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A} \qquad \ldots (6)$$

Where assuming, $A = \{K_1 - K_2\cos\beta - K_3\cos\theta + \cos(\theta-\beta)\}$

$B = 2(K_2\sin\beta + K_3\sin\theta)$

$C = \{K_1 + K_2\cos\beta + K_3\cos\theta + \cos(\theta-\beta)\}$

Derivation of Eq. (5) and (6) gives the value of ϕ_2. Four values may be indicated by the above equation. Value corresponding to the Fig. 1 is selected. Angle ϕ_1 is also calculated using equation similar to Eq. (6) and a suitable value is selected.

Values of ϕ_1 is used along with values of τ and AE for determining the position of E with respect to X, Z- coordinate system (Fig. 1).

$$X_E = r\cos\theta + AE\cos(\phi_1 + \tau) \quad \ldots (7)$$

$$Z_E = r\sin\theta + AE\sin(\phi_1 + \tau) \quad \ldots (8)$$

Calculation is carried out for determining the values of (X_E , Z_E) for different values of θ comprising full rotation of the crank.

These values are plotted in a X, Z space and joined in sequence in order to obtain the path of motion of point E. This is shown in Fig. 2 whereas Fig. 3 shows the path determined by graphical method.

Comparing the paths shown in Fig. 2 and Fig. 3 it can be inferred that both methods gave the same path.

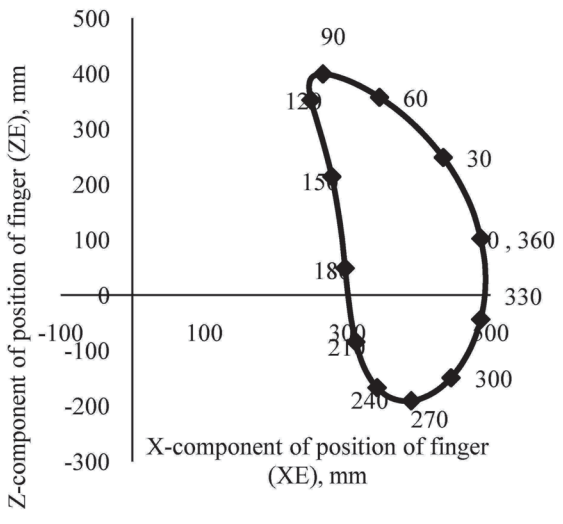

Fig. 2. Path of motion of finger point E obtained by analysis using vector loop method

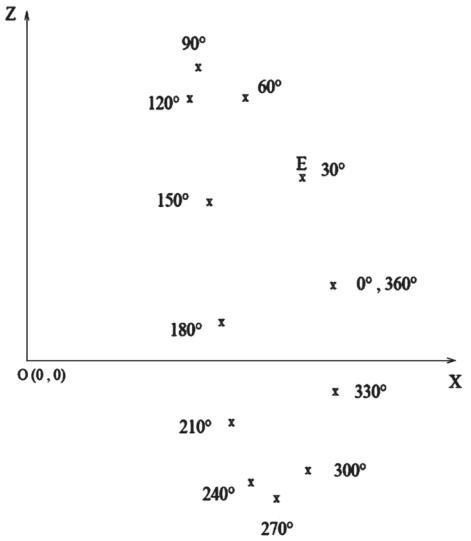

Fig. 3. Path generated by finger using graphical method

Development of four bar linkage mechanism of transplanting finger

For the development of manually operated rice transplanter, link length and link angles were maintained (Table 1). It was required to operate a link CE at a suitable speed. This was completed using a drive operated by a suitable rotating crank. The following requirements were considered while designing the drive:

(i) Link AE should pass through the tray slot and separate the seedlings during downward motion ii) Link AE is attached to a coupler link in a four bar mechanism. In the four bar linkage mechanism crank would make full rotation while the follower carrying link CB would oscillate. (iii) During return motion the finger should not pass through the tray slot. The finger would make the path.

A four-bar linkage having the configuration shown in Fig. 4 was examined on trial basis and found to meet the requirements listed above.The fixed link OC made an angle of 30° with the vertical. AE is attached with AB at an angle of 170°. With this arrangement, the finger point E passes through the tray slot nearly at the middle of the oscillation.

Point E represents position of finger. Angle of finger with respect to the line AE was designed keeping in mind the orientation of tip of finger at the mean position in the seedling.

Development of Manually Operated Two-Row Rice Transplanter

The manually operated 2-row rice transplanter which was developed in order to transplant root washed type seedlings using the four bar linkage mechanism consists of transplanting unit, seedling tray, float and power transplanting unit.

Components of the transplanting unit were crank, coupler link, follower link, finger, and frame for supporting planting mechanism. Crank was the driving member of the mechanism. Two numbers of cranks were used in the transplanting mechanism. Centre to centre distance between crank shaft and crank pin of the crank was 100 mm. Two

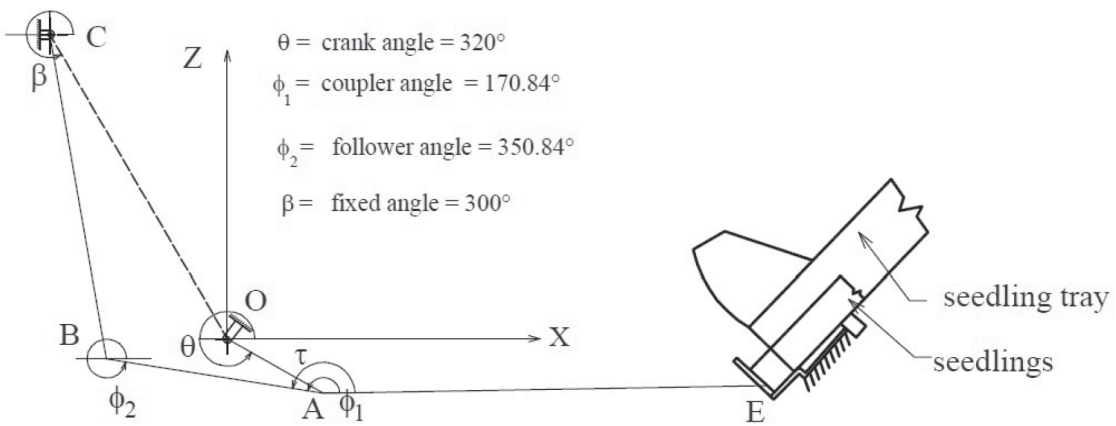

Fig. 4. Kinematic design of four-bar linkage of manual rice transplanter

number of follower links were used in the transplanting unit. Two coupler links with length 198 mm were used in the planting unit. Coupler extensions was made with m.s. flat (25 mm × 5 mm) to connect the fingers at proper position. One end of the coupler extension was welded with the coupler bush at fixed angle of 109° whereas, in the other end a provision was made to hold the finger.

Two numbers of fixed fork type fingers were used for transplanting of the seedlings. The finger was made with m.s. flat (20 mm × 5 mm). A notch (10 mm width and 30 mm depth) was made at tip of the finger to hold the seedling properly during planting. On the other side of the finger, a provision was made to tighten with the coupler extension at a required angle. The finger was adjusted and tighten with the coupler extension in such a way that the distance between the centre of coupler to the tip of the finger was 400 mm.

Float was designed on the basis of row-to-row spacing and number of rows used in the rice transplanter. Float also helps for proper movement of the rice transplanter in the muddy field. Front parts of channels were made upward nearly 45°with the horizontal so that the mud should not get inside during operation (Fig. 5).

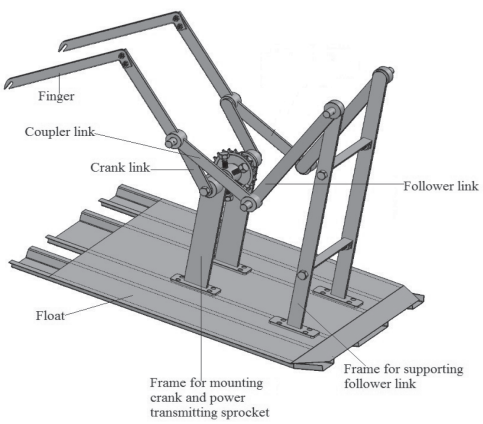

Fig. 5. Pictorial view of transplanting mechanism with the float

Rectangular shaped seedling tray was constructed with 18 gauge thick aluminum sheet**.** Seedling tray consists of two compartments**.** Each compartment had a width of 230 mm and a length of 520 mm. Both the seedling compartments were separated with a rib having a height of 30 mm and 1.5 mm thickness. Seedling tray was set at an inclination of 45° with the horizontal. The seedling tray was attached with a spring loaded lever to prevent the seedlings falling out accidently during loading as well as operation.

The machine is pull-type and it transplants root washed-type seedlings in two rows in a single pass. Two handles were used in the manual rice transplanter. One handle was used to crank the four bar linkage mechanism, whereas, the other handle was used to pull the transplanter during operation. Power developed at the handle of the transplanter was transmitted to the finger of the transplanting mechanism with the help of chain and sprockets. Two sprockets were used for transmitting the developed power. The power output of the handle drives the crankshaft through sprocket at 1: 2 ratio. Thus, one rotation of the handle shaft would produce twice rotation of the crank shaft. When the operator cranks the handle, the fingers moves through the seedling tray slot and takes a small cluster of seedlings. The fingers continue down into the puddled soil to a depth of 20 mm- 70 mm. After transplanting the seedlings in the

puddled soil, the finger return to its path. After transplanting the seedlings, the machine was pulled backward to a desired distance for next planting.

Detailed specifications of the developed manual rice transplanter is as shown in Table 2. Main frame consists of the frames to support the transplanting unit, seedling tray and power transmission system. Pictorial view of the manual rice transplanter is given in Fig. 6. A photograph of the developed manual rice transplanter is given in Fig. 7.

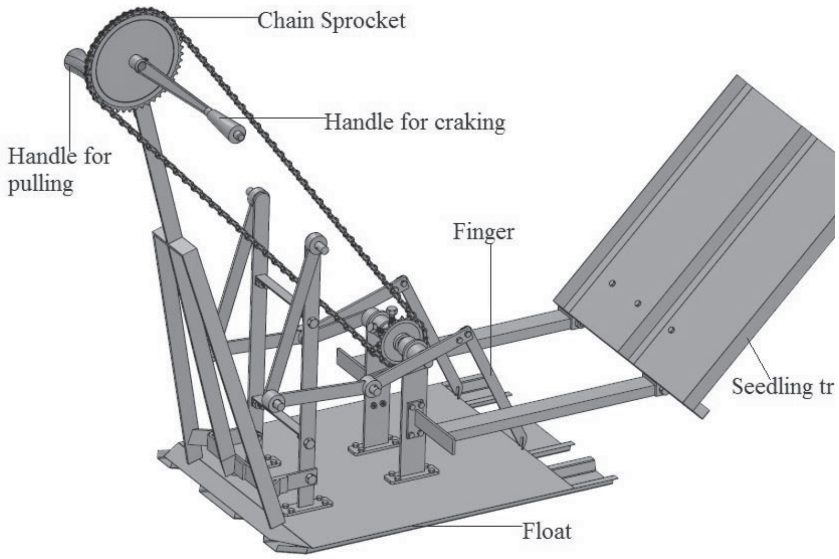

Fig. 6. Pictorial view of the manual rice transplanter

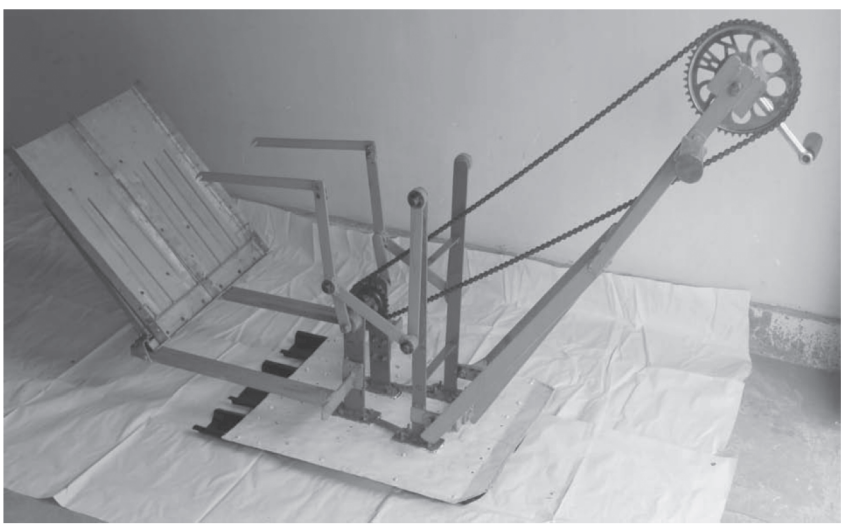

Fig. 7. Developed manually operated 2-row rice transplanter

Table 2. Specifications of the manually operated 2-row rice transplanter

	Parameters		Specifications
A.	Transplanting assembly		
	(i) Length of crank	:	100 mm
	(ii) Length of coupler	:	198 mm
	(iii) Length of follower	:	300 mm
	(iv) Length of fixed link	:	340 mm
	(v) Angle of fixed link with the horizontal	:	300°
	(vi) Angle of coupler extension with the coupler	:	170°
	(vii) Distance from crank center to tip of Finger	:	400 mm
	(viii) Maximum planting depth	:	60 mm
	(ix) Number of rows	:	2
B.	Seedling tray assembly		
	(i) Length of seedling tray	:	520 mm
	(ii) Width of seedling tray	:	465 mm
	(iii) Height of tray from ground level	:	600 mm
	(iv) Angle of seedling tray from horizontal	:	45°
	(v) Size of feed slot	:	20 × 20 mm
	(vi) Row to row spacing	:	240 mm
C.	Float		
	(i) Length of float	:	690 mm
	(ii) Width of float	:	480 mm
	(iii) Thickness of m.s. channels	:	18 gauge
	(iv) Thickness of m.s. sheet on the float	:	32 gauge
D.	Chain sprocket assembly		
	(i) Diameter of driver sprocket, D_1	:	200 mm
	(ii) Diameter of driven sprocket, D_2	:	100 mm
	(iii) Number of teeth on driver, T_1	:	48 mm
	(iv) Number of teeth on driven, T_2	:	22 mm
E.	Overall dimension of the machine (L×W×H)	:	1620×570×900 mm
F.	Total Weight	:	24 kg
G.	Approx. manufacturing cost of the machine	:	Rs 5000

Initial Performance Evaluation of the Developed Rice Transplanter

The developed two-row manually operated rice transplanter was tested in a plot (size 5 m × 5 m) at Rice Research Farm of Birsa Agricultural University, Ranchi (Jharkhand) during *kharif* season, 2016 (Nirala, 2016). Experiment was conducted with different age of seedlings *(i.e.* 20 days, 25 and 30 days old). The seedlings were uprooted from the nursery one by one, washed and bundled. The old aged seedlings were more taller and then were cut in required size, separated and placed over the seedling tray of the transplanter. Care was taken to maintain 10-30 mm of standing water in the field. Excess water, if any, was drained. While operating in the field, the machine was pulled through the field by the operator. As the operating handle was rotating, seedlings from the tray were picked by finger and transplanted in the puddledand levelled field. The operator then pulled back the pulling handle to retract the fingers and moved the machine for continuous transplanting. The cycle was repeated to transplant another two hills and continued till the completion of transplanting the seedlings in the entire field. The transplanter was then operated in the field to evaluate its performance in terms of field capacity, field efficiency, number of seedlings per hill, number of hills m^{-2}, missing hills, buried hills, floating hills, planting depth, cost of transplanting, etc following the standard procedure (Fig. 8).

From the measured observations during the field evaluation, the cost of operation of the developed two-row manual rice transplanter for root washed seedling was worked out as per standard procedure guided by Bureau of Indian Standards (BIS: 9164-1979). The cost, time and labour required for the developed manual rice Transplanter were computed. The operational cost of developed rice transplanter included fixed cost and variable cost.

RESULTS AND DISCUSSION

Determination of path of motion of finger in developed manual rice transplanter

The developed rice transplanter has fixed fork type planting fingers attached on coupler link extension of a planar four-bar linkage

Fig. 8. Developed 2-row manually operated rice transplanter during operation

mechanism. For determining the path of motion of finger, the fingertip was traced on a paper in the laboratory. A sharpened pencil was mounted with a clamp on the finger of the transplanting mechanism so that pencil tip and fingertip were on the same level. Path of motion of the finger was traced manually by rotating the crank slowly. Path of the transplanting mechanism traced as above is shown in Fig. 9. It can be observed that path of finger shown in Fig. 9 compares with that obtained by analytical calculations shown in Fig.2 and Fig.3. The path shows similar trend as described by Kumar (2013) and Thomas and Kumar (2017)

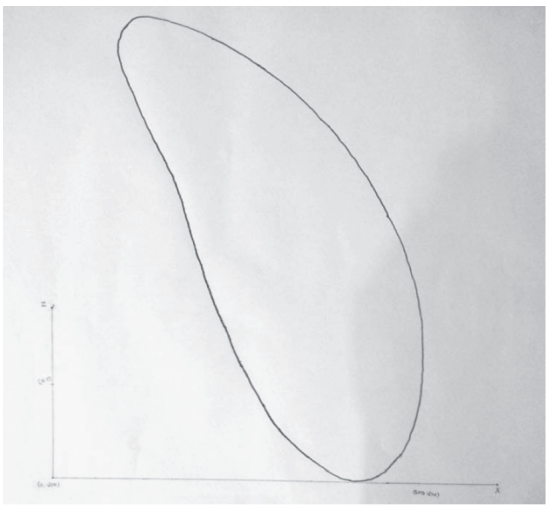

Fig. 9. Path traced by the tip of transplanting finger of the developed rice transplanter

Physical dimensions of the rice seedlings for transplanting

The height of shoot and number of leaves per plant at 20 days, 25 days and 30 days age were measured (Table 3). The data indicates that the maximum and minimum height of shoot at 20 days after sowing were 170 mm and 155 mm, respectively. Table 3 also shows that maximum and minimum height of shoot at 25 days after sowing were 208 mm and 178 mm, respectively, whereas, at 30 days after sowing corresponding values were 230 mm and 210 mm respectively. The average height of the seedlings were 162.2 mm, 190.35 mm and 220.55 mm at 20 days, 25 and 30 days after sowing, respectively. Similarly, number of leaves vary from 2 to 4, 3 to 4 and from 3 to 5 at 20 days, 25 days and 30 days after sowing, respectively. The average number of leaves were 2.9, 3.55 and 3.95 at 20 days, 25 days and 30 days after sowing, respectively.Height of shoot and number of leaves indicate the growth of plants and as the growth is more the amount of roots developed will also be more.

Performance Evaluation of the Developed Rice Transplanter

The developed manually operated 2-row rice transplanter was tested in the puddle field of size 5 m × 5 m. The plot was sub divided into three parts so that the transplanter can be operated in 4 passes, 4 passes and 2 pass for 20 days, 25 days and 30 days old seedlings, respectively. The transplanter transplanted 200 hills, 200 hills and 100 hills of 20 days, 25 days and 30 days old seedlings, respectively. Thus, all together 500 seedlings were planted with the developed manual rice transplanter. The transplanter transplanted 2 seedlings in one revolution of the crank sprocket.

Performance evaluation of the developed manually operated rice transplanter with different age of seedlings indicated that the average hill-to-hill spacing were found to be 199.28 mm, 200.644 mm and 200.75 mm for 20 days, 25 days and 30 days old seedlings, respectively

Table 3. Height of shoot and number of leaves per plant of root washed type rice seedlings at 20 days, 25 days and 30 days from the date of sowing (Variety : BVS-1)

S. No.	20 days after sowing		25 days after sowing		30 days after sowing	
	Height of shoot, mm	No. of leaves	Height of shoot, mm	No. of leaves	Height of shoot, mm	No. of leaves
1	161	3	195	4	220	4
2	160	3	190	3	215	3
3	166	2	183	3	223	5
4	168	3	191	3	230	4
5	167	3	190	4	225	3
6	164	3	192	3	230	4
7	167	4	178	3	230	5
8	155	3	189	3	220	3
9	160	2	200	4	215	4
10	159	4	179	3	218	3
11	162	3	186	5	225	4
12	158	2	192	4	210	5
13	164	4	183	3	215	4
14	161	3	192	3	210	4
15	155	3	186	4	212	3
16	169	2	194	5	220	4
17	157	4	190	4	225	3
18	170	2	205	3	218	5
19	164	2	184	4	226	4
20	157	3	208	3	224	5
Average	162.2	2.9	190.35	3.55	220.55	3.95

(Table 4). A crank speed of 25 revolutions per minute with an average forward operating speed of 0.36 km h^{-1} has been maintained by the operator. Thus, the overall average hill-to-hill spacing was 200.22 mm (varied from 170 mm to 210 mm). However, sometimes the variation noticed in hill to hill spacing might be due to improper pulling stroke of the operator.

The number of seedlings per hill were found to be 3.91, 3.978 and 4.295 for 20 days, 25 days and 30 days old seedlings, respectively. The average number of seedlings per hill was 4.06 (sometimes varied from 2 - 9) which is in the acceptable range but higher than the recommended (2 - 3 seedlings per hill). It depends on the cross sectional area of the stem of the seedlings and the opening of the transplanting finger slot.

The average depth of planting were found to be 62.11 mm, 61.274 mm and 61.589 mm for 20 days, 25 days and 30 days old seedlings, respectively. The average depth of planting was 61.66 mm (varied from 40 mm to 67 mm) which is in the acceptable range. Variations in depth has been occurred only onsmall depressions/ ditches made by the foot of the operator in the field.

The missing hills were found to be 9%, 10% and 12% for 20 days, 25 days and 30 days old seedlings, respectively. Similarly, the floating hills were found to be 6%, 6% and 6.5% for 20 days, 25 days and 30 days old seedlings, respectively. The visible damage were also found to be 4%, 2.5% and 2% for 20 days, 25 days and 30 days old seedlings, respectively.

Table 4. Performance evaluation of the developed manually operated rice transplanter with different age of seedlings

S.No.	Parameters	Age of rice seedlings			Overall Average
		20 days	25 days	30 days	
i.	Average hill-to-hill spacing, mm	199.28 (170 to 210)	200.64 (190 to 210)	200.75 (190 to 210)	200.22
ii.	Average number of seedlings per hill	3.91 (2 to 8)	3.98 (2 to 9)	4.30 (2 to 9)	4.06
iii.	Average depth of planting, mm	62.11 (52 to 69)	61.27 (54 to 68)	61.59 (40 to 67)	61.66
iv.	Average height of seedlings, mm	162.20	190.35	220.55	191.03
v.	Average missing hills, %	9	10	12	10.33
vi.	Average floating hill, %	6	6	6.5	6.17
vii.	Visible damage, %	4	2.50	2	2.83

(Note: Figures in Parenthesis shows the range)

Effective field capacity of the transplanter was found as 0.012 ha h^{-1} with field efficiency of about 70.50 per cent at an operating speed of 0.36 kmh^{-1}. The transplanter successfully transplanted 2 rows of seedlings at 240 mm row-to-row spacing.

Average hill-to-hill spacing was 200.22 mm with 4-5 seedlings per hill at average depth of about 61.66 mm. Further more, there were up to nine seedlings per hill (Table 5). Average missing hills, floating hills and visible damage were 10.33%, 6.17% and 2.83% due to various factors. Variation in number of seedlings per hill might be due to the entanglement of roots and uneven seedling growth, whereas, missing hills might be due to the entanglement of roots and buckling of seedlings. Floating hills were noticed at places where the height of standing water was more due to uneven field. This might be attributed to the inability of soil to retain the seedlings. It was found that 3.0 per cent of hills were damaged during operation but after a week hey recovered and resembled healthy hills.

Table 5. Comparative performance of the developed manually operated rice transplanter with traditional method

S.No.	Parameters	Performance Results	
		Developed Manually Operated Rice Transplanter	Manual transplanting (Traditional method)
i.	Variety of rice	BVS-1	BVS-1
ii.	Number of rows	2	-
iii.	Row to row spacing, mm	240	120
iv.	Average operating speed, km h^{-1}	0.36	-
v.	Field efficiency, %	70.5	-
vi.	Effective field capacity, ha h^{-1}	0.012	0.00385
vii.	Angle of inclination of transplanted seedlings, degree	71.5	85
viii.	Average hill-to-hill spacing, mm	200.22	105
ix.	Average number of seedlings per hill	4.06	2 - 3
x.	Average depth of planting, mm	61.66	50
xi.	Average missing hills, %	10.33	1
xii.	Average Floating hill, %	6.17	0.5
xiii.	Visible damage, %	2.83	0.5

The hills fixed by transplanter stood at an angle of 60 to 80 degree that became straight after 4-5 days of transplanting. A few times, clogging of transplanter fingers with seedlings was also observed due to buckling of seedlings at the base of the seedling tray. It has been also observed that hill-to-hill spacing was wider at some places and narrower at others resulting in deviation from the desired spacing. It might be due the fact that there were variations in length of pull by the operator. These results are in agreement with the findings of Kumar and Thomas (2019).

Economics of Transplanting by the Rice Transplanter

Cost of transplanting was Rs.7089 ha^{-1} by the machine which was much less as compared to Rs.12540 ha^{-1} by manual transplanting (Table 6). Nursery raising for hand transplanting as well as the machine were same. Considering the cost of mechanized transplanting using root washed seedlings was Rs.6500 ha^{-1}, whereas, for hand transplanting (conventional) it was Rs.11400 ha^{-1}, thus, a saving of about Rs.4900 ha^{-1}.

Table 6. Cost of nursery raising and transplanting

Method of transplanting	Manually operated 2-row rice transplanter			Manual transplanting (Traditional method)		
	Nursery raising	Transplanting	Total	Nursery raising	Transplanting	Total
Labour requirement, (man-hha^{-1})	32	167	199	32	320	352
Cost of operation, (Rs. ha^{-1})	1140	6500	7640	1140	11400	12540

Note: Labour charge @ Rs. 285/- per day for 8 hours

CONCLUSION

The manually operated two row rice transplanter was developed using a modified four bar linkage transplanting mechanism and working satisfactorily. Path traced by the tip of transplanting finger of the developed rice transplanter was in elliptical shape. The developed rice transplanter transplant root washed type seedlings on 2 rows at 240 mm row-to-row spacing. Effective field capacity of the manually operated rice transplanter was 0.012 ha h^{-1} at an operating speed of 0.36 km h^{-1}. Average missing hills, floating hills and visible damage of the seedlings by the transplanterwere 10.33%, 6.17% and 2.83%, respectively. Cost of transplanting by the developed rice transplanter was Rs. 6500 ha^{-1}, whereas, by manual transplanting (traditional method) cost was Rs.11,400 ha^{-1}, thus, there is a saving of Rs.4900 ha^{-1}.

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FORTIFICATION OF CAKE WITH CHICKPEA FLOUR AS A PROTEIN ENHANCER

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ABSTRACT

The study was conducted (2018-19) to develop high protein low calorie cake with chickpea flour along with whole wheat flour and other ingredients in different proportions as a protein supplement to combat malnutrition. Four cakes were prepared including control (whole wheat flour only).Nutritional quality and the sensory evaluation of cake was done in accordance with Nutritive value of Indian foods ICMR, numerical scoring test and nine point hedonic scale for six sensory characteristics respectively. Cake C3 prepared with ratio of 4:1 chickpea flour and wheat flour was found to be best one with respect to its nutritive value and sensory characteristics.Significantly high difference at $P<0.05$ between the cakes in respect of colour, appearance, taste, overall acceptance & texture was observed. Cost of the developed cakes was found to be two to three folds cheaper in comparison to cakes available in the market. Thus, Cake 3 fortified with chickpea flour with less sugar and less oil containing 12% protein can be recommended as a high protein supplement food to reduce malnutrition among children and starvation among adults.

KEYWORDS: Cake, Fortification, Chickpea flour, Low calorie, High protein, Protein enhancer

INTRODUCTION

Dual burden of malnutrition is a major public health problem all over the world and the major underlying causes are inadequate nutritional intake both in quality and quantity. Malnutrition is staggering the developing countries of the world today. In spite of the fact that Governments have initiated different programmes to end the tragedy of malnutrition, the battle against hunger is far from over. From Africa to Asia to Latin America and the near east, there are 821 million people - more than 1 in 9 of the world population who do not get enough to eat. India has 194.4 million undernourished people (14.37 % of world's population). Odisha ranked eleventh in the underweight category as per NFHS-4 data in India. Within Odisha socio-economic conditions as well as health conditions vary among the districts which in turn affect child nutritional status across the state. Out of the 30 districts in Odisha, 18 districts fall among the category of underweight (children below 5 years) which is below the state average (34.4 percent as NFHS-4). However, under-weight rate ranges between 16.5% in Jagatsinghpur and 51.8% in Malkanagiri a large gap (Bera *et al.,* 2019). Eventhough many varieties of foods are available in back yards of each and every individual household, lack of knowledge for its proper utilization is a major concern for prevalence of under nutrition especially in rural & tribal areas. In the above

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situation development of foods rich in protein and other mineral contents at household level is a better alternative. Legumes have been considered as rich source of protein throughout the world and contain approximately three times more quality proteins than cereals. Dried legume seeds generally promote slow and moderate postprandial blood glucose increase (Isabel and Garmen, 2003, Rincon *et al*., 1998). Regular consumption of pulses may have important protective effects on risk for cardiovascular disease. They are also rich in lysine which is an important essential amino acid which is limited in cereals grains whereas cereal grains are rich in methionine which is limited in legume proteins. Thus, combination of cereals and legumes in preparation of any food product along with milk and other ingredients will not only enhance the quality of food but also form a complete food from nutritional point of view. Chickpea (*Cicer arietinum* L.) is one of the top five important legumes on the basis of whole grain production (Ravi and Suvendu, 2004). It contains 20.8g protein, 5.6g fat and 2.7g minerals, 1.2g crude fibre and 59.8g carbohydrate, wherein the energy, calcium and iron being 372 Kcal, 56 mg and 5.3mg per 100g respectively (Iqbal *et al*., 2006). In this study, an attempt has been made to develop a cake with fortification of chickpea flour with whole wheat flour to make it highly rich in protein, calcium, iron, fibre etc. which can be used as a protein supplement to reduce malnutrition among children and starvation among elderly. It is hard to claim that a cake can do wonder but is an incredible food product in terms of its nutritional value and affordability.

Hence, this study was taken up to develop cost effective low calorie high protein cakes with chickpea flour with whole wheat flour in different proportions.

MATERIAL AND METHODS

The experimental work was carried out in the Food and Nutrition laboratory of P.G. Department of Home Science, Sambalpur University during the year 2018-19. For development of low calorie high protein cake, whole wheat flour (WWF), chickpea flour (CF), sugar, oil, baking powder, baking soda, milk and essence were chosen as base material, procured from the local market of Sambalpur, Burla.

Methods of preparation

Table 1. Major Ingredients of different cakes

Variation	WWF (g)	CF(g)	Sugar(g)	Oil (ml)	Milk(ml)	Total	Proportions
Cake- 0	100	00	50	55	50	255	1:0:0.5:0.55:0.5
Cake -1	50	50	25	30	100	255	0.5:0.5:0.25:0.3:1
Cake -2	40	60	25	30	100	255	0.4:0.6:0.25:0.3:1
Cake -3	20	80	25	30	100	255	0.2:0.8:0.25:0.3:1

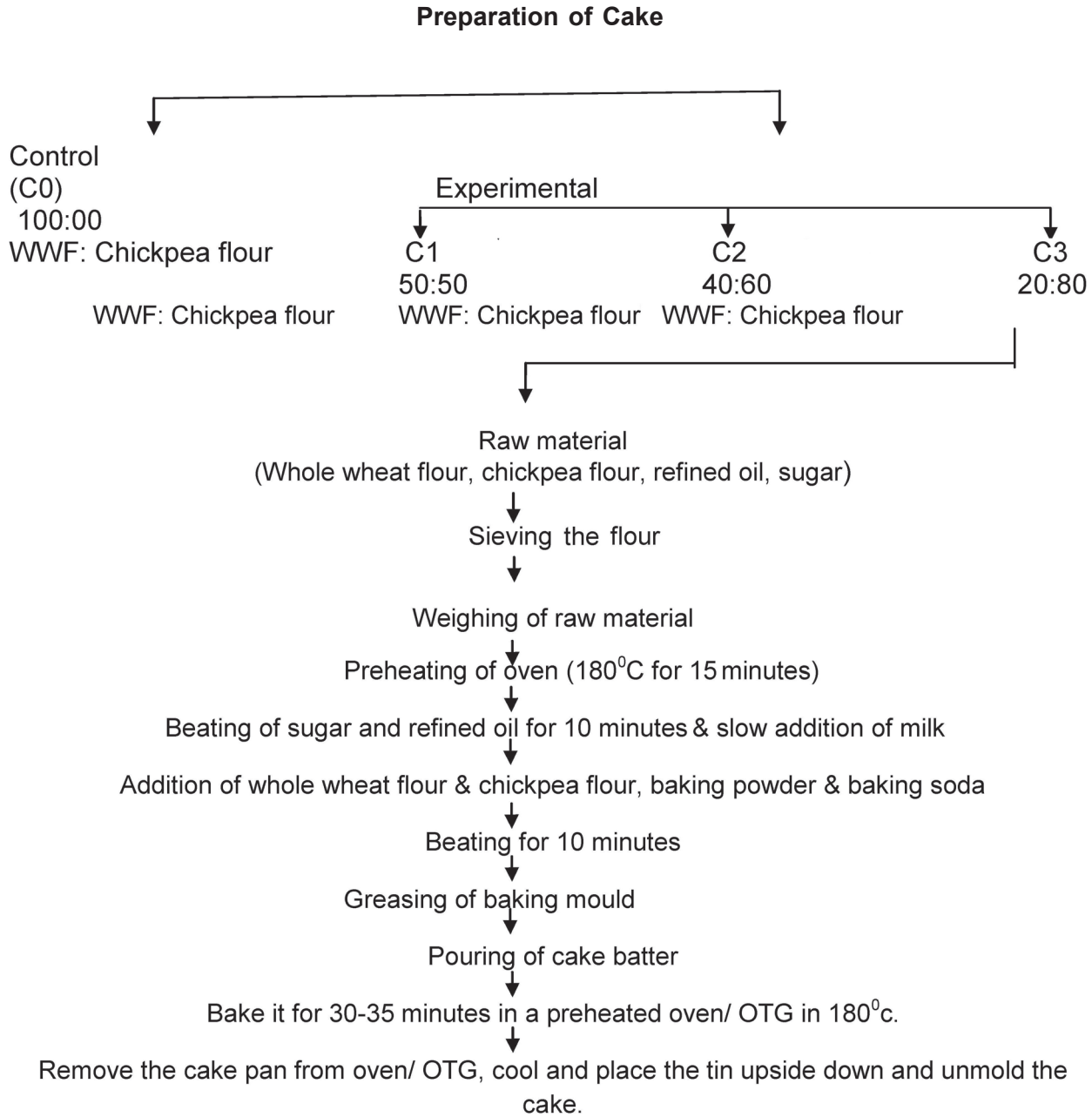

Fig. 1. Flow chart of cake preparation

Chemical composition of food products

Knowledge about nutritive value of developed cakes gives idea about the amount of nutrients present in each cake so that quality of cake can be assessed and the food can be used for different purposes. Therefore protein, fat, carbohydrate, energy, calcium, iron, fibre content of the developed cakes was calculated by using corresponding values of the food stuffs from Indian Food Composition Tables, ICMR (Longvah *et al.,* 2017).

Sensory Evaluation : Sensory characteristics were assessed under controlled condition in the laboratory. Ten panel members were selected for sensitivity taste, threshold tests for sweet, salty, sour and bitter tastes. Written consent for participation was obtained from the panel members. The samples were developed three times and evaluated three times on a nine - point hedonic scale for the organoleptic evaluation of the members and numerical scoring test for the six sensory characteristics namely colour, flavour, texture, taste, appearance and overall acceptability (Sri Lakshmi, 2015).

Digestibility of the cake was evaluated by feeding 20 g of the best cake per day to the panel members for a week and cost of the cakes were calculated and compared with market available cake.

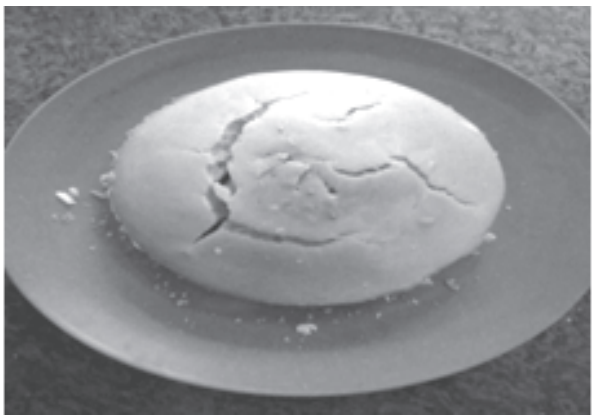

Fig. 2. Cake with CF (4) :WWF (1)

RESULTS AND DISCUSSION

Nutritional quality of cakes

Table 2. Nutritional composition of different cakes per 100g

Different Sample	Protein (g)	Fat (g)	CHO (g)	Energy (k cal)	Calcium (mg)	Iron (mg)	Fibre (g)
Cake- 0	5.45	22.92	47.86	418.78	51.37	1.95	4.90
Cake -1	9.65	14.45	37.04	323.06	89.57	2.43	5.45
Cake -2	10.35	14.58	36.58	326.94	91.29	2.51	5.56
Cake -3	11.77	14.83	35.68	334.16	94.80	2.67	5.78
Market cake	3-7	15.2-20	54-59	387-424	-	-	-

Highest protein content (11.77 g/100 g) was recorded in cake-3 compared to other developed cakes *i.e.* 5.45g, 9.65g and 10.3g per 100g in cakes C0, C1, C2 respectively (Table 2). It was interesting to note that the protein content of cake 3 prepared with incorporation 80% chickpea flour had more than twice the protein content of C0 (control cake) prepared with only wheat flour. Bread developed by Arab *et al.* (2010) with incorporation of chickpea flour has protein content 16.61g/100 g which was more than the protein content of the developed cake of the researcher, whereas, cookies developed by Thongram *et al. (*2016) and cakes available in market has protein content 9.48g/ 100g and 3-7g/100g respectively which was less than the protein content of the prepared cakes. Similarly, the fat, carbohydrate and energy content of C0 *i.e*. control cake was found to be more in comparison *i.e.* 22.92g, 47.86g

and 418.78 Kcal per 100g, respectively. The calcium, iron and crude fibre content of C3 cake was found to be 94.80mg, 2.67mg, and 5.78g per 100 g respectively which was 30-40 % more in comparison to other developed cake variations. Studies conducted by other researchers *i.e.* by Arab *et al*. (2010) and Hefnawy *et al*. (2012) shows low fat content and higher carbohydrate content in their developed cake. Thongram *et al.* (2016) found 20.25g fat, 65-67g carbohydrate in their developed bread which was at par with the values of control cake (C0) but more than the values of the experimental ones. Similarly, the nutritive value of market cake was found to be less for protein, at par for fat and energy and more for carbohydrate content in comparison to developed cakes. As the protein, calcium, iron and crude fibre content of cake C3 was more when compared to other developed cakes, the fat and energy content of cake C3 was less than control cake but more than C1 and C2. Carbohydrate content of cake C3 was less than other variations, thus, it can be concluded that C3 is best for children as well as adults.

Sensory evaluation of cakes by numerical scoring test

The mean score for colour of developed cakes varies from 5.8±0.45 to 7.2±0.45 and the cake C3 had the highest score for colour *i.e.* 7.2±0.45 (Table 3). Studies carried out by other researchers in development of bakery products with chickpea flour also shows that the score for colour varies from 7.01±1.51 to 8.3. Colour for product development by Dandachy *et al.* (2019) has mean score 7.01 ±1.51 which is at par with the score of the developed product in the study. Similarly, the mean score for flavour, texture, taste, and appearance and over all acceptance of developed cakes varies from 5.8±0.84 to 6.4±0.45, 5.4±1.1, 7.6±0.89, 5.4±0.55 to 7.6±0.89, 5.4±0.8 to 7.2±0.45 and 5.9±0.03 to 7.1±0.41, respectively. Cake C0 had the highest score for flavour *i.e.* 6.4±0.55, whereas, C3 got the highest score for texture, taste, appearance and overall acceptance *i.e.* 7.6±0.89, 7.6±0.89, 7.2±0.45 and 7.1±0.41 respectively. While compared with the results of other researchers it was observed that scores obtained by Arab *et al.* (2010), Hefnawy *et al*. (2012) and Man *et al*.(2015) were at par with the mean scores of the study for texture, taste, appearance, overall acceptability, respectively. However, mean highest score for flavour of this study was less when compared to studies of other researchers. Since the mean value of sensory attributes of the developed cakes was at par or within the range of the bread developed by Man *et al*.(2015) and Pastry developed by Dandachy *et al.* (2019) it can be concluded that the developed cakes were acceptable for all of its sensory attributes similar to other bakery products such as bread, cookies and pastry. The highest score for colour, flavour, texture, taste, appearance and overall acceptability were 7.2, 6.2, 7.6, 7.6, 7.2 and 7.1, respectively for cake C3. Statistically the sample C3 was also significantly different from sample C0, C1 and C2 for their colour, texture, taste, appearance and overall acceptability at $P<0.05$. The mean score for overall acceptability obtained from different parameters like colour, flavour, texture, taste and appearance of cake C3 was found to be 7.1±0.41 which was more than acceptability

Table 3. Mean sensory evaluation of the cakes by numerical scoring test

Sensory attributes	WWF:CF Cake-0	WWF: CF Cake-1	WWF: CF Cake-2	WWF: CF Cake-3	P-value	Arab *et al.* (2010)	Hefnawy, *et al.* (2012)	Man *et al.* (2015)	Dandachy *et al.* (2019)
	100:00	50:50	40:60	20:80					
Colour	5.8±0.84	5.8±0.84	5.8±0.45	7.2±0.45	0.008	7.86±0.1	8.3	8.27	7.01 ±1.51
Flavour	6.4±0.55	5.8±0.84	6.0±0.71	6.2±0.84	0.620	-	7.5	7.67	-
Texture	7.4±1.1	5.4±1.1	6.2±0.45	7.6±0.89	0.006	7.38±1.13	8.2	8.0	6.95 ±1.35
Taste	6.6±0.89	5.4±0.55	6.2±0.45	7.6±0.89	0.001	7.24±1.16	7.6	7.7	6.86 ±1.37
Appearance	7±0.71	6.2±0.45	5.4±0.89	7.2±0.45	0.001	7.46±1.09	7.5	-	-
Over-all Acceptance	6.7±0.74	5.9±0.32	6.0±0.77	7.1±0.41	0.019	-	7.1	7.97	6.95 ±1.24

level of other developed cakes. It was clear that the colour, texture, taste, appearance and overall acceptability of the cake C3 was significantly better than other prepared cake samples and most suitable as a protein supplement (Table 3).

Sensory evaluation of cakes by hedonic scale

Mean sensory scores with regard to colour, flavour, taste, appearance and overall acceptability of cake is shown in Table 4. It was observed that cake C3 was liked extremely by 75% judges, whereas, other cakes were liked extremely *i.e.* 50% for C2, 45% for C1 and 43% for C0 by the judges. Thus, it can be concluded that cake C3 was best from low calorie as well as sensory evaluation point of view.

Table 4. Mean sensory characteristics of cakes using Hedonic Scale

Nine Point Hedonic Scale	**Cakes (%)**			
	Cake-0 (100:00)	**Cake-1** (50:50)	**Cake-2** (40:60)	**Cake-3** (20:80)
Liked extremely	43	45	50	75
Liked very much	15	10	15	14
Liked moderately	11	13	11	09
Liked slightly	15	13	15	02
Neither like nor dislike	16	19	09	-
Disliked slightly	-	-	-	-
Disliked moderately	-	-	-	-
Disliked very much	-	-	-	-
Disliked extremely	-	-	-	-

Digestibility of cakes

Digestibility is one of the most important criteria for evaluation of any food product. As cake C3 was found to be best among other developed cakes it was fed to panel member for one week *i.e.* 20g per day. No significant health complications such as diarrhoea, skin allergy, indigestion, etc. were found among the members. Hence, it can be concluded that there is no problem in digestibility of developed cakes with chickpea flour.

Cost of Cakes

Table 5. Cost incurred in the preparation of cakes

S.No.	Cake variant	Cost (in rupees)/100g
1.	Cake 0	8.75
2.	Cake -1	12.83
3.	Cake -2	13.65
4.	Cake -3	15.97
5.	Market Cake	30

It was observed that cost of different developed cakes was found to be very less as compared to cost of market cakes (Table 5).Cost of the developed cakes was found to be Rs. 8.75/100g, Rs.12.83/100g, Rs. 13.65, Rs. 15.97/100g for C0, C1, C2, and C3, respectively. Whereas, cost of market cake was found to be Rs. 30/- per 100g. Thus, it was found that cost of developed cakes were 2 to 3 folds lower in comparision to market available cakes.

CONCLUSION

Among the different cakes developed, Cake 3 was found most suitable for children from nutritional point of view as well as overall acceptability which was prepared with chickpea flour and wheat flour in 4:1 ratio and contain 12 g protein per 100 g. In view of high protein, calcium, iron and crude fibre content,low fat, carbohydrate and energy content and low cost, the cake C3 is best for children as well as for people of other age groups suffering from starvation. Sensory taste and digestibility of the cake C3 was also best. Thus, cake fortified with 80% chickpea flour with less sugar and less oil containing less calories, less fat content can be recommended as a protein enhancer to reduce malnutrition among children and starvation among adults.

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ANTIMICROBIAL ACTIVITY AND PHYTOCHEMICAL SCREENING OF THE PEEL EXTRACTS OF *Luffa acutangula*

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ABSTRACT

The study was conducted to evaluate the antimicrobial and phytochemical activities of the peel extracts of *Luffa acutangula*. The antimicrobial activity of aqueous, petroleum ether, acetone and chloroform peel extracts was tested against the selected bacterial and fungal isolates using agar well diffusion method. The results proved that the acetone extract exhibited maximum antimicrobial activity against the tested bacterial and fungal isolates when compared to chloramphenicol and flucanazole (standard antibiotics) respectively. Preliminary phytochemical screening was carried out in the acetone extract of *L. acutangula* which revealed the presence of secondary metabolites such as saponins, phenols, terpenoids, tannins, flavonoids, sterols, anthocyanin, carbohydrates and amino acids. The FT-IR analysis revealed the presence of hydroxyl, amines and carboxylic acids as functional groups in *L. acutangula.*

Keywords: *Luffa acutangula,* Phytochemicals, Antimicrobial activity, FT–IR spectroscopy

INTRODUCTION

Although, there has been significant development in the field of synthetic drug chemistry and antibiotics, the awareness of wide spread toxicity and harmful after effects associated with their long use, in the societies prefer drugs from natural sources than synthetic ones. Plants constitute one of the major sources of raw materials for the manufacture of drugs and for treating various ailments of human beings without any adverse effects (Andrade *et al.,* 2019). A large variety of plant based drugs mentioned from the Indian system of medicines are found to possess antibacterial and antifungal properties (Semwal and Painuli, 2019).Vegetables collected from plants have shown to be the potential source for new medicines with phytochemical properties. Hence, vegetables with possible antimicrobial activity should be tested against an appropriate model in recent years (Begum and Poonkothai, 2013).

Now-a-days, phytochemicals in plants have received a great attention to prevent human diseases caused due to oxidative stress which releases the reactive oxygen species involved in a number of disorders like cardiovascular breakdown, tissue injury and DNA damage. They are great source of carotene, ascorbic acid, riboflavin, folic acids and minerals like calcium, iron and phosphorus (Fasuyi, 2006). In many developed countries,

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traditional herbal remedies are making a comeback as alternatives to modern medicine. The existence of traditional medicine depends on plant diversity and the related knowledge of their use as herbal medicine. This has necessitated searching for the new antimicrobial compounds from vegetable species with diverse chemical structures and novel mechanisms of action to combat multiresistant microorganisms (Dutt *et al.,* 2019).

Luffa acutangula L., commonly known as ridge gourd belongs to the family Cucurbitaceae, is a tropical climbing herb cultivated throughout India. It is traditionally used for many cures in various systems of medicine such as Ayurveda, Siddha, etc. It has nutrition values, low in saturated fat, high in dietary fiber and has blood-purifying properties. It contains insulin regulatory properties and thus facilitates in lowering blood and urine glucose levels. It is best for weight loss as it has fewer calories used for the treatment of ulcers and sores (Anitha and Miruthula, 2014). Presence of high fibre content assist with proper functioning of digestive and excretory system and found to be an energy supplement. Consumption of ridge gourd lowers the body temperature largely, acts as a natural detoxifier by purifying the blood and it also helps in building immune system (Manikandaselvi *et al*., 2016). Dietary intake of fibre rich ridge gourd peel is less and considered as an edible biowaste.Hence, the study is an attempt to investigate the in-vitro antimicrobial activity and phytochemical properties of *Luffa acutangula* peel extracts.

MATERIAL AND METHODS

Collection of the sample

Ridge gourd samples were collected from the local markets of Ooty, Nilgiris district during 2016-17 and washed thoroughly with running tap water to remove the dirt. The ridge gourd peel was shade dried at room temperature, powdered and used for further analysis.

Extract preparation

The ridge gourd peel (10g) was dissolved in the solvents namely, aqueous, petroleum ether, acetone and chloroform separately, homogenized and left overnight in the shaker at room temperature. The supernatant with the peel extract was concentrated by evaporating the solvent at 60º C, weighed and dissolved in a known volume of dimethyl sulphoxide. The extraction yield was expressed as follows,

$$\text{Extraction yield (\%)} = \frac{\text{Weight of the dry extract (g)}}{\text{Weight of the sample used for the extraction (g)}} \text{ X } 100$$

(Abirami *et al.,* 2017)

Microorganisms used

The bacterial and fungal isolates used in the study were *Staphylococcus aureus, Bacillus subtilis*, *Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Proteus vulgaris, Salmonella typhi* and *Aspergillus niger, Aspergillus flavus, Aspergillus fumigatus, Candida albicans* and *Rhizopus* species, respectively.

Antimicrobial activity of peel extracts

The antimicrobial activity of the peel extracts of ridge gourd was determined by agar well diffusion method. The bacterial and fungal

cultures (100 µl) were swabbed on sterile Muller Hinton and rose bengal chloramphenicol agar media separately. Six wells were made on each agar plate and 20 µl of the peel extracts (aqueous, petroleum ether, acetone and chloroform), chloramphenicol (bacteria) and flucanozole (fungi) which served as positive control/reference antibiotics and DMSO (negative control) were added into the well separately and incubated at 37°C for 24 h (bacteria) and at room temperature for 5 days (fungi), respectively. At the end of the incubation period, the diameter of the zone of inhibition was recorded (Bauer *et al.,* 1966).

Phytochemical and FT – IR analyses

The ridge gourd peel extracts were screened for the presence of phytochemicals as per the standard methods proposed by Harborne (1984). A small quantity of the peel extract was mixed with KBr and the sample was scanned to analyse the presence of functional groups using Fourier Transform Infrared Spectrometer (Shimadzu, IR Affinity 1, Japan) in the range of 4000 cm^{-1}- 400 cm^{-1}.

RESULTS AND DISCUSSION

Extraction

Acetone extraction of *Luffa acutangula* peel produced maximum yield of 25%, petroleum ether yielded 18%, whereas, the ethanol and aqueous extract yielded 15% and 10% respectively. The extractive yield was miscellaneous among diverse fruit and vegetable peels with difference in solvents used.

Antimicrobial activity of *Luffa acutangula* peel extracts

Acetone extract of ridge gourd peel had the maximum zone of inhibition against *Bacillus subtilis* (20.33 ± 2.08 mm), followed by *Staphylococcus aureus* (17.6 ± 0.5 mm), moderate activity was observed in chloroform and petroleum ether, whereas, aqueous extract showed a maximum zone of inhibition against all the microbial isolates (Table 1). The antifungal activity showed that acetone extract of the *Luffa acutangula peel* had maximum activity against *Aspergillus niger (*15.6 ± 0.57 mm) followed by *Candida albicans* (14.6 ± 0.57 mm), whereas, minimum inhibitory activity was found in *Aspergillus fumigatus* (10 mm) (Table 1). The zone of inhibition of all the extracts against the tested microbes ranged from 7-20 mm which was analogous with their positive control (14mm - 28mm). All the extracts of ridge gourd peel exhibited inhibitory effect against the tested bacterial and fungal isolates. The inhibitory antimicrobial activity may also be attributed to the presence of some active principles in the peel extract which are able to restrict the growth of bacteria. These active principles may inhibit the protein synthesis of bacterial cell wall or alter the membrane function, inhibit protein synthesis or synthesis of purines and pyrimidines, hinder respiration or antagonize the metabolic pathway of microorganism leading to retardation of growth of bacteria (Sharma *et al*., 2010). The results of the study show that the organic extracts exhibited better antimicrobial activity than the aqueous extract which might be due to the solubility of active principles which are either polar or non polar and effectively extracted through them.

Table 1. Antimicrobial activity of *Luffa acutangula* peel extracts

Microorganisms	Zone of inhibition (mm)					
	PEE	CHE	ACE	AQE	PC	DMSO
Bacterial isolates						
Pseudomonas aeruginosa	10±1	8.33±0.57	11±1	7.76±0.57	28.67±2.08	-
Proteus vulgaris	9.3±1.15	11±1	9.33±1.15	8.66±0.57	18.67±1.15	-
Salmonella typhi	9.66±0.57	10.3±0.57	14.6±0.57	8±0	25±2	-
Staphylococcus aureus	8.67±1.15	10.3±1.5	17.6± 0.57	8.66±0.57	25.34±2.08	-
Escherichia coli	11.66±0.57	8±0	16.6±1.52	8.33±0.57	23±2.64	-
Bacillus subtilis	9.67±0.57	10±1	20.33±2.08	9±1	28.67±1.5	-
Klebsiella pneumonia	10.67±1.15	13.66±1.52	17.5±4.35	10.33±0.57	27.34±2.08	-
Fungal isolates						
Aspergillus niger	15.33±0.57	10±1	15.6±0.57	10.6±1.52	19.3±0.57	-
Aspergillus flavus	9.66±0.57	9±1	14.3±1	9.6±0.57	16.6±1.52	-
Aspergillus fumigates	10.66±1.52	10.6±0.57	10±0	9.6±1.15	17.6±0.57	-
Rhizopus species	10.33±0.57	9.66±1.15	11±1	13±11	17.3±1.52	-
Candida albicans	9.6±1.15	10.66±1.52	14.6±0.57	10±1	14.3±1	-

PEE – Petroleum Ether Extract, CHE – Chloroform Extract, ACE – Acetone Extract, AQE – Aqueous Extract

PC - Positive control (CL – Chloramphenical, Flucanazole - Fungi), DMSO – Dimethyl Sulphoxide

Phytochemical analysis of *Luffa acutangula* peel extract

The phytochemical analysis in the ridge gourd peel extract revealed the presence of saponins, phenols, terpenoids, tannins, flavonoids, sterols, anthocyanin, carbohydrates and amino acids were present in the acetone extracts. Alkaloids, quinones, glycosides, leucoanthocyanins and volatile oils are absent in all tested extracts (Table 2). The presence of hydroxyl group in phenolic compound might influence their antimicrobial effectiveness by binding to the active site of enzymes, form hydrogen bonds with enzymes and alter their metabolism, the lipid solubility and the degree of steric hindrance (Ceylan and Fung, 2004). The presence of terpenoids in the ridge gourd peel extracts may improve the overall appearance of vegetable and contribute to consumer's health and well-being. They are widely ingested by humans and their daily intake has been estimated at around 160mg (Passamonti *et al.*, 2013). The tannins present in the peel extracts of *Luffa acutangula* make it useful in bathing or cleansing the surface of the skin in infectious skin diseases. Tannins in this extract were believed to act by coagulating the cell wall protein. Saponins are surface active agents which interfere with or alter the permeability of cell wall. This therefore facilitates the entry of toxic materials or leakage of vital constituents from the cell. Saponins were reported as major components in acting as antifungal secondary metabolites (Onwuliri, 2005).

Table 2. Phytochemical analysis of *Luffa acutangula* peel extract

S. No.	Phytochemicals	Acetone extract
1	**Alkaloids**	
	Mayer's Reagent	-
	Dragendroff's Reagent	-
	Wagner's Reagent	-
	Hager's test	-
2	**Phenols**	
	Ferric chloride test	+
	Phosphomolybdic acid test	+
3	**Amino Acids**	
	Ninhydrin test	+
	Milon's test	+
	Biuret test	+
	Bradford test	+
4	**Flavonoids**	
	Schinoda's test	+
	Lead Acetate Test	+
	Decolourisation Test	+
5	**Saponins**	
	Froth test	+
6	**Tannins**	
	Breamer's test	+
	Hydrolysable tannin	+
7	**Quinones**	
	Borntrager's test	-
8	**Sterols**	
	Libermann – Buchard test	+
	Salkowski test	+
9	**Glycosides**	
	Legal's Test	-
10	**Leucoanthocyanins**	-
11	**Anthocyanin**	+
12	**Volatile oil**	-
13	**Terpenoids**	+
14	**Carbohydrates**	
	Fehling's test	+
	Starch test	+

Note : (+) indicates presence and (-) indicates the absence

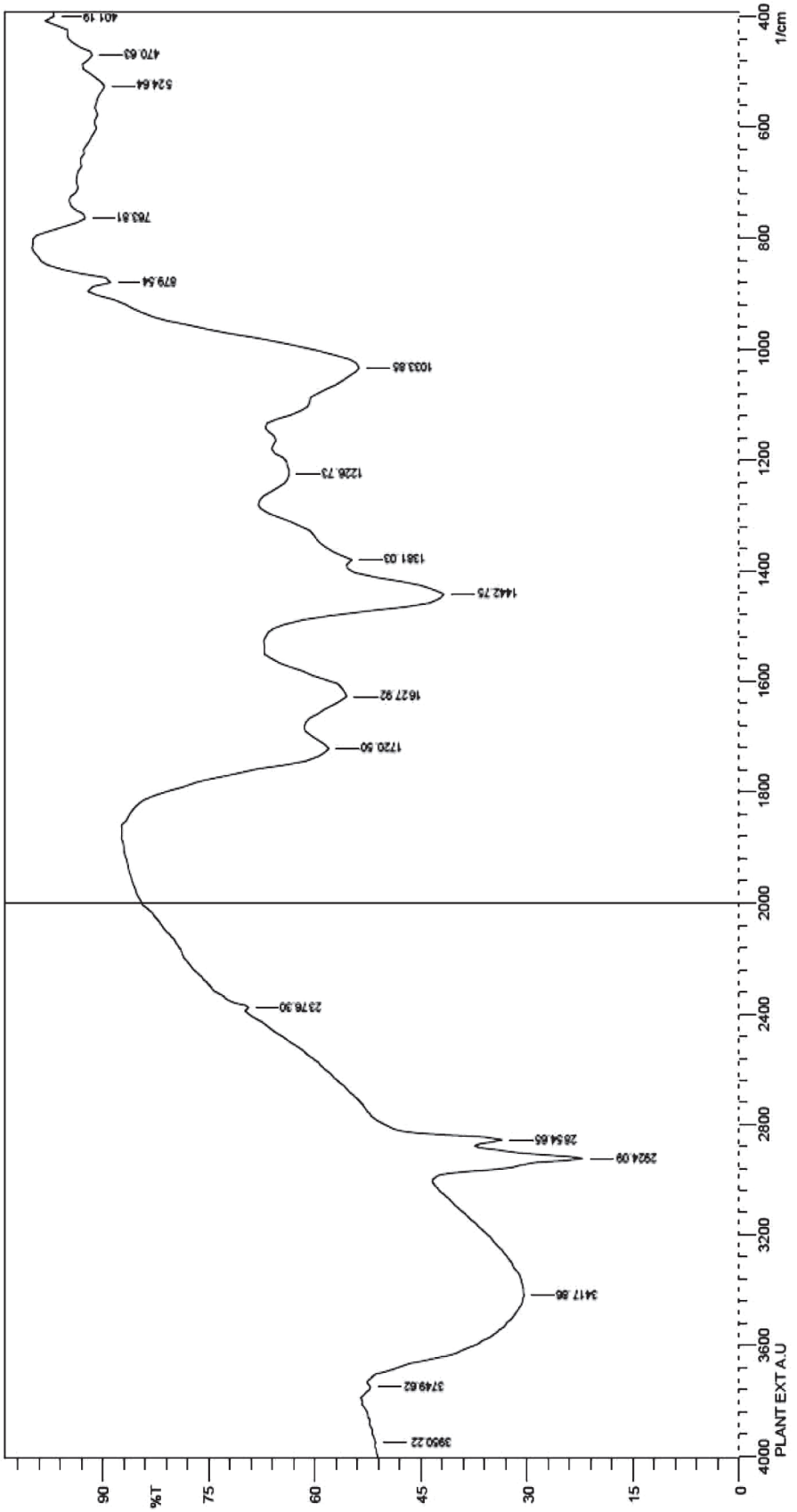

Fig. 1. FT –IR spectrum of *Luffa acutangula* peel

Hence, the research showed that the complex mixture of phytochemicals in vegetables provides a better protective effect on health than a single phytochemical. Therefore, the complex components of ridge gourd peel extracts needs to be scrutinized in depth in order to find out the best mixture of effective components that had role in the currently shown antibacterial and antifungal actions.

Characterisation of *Luffa acutangula* peels by FT –IR spectral analysis

FT-IR spectral analysis of acetone extract of *L. acutangula* peel extract revealed the presence of different functional groups (Fig. 1). A strong band at 3417.86 cm^{-1} was due to -OH and -NH stretching vibration, the peak appeared in the range of 2924.09 – 2854.65 cm^{-1} is ascribed to the stretching vibration of -CH. The peak intensities at 1720.50 and 1627.92 cm^{-1} in the IR spectrum corresponds to -C=O and C=C stretching. The peak observed at 1442.75 and 1033.85 was assigned to O-H bending and C-O stretching respectively. Spectral data of the extract confirmed the presence of functional groups such as–OH, NH and–COOH.

CONCLUSION

The peel extracts of *L.acutangula* contains significant antimicrobial activity and also the phytochemicals may prevent different infectious diseases and can be recommended for further pharmacological assessment.

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EFFECT OF OZONE TREATMENT ON CAULIFLOWER

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ABSTRACT

The study focused on the effect of ozone treatment on cauliflower and to determine an optimum treatment time for effective disinfection without alterations in the keeping quality and sensory attributes of the treated sample. A domestic bubbling ozone generator was used in this experiment. To assess the time required for disinfection, four time intervals were tested with an interval of 5 minutes upto 20 minutes.Treated samples of cauliflower were analysed for microbial tests, keeping quality and sensory evaluation. Microbial tests showed a prominent decrease in microbial population after each treatment. Also, the keeping quality of the treated samples under refrigeration and room temperature gave a satisfactory score for freshness. Sensory evaluation for ozone-treated samples was conducted to examine the changes in the sensory attribute after variation. Among the different time intervals, 20 minutes of disinfection with ozone had a better score than other time intervals in all the experiments.

Key Words: Ozone Treatment, Cauliflower, Disinfection

INTRODUCTION

Vegetables are an important source of well-being as they provide essential vitamins, minerals, dietary, and phytochemicals. The number of nutrients especially the phytochemical combinations varies according to their classification of vegetables which prompts a difference in the vegetable group. Similarly, the classification of vegetables according to their perishability has a greater impact on food preservation. In this way, highly perishable vegetables are easily subjected to contamination by microorganisms (Carletti *et al.,*2013). To eliminate harmful microorganisms, many utilize technologies that apply heat as a major source where it can destroy microorganisms and inactivate enzymes. However, heat influences the organoleptic properties and bio-availability of nutrients after the disinfection of fresh produce. Alternatively, applying chemicals for disinfecting fresh produce can leave harmful residues. In order to avoid the detrimental effects of thermal and chemical disinfection agent on fresh produce, non-thermalalternatives are developed (Lee *et al.,* 2014). One such non-thermal preservation method is ozone treatment (Guzel-Seydim *et al.,* 2004). Microbiological safety of the food should be considered while adapting novel food processing and preservation technologies.

Ozone is a triatomic molecule that contains three atoms of oxygen which is electrically

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bounded but unstable in the atmosphere and decays itself into a normal oxygen molecule. Ozonized water is considered as "Generally Recognized as Safe(GRAS)" (Fishburn *et al.,* 2012). Also, it is categorized as an organic-chemical disinfectant as it never leaves any toxic residues on the surface after reaction with micro flora. It has the potential to inactivate or kill bacteria and fungi which also restricts their development. Thus, ozone is considered as a powerful antimicrobial and sterilizing agent in the world which has several applications in the food industry. It has more advantages over traditional antimicrobial agents (Muthu-kumarappan *et al.,* 2000). Destruction of bacteria by ozone has been studied extensively, but only a little information is available on the effect of ozone on keeping quality and sensory quality of the ozone-treated vegetables. The main purpose of this study was to determine the duration required for the disinfection of cauliflower without altering the keeping quality and organoleptic properties after ozone treatment.

MATERIAL AND METHODS

Selection of raw material

The study was conducted in the Food Science laboratory, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore in the months of January and February, 2020. Fresh cauliflowers without any infestations or blemishes obtained from the local market of North Coimbatore. Selected raw material was carefully transported to the laboratory setup and analysed on the same day. Cauliflowers were chopped into equal size with mean weight and length of 23.00±2.00g and 4.00±1.00 cm, respectively with a sterile knife.

Ozone treatment for vegetables

The samples that were pre-processed was immersed in an air-tight treatment container containing clean water. The water for washing was enough for the quantity of the raw material taken and should be deeper enough such that the ozone diffuser should get immersed in it. (Wang *et al.,* 2019)

The tube that carries ozone from the generator is plunged into the container. The ozone generator is turned on and the ozone gas bubbled in the container which holds wash water and thus the process of washing commences. The treated samples are derived from the treatment container at an interval of 5 minutes, for upto 20 minutes. Each of the samples, including an untreated sample, is then subjected to testing methods including the Total Bacterial Count and Yeast and Mould Count. The shelf life of the cauliflower was also tested by refrigerating it under 4°C and at ambient room temperature by packing it in a punctured bag of polypropylene. All the treated samples were compared with the untreated samples and also they are compared among themselves to determine the optimum time limit required for the treatment of cauliflower.

Storage of the ozone treated samples

Samples were selected randomly from each treatment, carefully packed into polypropylene bags having holes in it and each

sample was marked simultaneously. Samples were held at one of the two temperatures. Initially, 3.00±0.15°C (Refrigerated temperature) was set as the first temperature as it is recommended for most of the fresh produce. Moreover, the second temperature of 16.00±1.00°C was chosen to assess the efficiency of the ozone-treated sample on its qualitative characteristics in the actual condition of the kitchen setup. No other products were kept closer to the test samples, which can influence the effect of ozone treatment. All the treated samples were scored with a five-point hedonic scale for colour and firmness which is a major concern for almost all consumers (Nunes *et al.,* 2007)

RESULTS AND DISCUSSION

Ozone has a strong capacity to disinfect and sterilize, which makes it a unique oxidant. It holds a high chemical reactivity due to its stable electronic configuration which impels to seek another electron from other molecules(Goncalves, 2009). Ozone is depleted after the oxidation process and an oxygen atom is released without producing any harmful atmospheric pollutants when reacting with other molecules. Also, the process does not leave any residues in the treated samples. The results based on the microbial analysis of the ozone treated samples for the presence of any potential microorganism before and after the treatment are discussed.

Table1. Microbial Analysis of Cauliflower

S.No.	Sample description	Parameters	
		Total Bacterial Count (cfu/g)	Yeast and Mould Count (cfu/g)
1	Cauliflower (Untreated)	4.40	66.50
2	Cauliflower (5 Min)	4.28	44.50
3	Cauliflower (10 Min)	4.10	21.00
4	Cauliflower (15 Min)	3.60	6.00
5	Cauliflower (20 Min)	3.39	5.00

Microbial analysis for the test samples

The test samples were subjected to a microbial estimation processfor Total Bacterial Count (TPC) test and Yeast and Mould Count (Table 1).TBC is carried out at 37°C and the microbes are determined in Colony Forming Units.

In general, the microbial population was reduced in concern with an increase in time. In specific the TBC, initially was found to have 4.40 x 10^3 log cfu/g and it was reduced to 3.39 x 10^3 log cfu/g, whereas YMC was found to be 66.50 cfu/g where it reduced to 5 cfu/g after

Evaluation of shelf life

Table 2. Evaluation of visual quality characteristics of the ozone-treated cauliflower

Day	Room Temperature										Refrigerated Temperature									
	Colour					Firmness					Colour					Firmness				
	0'	5'	10'	15'	20'	0'	5'	10'	15'	20'	0'	5'	10'	15'	20'	0'	5'	10'	15'	20'
Day 1	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Day 3	5	5	5	4.8	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Day 5	4	4.8	4.2	4.8	4.8	4.8	4.8	5	4.2	4.8	4.8	5	4.8	5	5	5	4.8	5	4.8	5
Day 7	3.6	4	4.2	4.2	4.2	4	4.2	4	4.2	4.2	4.2	5	4.2	4.8	5	4.2	4.2	4.8	4.8	4.8

Legend: ' denotes minutes

treating for 20 minutes. A similar level of microbial reduction has been reported by Musaddad (2013) when compared to fresh-cut cauliflower under normal water wash and ozone water wash; (Renumarn *et al.,*2014) observed a decline in the number of aerobic bacteria with an increase in time of ozone treatment.

The results of visual quality analysis of the treated sample are presented in Table 2. The freshness of the cauliflower was evaluated based on colour and firmness by five trained panelists. The entire sample irrespective of storage condition scored highest (Mean=5) on the first day of storage, whereas, on Day 7, samples stored under room temperature scored (Mean=4.08) lesser than the samples store under refrigerated temperature (Mean=4.6). When scores were analysed vertically and horizontally, samples treated for 20 minutes had better retention of colour and firmness on par with samples treated for 15 minutes.

Sensory evaluation for the test samples

Sensory analysis of the sample was carried out to assess whether the sample after ozone treatment gives satisfactory results in concern with the untreated product using a five point hedonic scale. The panel consisted of five judges, rated the sample from 1 to 5 (5 point hedonic scale) according to the following criteria 1-Poor; 2-Fair; 3-Good; 4-Very Good; 5-Excellent (Table 3).

Sensory evaluation of cauliflower after the treatment

Sample A: Cauliflower which is untreated is salted and cooked for 3 minutes

Sample B: Cauliflower is treated for 5 minutes and is salted and cooked for 3 minutes

Sample C: Cauliflower is treated for 10 minutes and is salted and cooked for 3 minutes

Sample D: Cauliflower is treated for 15

Table 3. Sensory evaluation of the cauliflower samples after treatment

Treatment	Sample	Appearance	Colour	Aroma	Texture	Taste	Overall Acceptability
Ozonized Water	Sample A	4.6±0.55	4.6±0.55	4.4±0.55	4.6±0.55	4.8±0.02	4.6±0.45
	Sample B	4.8±0.2	3.8±0.84	4.4±0.55	4.2±0.45	4.6±0.55	4.0±0.55
	Sample C	4.4±0.55	4.2±0.45	4.6±0.55	4.6±0.55	4±0.01	4.4±0.45
	Sample D	4.4±0.55	4.2±0.84	4.2±0.45	4.6±0.55	4±0.01	4.2±0.45
	Sample E	4.6±0.55	4.2±0.84	4.2±0.45	4±0.01	4±0.71	4.4±0.55

minutes and is salted and cooked for 3 minutes

Sample E: Cauliflower is treated for 20 minutes and is salted and cooked for 3 minutes

The mean scores of the sensory evaluation of the cauliflower samples after ozone treatment are presented in Table 3. The overall acceptability of the samples treated for 10 minutes (Sample C) and 20 minutes (Sample E) was similar and almost minimal variation in scores of the other two-time intervals (5 minutes and 15 minutes) was observed.

CONCLUSION

The ozone treated samples had a better disinfection rate at 20 minutes with respect to Total Bacterial Count and Yeast and Mould Count. Evaluation of storage condition after ozone treatment did not show much difference in their freshness index yet the refrigerated samples were better than room temperature samples. Similarly, sensory evaluation of the cauliflower samples indicated that there were no major deviations in the sensory attributes after ozone treatment and was well accepted. Hence, treatment with ozone can be used for the disinfection of fresh produce of cauliflower which does not influence the nature of the cauliflower.

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DETERMINANTS OF CLASSROOM SEATING ARRANGEMENT IN HIGHER EDUCATION INSTITUTIONS

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ABSTRACT

The study was to assess and evaluate the determinants of classroom seating arrangement in higher education institutions in Guntur district of Andhra Pradesh. Thirty higher educational institutes (30 respondents) were selected for the study. Eleven design features that guide the seating arrangement in a classroom proposed by various higher educational institutes and official bodies served as a base for identifying the features to evaluate the seating arrangement in a classroom. The results showed that educational institutes were not paying attention to the modified fan-shaped design configuration, theatre-style seating, and seating arrangement for students with disabilities. The total strength of the students and year of establishment of the institution were the deciding factors in designing a seating arrangement in a class, row to row clearances, passage clearances, minimum and maximum distance between the last row to end wall, clearances from the student's desk adjacent wall, desk to desk clearances, seating for students with a disability and seating design configuration.

Keywords: Determinants, Classroom, Seating arrangement, Higher education institutions

INTRODUCTION

The classroom seating arrangement impacts the learning process. It has to be planned with more comfort to gain a measurable increase in the students' performance. It not only determines the room layout but also facilitates communication. The overall recommended seating area per student is 18 - 20 sq. ft. In the case of limited space, there should be at least 10.5 sq.ft per student for the seating area for circulation space amongst the seats (Arizona State University, 2019).

As per the Bureau of Indian Standards (1978), the classroom apart from satisfying the minimum requirements of space, fittings and furniture, shall be designed to meet the adequate functional and environmental requirement.

Seating in a classroom should be comfortable for everyone ranging in size from the fifth percentile to the 95th percentile male. Classroom chairs should meet ergonomic guidelines and provide options for a variety of seating or adjustability. All chairs should have corrected lumbar support. The backrest for a classroom seating must have a slope ranging from12 degrees to 30 degrees. The height of the backrest of the seating should not exceed two feeteight inches from the floor level.

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Upholstered seating is preferred in lecture halls only where problems due to the reverberation of sound exist. All the other rooms can have non-upholstered seating. To fulfill the ergonomic needs of the students; the broadest range of users seats that can be adjusted in seat depth, width, height, or a variety of seating should be provided (University of Connecticut, 2016).

Solunac and Stevens (2010) recommended that at least 10 percent of the seating in all lecture halls should be provided for left-handed students. All classrooms shall provide seating for learners with a disability *i.e.*one seat for up to 25 students, two for 26 to 50, four for 51 to 300, six for 300 to 500. Tablet armchairs shall provide the student with at least 150 square inches of the writing surface and 13 to 15 square feet of space.

University of Cincinnati Design Guidance (2003) suggested that minimum access aisles seating should be three feet wide aisle leading to front of room, minimum one feet seven inches (1' 7") clearance between tablet-arm supports, minimum one feet clearance between tablet arms in use and seat backs and minimum 2 feet 3 inches (2' 3") wide aisles in other locations.

According to Chiara and Callender (1987), the seating arrangement is the most important feature in determining the size and shape of a classroom. In a lecture hall, visibility for students depends upon many factors such as display of chalkboards, projection screens, and seating arrangement. It is the most crucial aspect to be considered for the avoidance of obstructions, the slope of the flooring and tallness of the speaker's platform, viewing distance, and the intense vertical and horizontal viewing angles. Based on these insights, this research was taken up to understand the existing classroom design in higher educational institutes and discover the determinants of classroom seating arrangement.

MATERIAL AND METHODS

The study was conducted in Guntur district of Andhra Pradesh during the year 2020. A list of higher education institutions was made and they were selected by random sampling techniques. Thirty higher educational institutes willing to take part in the investigation were selected for the study (included not only universities but also various professional colleges) that provide preparation in fields such as engineering, agriculture, medicine, and pharmacy. An interview cum observation schedule was used for the data collection. Thirty respondentswere taken from the thirty educational institutes for the study. Eleven design features that guide the seating arrangement in a classroom proposed by various higher educational institutes and official bodies served as a base for identifying the features to evaluate the on-hand situation of seating in a classroom. It was evaluated in terms of these standard features. To quantify the responses, score three was given if the existing feature was 'fully provided' as per the recommendations. Score two was given if the existing feature was 'partially provided' and score one was given if the existing features were 'not at all' provided in the classroom.

The year of the establishment of the institution, type of management, and the total strength of the students in the college were

Table 1. Classification of educational institutes by the classroom seating arrangement features

Design features	Above the recommendations		As per the recommendations		Below the recommendations		Total	
	f	%	f	%	f	%	f	%
Theatre-style seating with a curved configuration was preferred wherever possible.	0	-	8	26.66	22	73.33	30	100
For the classroom with tiered seating, tablet armchairs should be preferred.	14	46.66	4	13.33	12	40	30	100
Preferred row to row distance is three feet.	9	30	15	50	6	20	30	100
The recommended distance should be one feet one inches to one feet two inches (1’ 2") between rows for passage clearance.	6	20	14	46.66	10	33.33	30	100
The space from the last row to the end wall should be minimum of two feetone inches (2’ 1").	10	33.33	7	23.33	13	43.33	30	100
The preferred maximum distance between the last row to end wall was four feet.	2	6.66	8	26.66	20	66.66	30	100
Seating arrangement in the lecture halls should be a modified fan-shaped design configuration to allow greater seating area to provide good sight lines and acoustics.	5	16.66	9	30	16	53.33	30	100
The clearance from the student desk to adjacent wall for the both the sides should be one feetfive inches (1’ 5").	14	46.66	7	23.33	9	30	30	100
The student desk to desk clearance for moving vertically should be one feet six inches approximately(1’ 6").	2	6.66	9	30	19	63.33	30	100
All classrooms shall provide seating for students with disabilities (one seat for up to 25 children, two seats for 26 – 50, four seats for 51 – 300, six seats for 300-500)	1	3.33	3	10	26	86.66	30	100

identified as independent variables. It was assumed that there exists an association between independent variables and seating arrangements in a classroom. Hence, the chi-square test was used as a statistical tool to study the association.

RESULTS AND DISCUSSION

Thirty higher educational institutes started were selected through random technique. An equal percentage of institutes were chosen *i.e.* Government, Government aided, private and autonomous bodies. The strength of the students in the thirty educational institutes ranged from 500 to 2000.

Existing classroom seating arrangement

The existing seating arrangement was evaluated in terms of standard design guidelines documented in the study. Theatre-style seating with a curved configuration was not found in the majority of the educational institutes. A tablet armchair with theatre-style seating was present in only 60 percent of the educational institutes. Passage clearance between rows in all educational institutes was found as per recommendations *i.e.*one foot (1') to one foottwo inches (1'2"). Fan-shaped design seating configuration was absent in more than 50 percent (53.33%) of the educational institutes. The clearance between desk to the adjacent wall for both sides was above the recommendation in 46.66 percent educational institutes. The desk to desk clearance was below the recommendation (one feet six inches) in 63.33 percent of the educational institutes. More than 80 percent (86.66%) of the educational institutes did not provide seating for students with disabilities.

The seating arrangement is the prominent feature in determining the size and shape of a classroom. Tiered seating with tablet armchairs, desk clearance, clearance from the student desk to an adjacent wall for both sides, and row to row distance was found to be as per the recommended guidelines. It is reported that educational institutes were not paying attention to the modified fan-shaped design configuration, theatre-style seating, including seating for students with disabilities.

Association between the independent variable and seating arrangement in the classroom

H_o: There exists no significant association between type of management, year of establishment, the strength of the college, and seating arrangement in the classroom.

There were eleven standard design recommendations to measure the variable "Seating arrangement in the classroom". Chi-square analysis was used to find out the association between dependent and independent variables. Question-wise chi-square test was performed for dependent and independent variables and considered the total number of observations as the number of questions multiplied with the size of the sample. Thus, the total observations were 11×30=330.

Table 2. Association between type of management, year of establishment, strength of the college and seating in seating arrangement

Independent variables	Seating arrangement			Total Observations	Level of significance
	Above the recommen-dations	As per the recommen-dations	Below the recommen-dations		
Type of Management					
Government	19	34	46	99	Not significant
Government aided	2	1	8	11	
Private	37	34	50	121	
Autonomous	20	26	53	99	
Total	78	95	157	330	
χ^2 value	9.9320				
Probability	0.1275				
Year of establishment					
below - 1990	21	33	56	110	Not significant
1991-2000	31	42	70	143	
2001-2017	26	20	31	77	
Total	78	95	157	330	
χ^2 value	6.0012				
Probability	0.1991				
Strength of the college (students enrolled)					
Below 1000	14	32	64	110	Significant at 1 percent level
1000- 2000	39	29	64	132	
2000- above	25	34	29	88	
Total	78	95	157	330	
χ^2 value	20.0146				
Probability	0.0005 *				

The Chi-square value revealed no significant association between (i) Type of Management and seating in the classroom (ii) Year of the establishment of the institution and seating arrangement in the classroom. The association between the strength of the college (students) and seating in the classroom was found to be significant at one percent level. The strength of the educational institute (students enrolled) was found to be one of the influencing factors in providing seating in the classroom. Hence, the null hypothesis was accepted in case of association between type of management and seating in the classroom, year of establishment, and seating in the classroom and rejected in case of association

between the strength of the students in the college and seating arrangement in the classroom.

Percentage contribution of independent variable towards the existing classroom seating arrangement

Regression analysis was performed to estimate the contribution of three independent variables *viz.,* type of management, year of establishment, and the total strength of the institutes towards the dependent variable of the study. The total strength of the organization contributed 78.21 percent and the year of establishment contributed 21.79 percent towards the classroom seating arrangement. The contribution of the type of management was negligible.

Table 3. Percentage contribution of independent variable towards the existing classroom seating arrangement

Dependent variable	Independent variables	Estimate	Std Err	t Value	Pr> |t|	Percentage contribution (%)	Rank
Seating arrangement	Type of management	-0.36	0.42	-0.86	0.40	0.01	3
	Year of establishment	1.81	0.67	2.69	0.01	21.79	2
	Total strength of the institute	2.53	0.63	4.04	0.00	78.21	1

The total strength of the institute (students enrolled) is the deciding factor in designing the seating arrangement in a classroom for higher education institutions. Total strength was the more contributing factor than the type of management and year of the establishment towards the existing classroom seating arrangement.

CONCLUSION

There was no significant association between the type of management and seating arrangement in the classroom and year of establishment and seating arrangement in the classroom. The association between the strength of the college and seating arrangement in the classroom was found to be the only significant determinant at one percent level.The regression analysis was revealed that the total strength of the institute and year of establishment of the institute are the deciding factors in designing the seating arrangement in a classroom. These determinants assess the classroom seating arrangement *i.e.,* row to row clearances, passage clearance., the minimum and highest distance between the last row to end wall, clearance from the student desk to the adjacent wall, desk to desk clearance, chairs for learners with a disability and seating design configuration. By taking into consideration these

determinants related to seating arrangement into the existing classrooms in higher education institutions can be implemented for better outcomes.

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CAUSATIVE VARIABLES FOR DROP-OUT AND SUGGESTIONS FOR RETENTION OF STUDENTS IN HOME/ COMMUNITY SCIENCE

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ABSTRACT

The research (conducted under the ICAR funded extramural project) was carried out purposively with the college students and faculty staff selected from Home/Community Science colleges/departments from six universities across five states to find out the causative variables that have an impact on the enrolment percentage in Home/Community Science. The information was collected through an online Google form, from a total of 166 students and 51 faculty staff, respectively. According to the respondents, inactive placement cell (66.3% students & 56.9% faculty staff), lack of collaboration with the industries, institutions, and universities (48.2% students) and less dynamic practical classes linked to job providers (49.4% students & 49% faculty staff) were the major causes that lead to student drop-outs. Furthermore, the suggestions for retention of students pertained to holding open sessions on career opportunities and higher studies (65.7% students), regular orientations among students and industry representatives (57.8% students), and publicity of the subject through online media platforms (88.2% faculty staff) promotes effective and efficient working. It was clear from the study that there is a need to upgrade the operation of Home/Community Science education.

INTRODUCTION

One of the major trends in today's society for the long term future is digitalization. In this science-driven world, digital advancement is playing a critical role. However, there is still no substitute for traditional sciences such as agriculture and its allied fields viz. Home/ Community Sciences, Horticulture, etc. While the need for proficient agricultural and Home Scientists is still there, it is not necessarily translated into higher enrolments of students in these areas, posing a risk to the longevity and quality of these sciences. Home/ Community Science is the education that relates to both home and family. It is the education that provides a piece of basic knowledge and assists human to attain more self-reliant and fulfilled living. Home/ Community Science deals with all aspects of family living variables as it unifies the knowledge from all disciplines of biology, physics, arts, humanities for effective home management.

With a booming education sector in the country, India has the largest student population of over 350 million in the world. To ensure that this younger generation gets itself involved in fields requiring most consideration, efforts will have to be put to provide the direction, right from school time. According to the All India Survey on Higher Education (2015-16) conducted by the Ministry of Human Resource Development, Department of Higher Education, GoI, New

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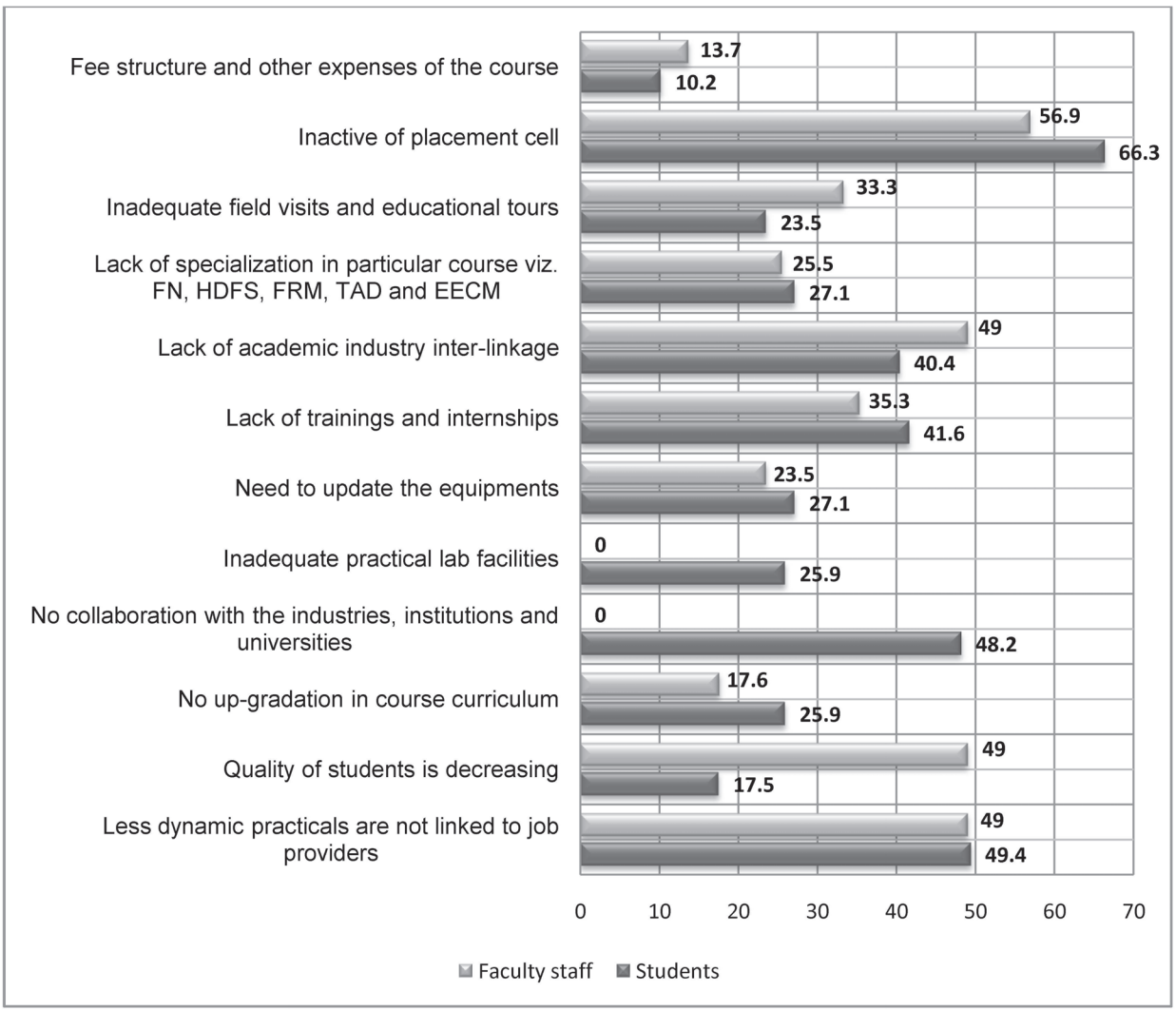
Delhi, there are only 9,970 students enrolled in higher education under Home/Community science, and 98,876 students in B.Sc. (Agriculture) as compared to 5,09,031 students in Bachelor of Sciences and 13,80,583 in Bachelor of Arts. The Gross Enrolment Ratio in higher education for Rajasthan is only 18.50 percent for females when compared to Chandigarh (70.40%), Delhi (48.20%), Tamil Nadu (42.40%), and Himachal Pradesh (35.50%). Home Science is the subject that prepares young learners for the two most important goals in their lives - looking after their home and family and preparing for a career or vocation in life. However, for any subject to thrive and prosper, it requires a constant inflow of talented students (GoI, 2019). There is a constant decline in students opting for Home/ Community Science in higher education due to lack of awareness about the subject as a profession, rigorous marketing practices of educational institutes concerning non-agricultural education, and numerous other reasons.

Home/ Community science as a discipline has undergone a great revolution in its definition. Home science initially started as a subject for women and girls in preparation for motherhood and domestic life but with the advancement in subject and time, it is now described as a multi-purpose program of study taken up by both girls and boys. It has attained new dimensions in its concerned departments *viz.,* foods and human nutrition, family resource management, human development and family studies, clothing and textiles; and for the popularization of these departments there is the inclusion of Extension Education and Communication Management. It encourages and gratifies the individual's interest and develops skills and capacities for better vocations, careers and professions. Hence, it has evolved as an imperative tool for empowering women at the household and community level (Raghuvanshi, 2018).

However, our younger generation is moving away from this area of education on account of prevalent misconceptions and dominance of basic sciences and arts. According to AISHE (All India Survey on Higher Education) report (2015-16), only 650 students got enrolled in Ph.D. in Home Science; with a total number of 9972 students enrolled at Post-Graduation level (945 males and 9027 females). The Home Science sub-stream alone has a total number of 8361 students at PG with 7590 females and 771 males, whereas, Nutrition has 1008 students at the PG level with 984 females. Higher education encourages technical know - how, skills, careerplan, responsibility and prosperity among the youth of the nation besides dealing with the development of moral character and intellectual level of youth. According to Mittal *et al.* (2020), Home Science prepares its students to develop themselves with multiple vocations and career options. The study concluded that 94.5 per cent students have passed out, out of 599 students admitted, while 5.84 per cent students were drop-outs before completing their degree before completing their degree. Overall, more than one-third of the students opted for Ph.D. after completing their Master's program. Home Science students are competing well in the fast-changing job market scenario and possess



Note: Multi- responses figure; percentage of the student and faculty respondents for each statement

Fig. 1. Causative variables resulting in drop-out from Home/ Community Science

professional skills needed for employment.

While student engagement and causative variables for drop-outs are a more recent focus for research, it has now overtaken student retention in importance. Hence, there is a need to understand the causative variables for drop-out and suggestions for retention of the students. Therefore, keeping the above factors in mind, the study was designed with the objectives: to identify the causative variables for students drop-outs in Home/Community Sciences and to elicit the suggestions from Home/Community Science students and faculty members for attracting and retaining students in this field of education.

MATERIAL AND METHODS

The research (conducted under the ICAR funded extramural project) was carried out purposively with the college students and

teachers/ professors selected from Home/ Community Science colleges/departments from Maharani College (University of Rajasthan, Jaipur, Rajasthan), Choudhary Charan Singh Haryana Agriculture University, Hisar (Haryana), Gobind Ballabh Pant University of Agriculture and Technology, Pantnagar (Uttarakhand), MaharanaPratap University of Agriculture and Technology, Udaipur (Rajasthan), Maharaja Sayajirao University, Vadodara (Gujarat) and Avinashilingham Institute of Home Science and Higher Education for Women, Coimbatore. The study was carried out for 3 months from November 2019 to January 2020. The information pertaining to the causative variables for drop-out and suggestions for their retention was collected through an Online Google form. Few respondents were also contacted either personally or through the e-mail-id, thus, making a total of 166 students and 51 teachers/ professors as respondents.

RESULTS AND DISCUSSION

Deriving causes behind students drop-out from concerned subject teachers and students

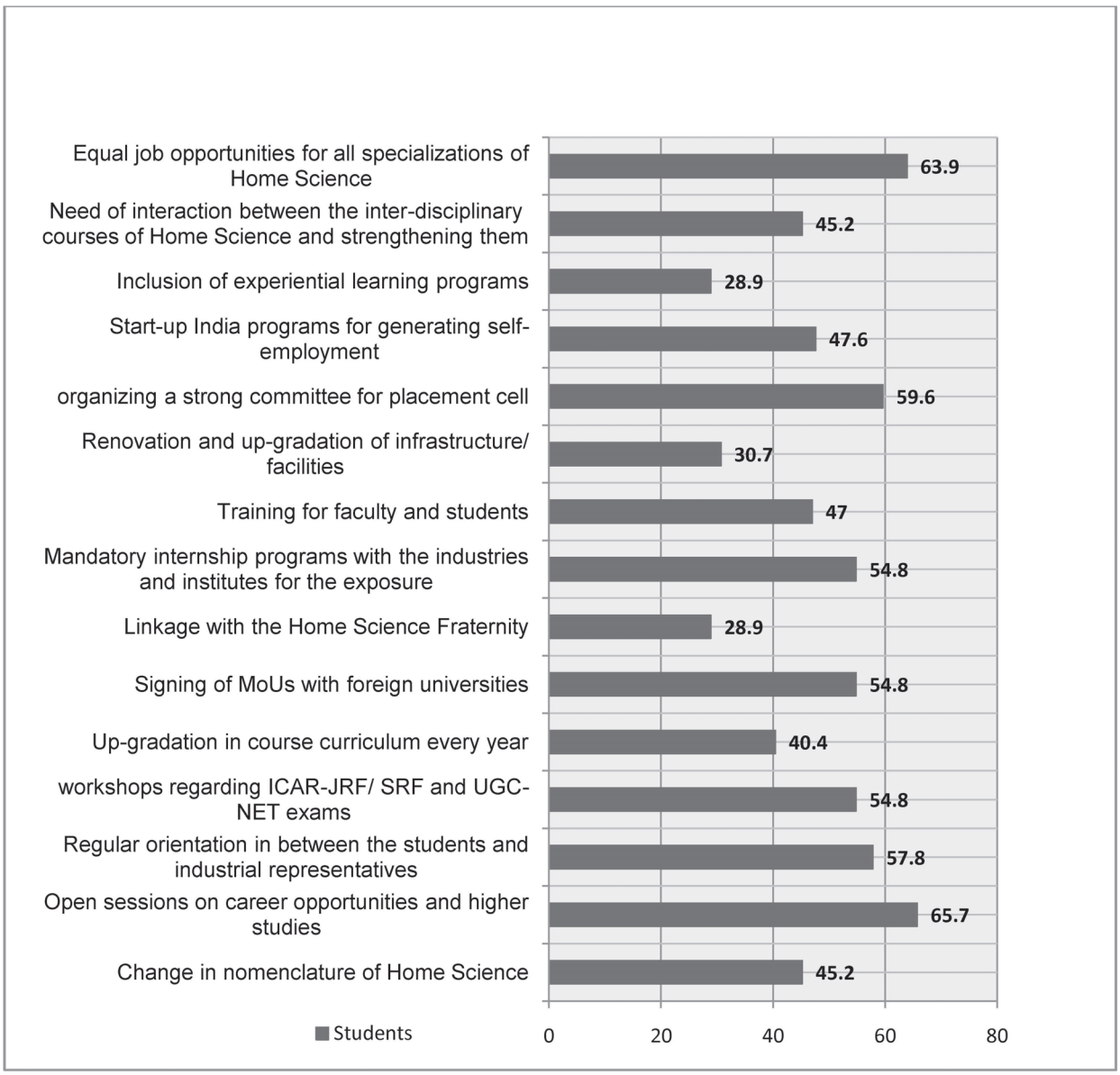
Data in Fig. (1) highlights the causes that lead to student drop-outs in Home/ Community Science colleges. The majority of the students pointed out that that inactive placement cell (66.30%), less dynamic practical classes that are not linked to job providers (49.40%) and absence of collaboration with the industries, institutes, and universities (48.20%) has resulted in student drop-out. The faculty staff also expressed the same reasons in that order as most of them believed that inactive placement cell (56.90%), less dynamic practical classes without linking to job providers (49.00%), lack of academic-industry inter-linkage (49.00%), and decreasing knowledge (quality) of students (49.00%) that resulted in student drop-outs.

Apart from the variables mentioned in the figure, faculty staff also discussed some other causes behind drop-outs like misconceptions related to Home Science and its lack of publicity, poor guidance, and fewer job opportunities, gender-based selection in some colleges, and absence of vocationally oriented courses. Faculty staff agreed that many of the students face social stigma and peer pressure due to the misconceptions among the general public that Home Science is only about cooking and stitching and it is meant for students with poor academic performance. Presumptions of the society that it is an easy subject and its students can't compete with other streams of education are far more damaging.

Suggestions received to attract and retain the students in Home/ Community Science

A perusal of Fig. (2 and 3) infers the suggestions received from the students and faculty staff to attract and retain the students for enrolment enhancement in Home/ Community Sciences.

The majority of the students (65.7%) suggested conducting open sessions on career opportunities and higher education, while 63.9 percent suggested having equal job opportunities for all specializations of Home Science and strengthening of placement cell (59.6%) as top suggestions. Furthermore, the students reported that regular orientation



Note: Multi- responses figure; percentage of the student respondents for each statement

Fig. 2. Suggestions to attract and retain the students in Home/ Community Science (From the student's perspective)

between the students and industrial representatives (57.8%), workshops regarding ICAR-JRF/ SRF (Indian Council of Agricultural Research-Junior Research Fellowship/ Senior Research Fellowship) UGC-NET (University Grants Commission-National Eligibility Test) Exams (54.8%), mandatory internship programs with the industries and institutes for the exposure (54.8%), signing of MoUs with foreign universities (54.8%), Start-up India programs for generating self-employment (47.6%), training for faculty and students (47.0%), change in the nomenclature of Home Science (45.2%), need of interaction between

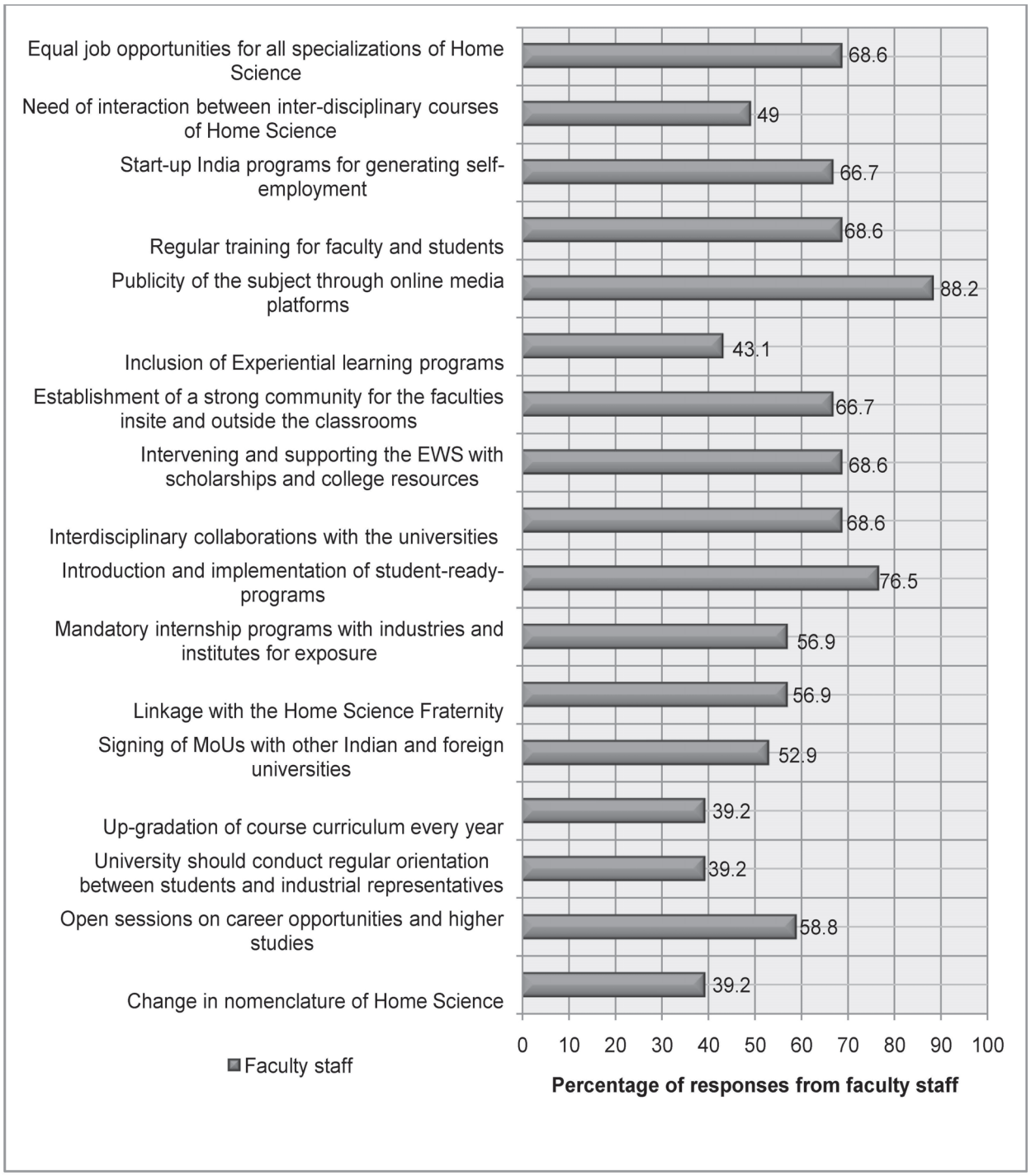
the inter-disciplinary courses of Home Science and strengthening (45.2%) and up-gradation in course curriculum every year (40.4%), respectively for increasing the enrolment percentage (Fig. 2).

The majority of the faculty members (88.2%) suggested that there is a need to publicize the core departments of Home/ Community Sciences through various media platforms such as social media and electronic/ print media, followed by the introduction and implementation of student-ready programs (76.5%) with some optional multidisciplinary courses which can diversify the field of knowledge and build confidence among the students (Fig. 3).

Results further highlighted that there should be regular training for faculty staff and students (68.6%), equal job opportunities for all specializations of Home/Community Science (68.6%), interdisciplinary collaborations with the universities (68.6%), intervening and supporting the economically weaker sections with college resources and scholarships (68.6%) to retain the students. Furthermore, the universities/ colleges should make it mandatory for their students to ensure their good academic standing and opportunities that they can avail of from their campus resources. Inter-disciplinary collaborations with the universities and developing actionable plans would improve retention rates in the subject. Fig. 3 also shows that the majority of the faculty staff opined that there should be start-up India programs available for the students to generate their self-employment (66.7%) as this will entail a sense of stability and confidence among the students and they could be more motivated towards the subject. Faculty staff (66.7 %) also felt the need of establishing a strong community for the faculty staff inside and outside the classrooms so that their students can perform effectively in their academics.

There were two trends visible in the responses provided by teachers and students. Students' suggestions were more inclined towards highlighting the job potential of Home/ Community Science education. This further throws light on the serious need to convey and aware the masses about the job potentials in various streams of Home/Community Science because it will also address the prevalent misconceptions and build confidence among the Home/Community Science fraternity to compete with other streams of education. Students felt the need for more dynamic syllabi/ curriculum which can go beyond the traditional knowledge base and also include the aspects of making students' job/ industry-ready. This includes workshops on scholarships/ fellowships, research, and extension based jobs, major examinations like NET (National Eligibility Test), SET (State Eligibility Test), etc.

The trends visible in faculty staffs' responses were more inclined towards online publicity, training and encouraging entrepreneurial know-how so that the students can benefit from programs like the start-up India. The teachers felt that through such changes, Home/Community Science students can become part of a larger ecosystem of entrepreneurs and in turn, take the subject further. Faculty members believed that Home/ Community Science as a subject is restricted



Note: Multi responses figure; percentage of the faculty respondents for each statement

Fig. 3. Suggestions to attract and retain the students in Home/ Community Science (From the Faculty staff's perspective)

to its own boundaries. Collaborative researches, MoUs, and diverse linkages will help in building up an inclusive image and will further the opportunities to its students, helping in better retention and lower drop-outs.

Apart from the tabulated suggestions, students reported that there should be a change in conventional ideas of teachers. They should be more flexibility, admission criteria should be opened for inclusion of boy students and electronic/print media should be included in motivating people and popularizing the subject at a wider level. The faculty staff suggested that the nomenclature of Home Science should be modified across the universities and colleges. The government should take appropriate efforts to bring out policies, to popularize the subject in the masses. According to Crosling *et al.* (2009), the development and utilization of learning and teaching strategies would promote an active student-centered approach to learning, draws on students' previous experiences and interests, help in enhancing student engagement, commitment to the course and thereby retention on the program.

CONCLUSION

The study led to conclusions which demand introspection and hard-work on the part of the Home/Community Science fraternity. The prominent reasons for low enrolment percentage and higher drop-out rate were poor linkage with job-providers, inactive placement cells, prevalent misconceptions, and poor publicity. Conducting open sessions on career opportunities and higher studies (65.7%), upgrading the syllabi by moving beyond the conventional knowledge base (40.4%) are some of the suggestions to address the causative factors. Furthermore, there is a need to upgrade the subject matter by collaborating with other disciplines to popularize the subject. Efforts will have to be directed towards ensuring better enrolments and spreading awareness among young students about the true potential of Home/Community Science. Taking advantage of the digital measures and tools available today to reach larger sections of the student population is also recommended.

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SIBLING RELATIONSHIP DURING MIDDLE ADULTHOOD IN RELATION TO FAMILY ENVIRONMENT

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ABSTRACT

The study was conducted in the year 2019 with adults aged between 40 to 50 years old in Uttarakhand and Haryana states. The total sample was composed of 240 adults, 120 from Haryana and 120 from Uttarakhand (60 males and 60 females from both the states). It was recorded that 63.3% respondents from Uttarakhand and 68.3% respondents from Haryana perceived average level of overall family environment. Respondents with high level of family environment had more contact with their siblings (Mean=26.72), experienced more emotional closeness (Mean=25.96) and less conflict (Mean=24.38) with their siblings, and also confided more (Mean=16.45) with their siblings in comparison to the respondents with low and average family environment. Overall, sibling relationship was better when family environment was better. Regression analysis unveiled family environment as a predictor and accounted for 6.7 percent variance in sibling relationships, F (1,239) = 18.24, P<.001.

Keywords : Middle adulthood, Sibling relationship, Family environment, Uttarakhand, Haryana

INTRODUCTION

The sibling relationship is one of the enduring and long-lasting relationships in everyone's life. Relationships between siblings are viewed as the most secure relationships that are maintained lifelong. As individuals grow old, contacts with their siblings increase and during middle adulthood, they generally feel more emotional closeness and encounter fewer conflicts. They often view one of their siblings to be close friends and confidants. Siblings share biological and cultural heritage, as well as memories based on shared history (Negi and Balda, 2019a).

Adult sibling relationship is the most significant relationship and has a great influence on everyone's life. Sibling relationship consists of a collective rearing, shared genes, and shared secrets. It can then lead to preventing health risk behaviour and sibling rivalry (Feinberg *et al.*, 2012; Negi and Balda, 2019b). Sibling relationship during youth has a significant influence on their socio-emotional development during adulthood (Nauret, 2018).

Campione-Barr and Killoren (2015) and Negi and Balda (2019b) have described the importance of sibling relationships for developing social competence and adjustment with others. These authors have reported the scarcity of research on sibling relationships and that these are the longest-lasting relationship throughout the entire life and it serves unique developmental functions.

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Hashim and Ahmad (2016) observed that family relationships are highly dependent on the abilities of both the parents- father and mother. Family serves as the base and from here, the kinship and family dynamics among siblings are developed positively or negatively throughout life. McHale *et al.* (2012) reported that family experiences have a strong and lasting influence on the development of children. Parents are primary caregivers and act as role models in relation to social and cognitive development. They have a substantial influence on relationships within the family including sibling relationships.Considering the importance of sibling relationships and family environment, they were analyzed in this study with the objective to study sibling relationship during middle adulthood in relation to the family environment.It was assumed that: **Assumption 1:** There is no association between the geographical location of residence and family environment as perceived by adults. **Assumption 2:** Family environment has a significant effect on sibling relationship during middle adulthood. **Assumption 3:**There is no association between gender (male and female) of respondents and sibling relationship.

MATERIAL AND METHODS

The study was conducted in Uttarakhand and Haryana states in rural and urban areas in the year 2019. The total sample included 240 adults, 120 from Uttarakhand, and 120 from Haryana. From each state, 60 males and 60 females were included. These adults ranged in age from 40 to 50 years. The mean age of adults from Haryana was 44 years and that of adults from Uttarakhand was 45 years.

Family environment was assessed by Family Environment Scale (FES) by Bhatia and Chadha (1993). The FES consists of 69 items and is scored on a five-point scale - strongly agree (5) to strongly disagree (1). The measure consists of 8 subscales - cohesion, expressiveness, conflict, acceptance and caring, independence, active-recreational orientation, organization, and control. The scale has seven positive aspects- cohesion, expressiveness, acceptance, independence, active-recreational orientation, organization and control; and one negative aspect, that is, conflict. Negative statements were reverse coded and total scores were computed for the overall family environment. Maximum obtainable score was 345 and minimum obtainable score was 69. Sibling Relationship Scale developed by Nandwana and Katoch (2010) was used to assess the sibling relationship of selected adults. The scale has four dimensions *i.e.* Contact, Emotional Closeness, Confiding and Conflict. Total scores were computed for different dimensions and for overall sibling relationship. Maximum obtainable score was 150 and minimum obtainable score was zero.

RESULTS AND DISCUSSION

Total scores of different sub-scales of the family environment as perceived by adults were computed separately for Uttarakhand and Haryana states. Total scores of sub-scales were added to get scores for the overall family environment. Higher scores mean high/better family environment and lower scores meanlow/ poor family environment. Three categories were made for overall family environment on the basis

of standard deviation values- low(237 and below), average(238-279) and high(280 and above).

Family environment as perceived by respondents of Uttarakhand and Haryana

Majority of respondents from Uttarakhand (63.3%) and Haryana (68.3%) perceived their family environment as average; from Uttarakhand, 20.8% adults and from Haryana, 18.3% adultsperceived their family environment as high. However, 15.9%and 13.4% participants from Uttarakhand and Haryana respectively perceived their family environments as low. Chi-square (χ^2)was computed to explore the association between the geographical location of residence of respondents (Uttarakhand and Haryana) and the family environment as perceived by adults.The family environment was not significantly associated with the geographical location of residence (Table 1).

Table 1. Family environment as perceived by respondents of Uttarakhand and Haryana (n=240)

Levels of family environment	Uttarakhand n = 120	Haryana n = 120	χ^2-value
Low (237 and below)	19 (15.9)	16 (13.4)	3.20 NS
Average (238-279)	76 (63.3)	82 (68.3)	
High (280 and above)	25 (20.8)	22 (18.3)	

Note: Figures in parentheses indicate percentages; NS: Non-significant

Majority of the adults from Uttarakhand and Haryana state perceived average level of family environment*i.e.* they perceived conducive environment in their families. There was no significant association between the residential location of adults and their perception regarding the family environment. Hence, the assumption that there is no association between the geographical location of residence and family environment as perceived by adults was true.These findings are consistent with previous studies. The findings of Pandey and Audichya (2011) revealed that the majority of respondents were in the average category of all the dimensions of family environment and overall family environment. Gaur and Audichya (2016) reported that the majority of girls and boys (13-16 years) perceived average family environment. The study by Devi and Kiran (2014) revealed that majority of the adolescents had average perception about cohesion, expressiveness, acceptance and caring and active recreational orientation dimensions of family environment and overall family environment.

Sibling relationship among adults of Uttarakhand and Haryana

Fifty items in adult sibling relationship scale (ASRS) were scored on a 4-point scale in four dimensions- contact, emotional closeness, confiding and conflict. The score was computed for these four dimensions of sibling relationship and for overall sibling relationship. Three

categories were made for overall sibling relationship on the basis of standard deviation-low(54-75), average(76-87) and high(88-116). As indicated by Negi and Balda (2019a), majority of the respondents from both the states had a loyal and congenial relationship with their siblings. There was no significant association between geographical location and sibling relationship of adults during middle adulthood. Hence, for the study, data regarding sibling relationship was pooled from both the locations for further analysis.

Effect of family environment on sibling relationship

Effect of family environment on sibling relationship was examined by taking family environment as an independent variable and sibling relationship as the dependent variable and computed ANOVA followed by Duncan's multiple range test to find group differences in sibling relationship.

Table 2. Effect of family environment on sibling relationship (n=240)

Sibling relationship	Family environment			F-value
	Low Mean±SD	Average Mean±SD	High Mean±SD	
Contact	18.97[a] ± 5.60	21.70[b] ± 6.98	26.72[c]±6.45	15.21**
Emotional closeness	20.60[a] ± 5.74	21.85[a] ± 5.62	25.96[b]±5.47	11.97**
Confiding	13.00[a] ± 2.67	14.20[b]± 3.02	16.45[c]±2.79	15.79**
Conflict	32.09[c] ± 9.00	27.92[b]±8.31	24.38[a] ±8.80	8.24**
Overall sibling relationship	84.66[a] ± 9.73	85.67[a] ±10.33	93.51[b]±9.89	11.93**

Means in same row differ significantly at **p <.01 level of significance

A perusal of Table 2 unveils data concerning the effect of family environment on sibling relationship. Figures regarding the effect of family environment on sibling relationship revealed significant differences among respondents in all the aspects of sibling relationship viz. contact (F=15.21**), emotional closeness (F=11.97**),confiding (F=15.79**), conflict (F=8.24**) and overall sibling relationship (F=11.93**) at 0.01 level of significance. The Table 2 clearly shows that mean scores of all the dimensions of sibling relationship of respondents with high level of family environment were significantly greater than those with low and average level of family environment. Respondents with high level of family environment had more contact with their siblings (Mean=26.72), experienced more emotional closeness (Mean=25.96) and less conflict (Mean=24.38) with their siblings and also confided more (Mean=16.45) with their siblings as compared to the respondents with low and average family environment. Respondents with average family environment had significantly more contacts (Mean=21.70) with their siblings and less conflict (Mean=27.92) with their siblings, also confided more (Mean=14.20) with their siblings in

comparision to the respondents with low family environment. Respondents who perceived low family environment had a significantly lesser number of contacts (Mean=18.97), less emotional closeness (Mean=20.60), less confiding (Mean=13.00), and more conflicts (Mean=32.09) with their siblings.It can be elucidated from these results that better was the family environment, more were the contacts, emotional closeness and confiding and lesser were conflicts among siblings. Overall, sibling relationship was better with a high or better and average family environment.

Impact of family environment on sibling relationship

To predict the impact of family environment on sibling relationship during middle adulthood, linear regression was computed. The overall score of sibling relationship was taken as dependent variables and family environment was taken as an independent variable. Family environment accounted for 6.7% variance in sibling relationships.These results (Table 3) indicate that the family environment is a predictor of sibling relationship during middle adulthood.

Table 3. Linear regression between family environment and sibling relationship (n=240)

Model (s)	Unstandardized coefficients		Standardized coefficients	t – value	Adjusted R^2	F-value
Variables	**B**	**SE (B)**	B			
(Constant)	51.430	8.30		6.19**	0.067	18.24**
Family environment	0.137	0.032	0.267	4.27**		(df=1, 239)

Significant at **p <.01 level of significance; predictor family environment; dependent variable: overall sibling relationship

Hence, the assumption that the family environment has a significant effect on sibling relationship is true. It is universally true that social and emotional development of an individual is majorly influenced by the family environment. An enriched family environment fosters our growth and development and serves as a conducive surrounding to learn and develop. This results in a better understanding of relations in any society and family, and we tend to value relations with others outside the home and with our siblings and family members in our family. Therefore, it can be concluded that individuals from a good family environment have a good relationship with their siblings.These findings are consistent with previous research studies. Tippett and Wolke (2015) reported harsh parenting leads to elevation in sibling aggression, whereas, positive parenting tends to pacify aggression in siblings.

Preferential treatment towards one sibling develops rivalry and jealousy among siblings which leads to problematic sibling relationships (Hashim and Ahmad, 2016). Also, marital and family processes *viz.*, parenting behaviour and spousal conflicts are predictors of quality of sibling relationships (McHale *et al*., 2012; Pauldine *et al.*, 2015).

Association between gender and sibling relationship of respondents

Chi-square was computed between the gender of respondents and their sibling relationships (Table 4).

Table 4: Association between gender and sibling relationship of respondents (n=240)

Gender	Overall sibling relationship			χ^2-value
	Below average	Average	Above average	
Male	18(15.0)	47(39.2)	55(45.8)	0.98
Female	13(10.8)	51(42.5)	56(46.7)	NS
Total	31(12.9)	98(40.8)	111(46.3)	

Note: Figures in parentheses indicate percentages; NS: Non-significant

Gender and sibling relationship of respondents was not significantly associated, χ^2= 0.98 (d.f.=2), p>0.05. It can be interpreted from these results that the sibling relationship between male and female adult respondents was similar. Hence, the hypothesis that the gender of respondents and overall sibling relationship are not significantly associated was accepted. Singh and Sakshi (2015) also reported that there was no significant difference for mixed-sex vs. same-sex dyads on adult sibling relationship and its various dimensions.

CONCLUSION

Majority of the adults perceive their family environment as average irrespective of the geographical location of their residence. Family environment is a predictor of sibling relationship during middle adulthood and has a significant influence in developing and building relationship with others and particularly with siblings. The family environment plays a crucial role. A cordial and healthy family environment promotes interpersonal relationships, whereas, an uncongenial and poor family environment impedes interpersonal relationship. Siblings play the role of peers during the early years. Once relations are strong and healthy, they are likely to continue across the life-span, may it be middle adulthood.

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PERFORMANCE APPRAISAL OF PMFBY *VIS-À-VIS* RWBCIS IN INDIA

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ABSTRACT

The study aimed to overview the numerous crop insurance schemes in India from its initial schemes to the present schemes. The study appraised the performance of "Pradhan Mantri Fasal Bhima Yojana" (PMFBY) *vis-a-vis* "Restructured Weather Based Crop Insurance Scheme" (RWBCIS) from 2016-17 to 2018-19.The growth rate analysis calculated to examine the number of farmers covered and the total agriculture area insured under the schemes indicated that the number of farmers covered and total agricultural area insured under PMFBY and RWBCIS was negative (-1.04% & -4.86%) and positive (1.47% & 8.22%) respectively. The Analysis of variance (ANOVA) and Multiple Least Significant Difference (LSD) tests to compare the means of farmers' premium, gross premium, claims reported, and claims paid showed a significant difference among the parameters under both the schemes. Multiple LSD results revealed a significant difference between farmers' premium and other parameters under both the schemes. Also,there was a significant difference between gross premium and other parameters under PMFBY only denoting that the insurance companies were more benefited under the scheme.

Keywords: Agricultural sector in India, Crop Insurance, PMFBY, RWBCIS, and Agricultural Risk Management.

INTRODUCTION:

The economic transformation in India is highly dependent upon the development of agriculture and its allied sector as 54.6% of the Indian population engaged in agriculture and allied activities (GoI, 2011). More ever,70% of the rural households primarily depend upon agriculture for their livelihood. Also, India is one of the largest consumer countries in the world, consuming 27% of world consumption (FAO,2020). Since India is a consumer country, the nation has to safeguard its food security; this can be attained by developing agriculture in India. However, it is found that "agriculture contribution to national income gradually declined from 18.2 % in 2014-15 to 16.5% in 2019-20 (Economic Survey of India, 2020)." India's Agriculture sector is deprived by production failure from climatic aberrations, rainfall vagaries, pest attacks, etc. Because of this, farmers wouldn't be able to sustain smooth agriculture.

For ensuring security and doubling, the farmers' income, Government of India (GoI) has found Agricultural Insurance coverage as one of the essentialinstrumentsto mitigate farmers' financial loss. GoI has introduced "Pradhan Mantri Fasal Bima Yojana (PMFBY) and Restructured Weather Based Crop Insurance Scheme (RWBCIS)" on 18th February 2016 with

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the uniform premium rate.Under both the schemes, farmers have to pay 2 percent of the sum insured for all notified *Kharif* crops and 1.5 percent for all *Rabi* crops as premium. In the case of annual commercial or horticultural crops, the maximum premium is only 5 percent of the sum insured. PMFBY has replaced the erstwhile"National Agricultural Insurance Scheme" (NAIS) and "Modified National Agricultural Insurance Scheme" (MNAIS) where RWBCIS is a restructured form of "Weather Based Crop Insurance Scheme" (WBCIS). PMFBY provides the risk coverage for farmers against crop failures, which may occur due to natural calamities, pests attack & diseases from pre-sowing to post-harvest period. Likewise, RWBCIS provides risk coverage against crop loss on account of adverse weather conditions like rainfall (Deficit, Excess, Dry Spell or Wet Spell), temperature (High, Low, Mean), humidity, wind velocity, and solar radiation. Under PMFBY, crop losses are estimated based on area yield risk through the number of Crop Cutting Experiments (CCEs). In contrast,weather parameters are used as a proxy indicator for determining crop losses under RWBCIS.

Recently GoI approved the critical changes in the guidelines of PMFBY and RWBCIS, which are effective from the 2020 *Kharif* season. One of the substantial vital changes is,reduced its share of the premium subsidy from the current 50 percent to 25 percent in irrigated areas and 30 percent for unirrigated areas. However it specified that farmers' premium rate continues as it was before. Another critical change is that the Central governmentshare in premium subsidy to be increased to 90 percent for the North Eastern States from the existing sharing pattern of 50:50. However, despite GoI endeavors to insure farmers, the crop insurance schemes are not stretched to all farmers in the country. The success of the schemes can be measured by analyzing the benefits and acceptance level of the schemes by the farmers.Hence, the research is conducted to appraisal the performance of PMFBY and RWBCIS with theobjectives 1) to overview the historical development of Crop Insurance in India 2) to analyze the number of farmers and agricultural area covered under PMFBY and RWBCIS during the study periodand 3) to compare Farmers' Premium, Gross Premium, Claims Reported, and Claims Paid under PMFBY and RWBCIS in Indiaduring the study period.

Hypotheses: H_{a1}: There is a significant difference between Farmers' Premium, Gross Premium, Claims Reported, and Claims Paid under PMFBY; $H_{a2:}$There is a significant difference between Farmers' Premium, Gross Premium, Claims Reported, and Claims Paid under RWBCIS.

MATERIAL AND METHODS

The historical development of crop insurance schemes in India and their salient features and limitations have been understood by analysing various journals, annual reports, and committee reports, which were collected during 2019-20. For the appraisal of the performance of PMFBY and RWBCIS, the

secondary data was collected during 2019-20 from the Agricultural Statistics at a Glance, 2019, Directorate of Economics & Statistics, GoI website.

Growth Rate Analysis

There are many discrepancies year by year in the enrollment of farmers and agricultural area insured under both the schemes from 2016-17 to 2018-19; to analyse this, the growth rate analysis was caluclated

$$AAGR = \frac{GR_A + GR_B + \ldots + GR_n}{N}$$

In which,

AAGR = Average Annual Growth Rate

GR_A= Growth rate in period A

GR_B= Growth rate in period B

GR_n= Growth rate in period n

N= Number of years

The Annual Growth Rate (AGR) of the year is calculated by the current year value minus previous year value divided by the previous year value. If the AGR is positive, the variable starts increasing; likewise if it is negative, the variable starts decreasing year by year.It indicates the overall average growth rate of all years as it helps to determine long-term trends. The growth rates are calculated throughthe above formula and the rates are converted into a percentage form for better understanding.

Analysis of Variance

The Analysis of Variance (ANOVA) has been used to compare the means of farmers' premium, gross premium, claims reported, and claims paid during 2016-17, 2017-18, and 2018-19. Further more, to find out the significant difference between the parameter,the Least Significant Difference (LSD) test is used at 0.05 significance level as a post-hoc test. The outcomes of the ANOVA and LSD tests are calculated with the help of the Statistical Package for Social Sciences (SPSS) version 25.

RESULTS AND DISCUSSION

Historical Development of Crop Insurance in India

The history of crop insurance in India dates back to post Independence 1920 when Mr. J.S Chakravarti,finance secretary of the Mysore state came up with a book titled "Agricultural insurance: A practical scheme suited to Indian conditions" was published, which was a groundbreaking work on agriculture insurance. He had proposed rain insurance for the Mysore state to protect peasants against aberrations of monsoon. (Mishra, 1995; Bhende, 2005). After independence,with the support of Prof. V. M. Dandekar's review on the expert committee report,GoI had decided to launch crop insurance schemes in India. Consequently, in 1972 GoI introduced its first-ever individual approach crop insurance scheme to protect the farmers against crop failures. For flexible options,GoI has been introducing and restructuring the severalcrop insurance schemes to overcome the earlier insufficiencies, problems, and challenges in the domain of crop insurance to make the schemes 'farmer-friendly.'

Table 1. Crop insurance scheme in India (1972-2016)

Crop Insurance Scheme	Period	Approach	Crops Covered	Salient Features	Limitations
Individual Approach Scheme	1972-78	Individual approach (experimental basis)	H-4 Cotton, groundnut, wheat, potato	It was implemented only in six states (Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Tamil Nadu, and West Bengal)	Uneconomic & Unsuitable for large scale implementation
Pilot Crop Insurance Scheme	1979-84	Area approach (Pilot basis)	cereals, millets, oilseeds, cotton, potato, and chickpea	Coverage is restricted to only loanee farmers voluntarily & 50 percent of the premium was given as subsidy to the Small and Marginal farmers	Marginal & small farmers could not be able to participate. Major commercial crops are excluded
Comprehensive Crop Insurance Scheme	1985-99	Area approach	Foodgrains and oilseeds	It was compulsory for loanee farmers & The premium rate was 2 percent of the sum insured for cereals and millets and 1 percent for pulses & oilseeds	Manipulations in Crop cutting experiments & Coverage capped at `10000 per farmer
Experimental Crop Insurance Scheme	1997-98	Area approach	Cereals, pulses, and oilseeds and oilseeds	It had covered non-loanee, marginal and small farmers also. It was implemented in one districtof each fivestates (Andhra Pradesh, Assam, Karnataka, Orissa, and Tamil Nadu)	The high financial burden to the Governments
Pilot Scheme on Seed Crop Insurance	1999-2000	Pilot basis	Seed crops (Cereals, Lentils, Oilseeds, Cotton and jute and Potato)	The objective was to give financial security to seed breeders and seed growers against the failure of seed crops	Limited scope (Limited to seed croppers)

Crop Insurance Scheme	Period	Approach	Crops Covered	Salient Features	Limitations
National Agricultural Insurance Scheme	1999-2014	Area and Individual approach	All crops	Premium subsidy beginning with a 50 percent sponsorship in the first year, which would be diminished by 10 percent every year and was to be totally eliminated in five years	Private insurance companies are not involved. It has not considered Prevented sowing and post-harvest losses
Farm Income Insurance Scheme	2003-04	Area approach (Pilot Project)	Wheat and Rice	It covered yield risk and as well as market price risk & 75 percent Premium subsidy for small and marginalized farmers and 50 percent for other farmers	Price and Yield are negatively correlated; the probability of claim arises only when Price and Yield both go below the guaranteed level, which may be a rarity
Weather Based Crop Insurance Scheme	2007-16	Area approach	All crops	The claim amounts will be decided based on adverse weather deviations recorded in the Reference Weather station	The difference between actual farm loss and estimated loss calculated based on weather stations recorded data
Modified National Agricultural Insurance Scheme	2010-16	Area and Individual approach	All crops	The scheme unit area of insurance had been reduced to a village or village panchayat level for significant crops & It permitted Private-sector participation to create a competitive crop insurance atmosphere	Delay in claim settlement & less coverage of farmers

Source : Report of the Committee to Review the Implementation of Crop Insurance Schemes in India, 2014 and ICFA Business report.

Number of Farmers insured

The number of farmers covered under PMFBY and RWBCIS for both *Kharif* and *Rabi* periods in India has been presented and analysed in the following Tables.

Table 2. Number of Farmers Covered during *Kharif* and *Rabi* season

Year	Season	PMFBY	Total	AGR (%)	RWBCIS	Total	AGR (%)
2016-17	*Kharif*	39203607	56271840	—-	1544111	2099573	—-
	Rabi	17068233			555462		
2017 -18	*Kharif*	33906851	50773721	-9.77	1452642	2022758	-3.66
	Rabi	16866870			570116		
2018-19	*Kharif*	32929418	54685103	7.70	1400037	2126449	5.13
	Rabi	21755685			726412		
	AAGR			-1.04			1.47

Source: Agricultural Statistics at a Glance,DES, 2019.

The number of farmers covered under insurance schemes is one of the indicators of the success of the schemes. From Table 2, it can be observed that the AGR is negative under both the schemes in 2017-18, *i.e.,* 9.77percent and 3.66 percent, respectively. But in the year 2018-19 number of farmers covered is increased by 7.70 & 5.13 percent under PMFBY and RWBCIS, respectively,compared to the year 2017-18. The AAGR during the study period under PMFBY as recorded negative to the extent of 1.04 percent and RWBCIS recorded a positive growth rate of 1.47 percent.

Agricultural Area Insured

Table 3. Total Agricultural Area Insured during *Kharif* and *Rabi* season (ha)

Year	Season	PMFBY	Total	AGR (%)	RWBCIS	Total	AGR(%)
2016-17	*Kharif*	36923719	55365660	—-	1318443.49	1718455	—-
	Rabi	184419401			400011.51		
2017 -18	*Kharif*	31945190	49465305	-10.66	1654155.00	2033869	18.35
	Rabi	17520115			379713.87		
2018-19	*Kharif*	30442101	49930213	0.94	1472009.29	1994941	-1.91
	Rabi	19488112			522931.37		
	AAGR			-4.86			8.22

Source : Agricultural Statistics at a Glance, DES, 2019.

Table 3 indicates the total agricultural area insured under the PMFBY and the RWBCIS. In the year 2017-18, it has seen a negative annual growth (10.66 percent) compared to 2016-17 under the PMFBY scheme. However, in the same year, RWBCIS has recorded a positive growth rate of 18.35 percent. Moreover, in 2018-19, there is a positive growth in the agriculture area insured under PMFBY. However, in the same year under RWBCIS, the growth rate has decreased by 1.91 percent.

Comparative Analysis

In this section, an attempt has been made to compare farmers' premium, gross premium, claims reported, and claims paid under both the PMFBY and RWBCIS.Table 4 indicates increase in farmers' premium and gross premiums year by year. But in 2018-19, the claims reported and claims paid are decreased by 0.66 and 12.96 percent, respectively, despite the increase in farmers' premium and gross premium.

PMFBY

Table 4. Farmers' Premium, Gross Premium, Claims Reported and Claims paid under PMFBY

(Rs. in Lakhs)

Year	Farmers' premium	AGR (%)	Gross Premium	AGR (%)	Claims Reported	AGR (%)	Claims paid	AGR (%)
2016-17	381234	----	2024315	----	1511598	---	1510977	---
2017 -18	393596	3.24	2298639	13.55	2005094	32.65	1994371	31.99
2018-19	435036	10.53	2621442	14.04	1991944	-0.66	1735921	-12.96
Grand total	1209866	---	6944396	---	5508636	---	5241269	---

Source : Agricultural Statistics at a Glance, DES, 2019. **Note:** Gross premium includes farmers' premium plus central and state governments' share of the premium.

Table 5. Comparision of Farmers' Premium, Gross Premium, Claims Reported and Claims paid under PMFBY

Groups	Sum of Squares	df	Mean Square	F value	Significance
Between Groups	6054166787552.249	3	2018055595850.750	35.449	0.000057*
Within Groups	455430101622.000	8	56928762702.750		
Total	6509596889174.249	11			

Table 5 illustrates the ANOVA results. Since the p-value 0.000057* is lesser than the 0.05 significance level;hence,it is resulted in the acceptance of the alternate hypothesis and rejection ofnull hypothesis. Further, it can be inferred that there is a significant difference among the means of farmers premium, gross premium, claims reported, and claims paid under the PMFBY. However, which parameters significantly differ from other parameters is not being identified from the ANOVA test. Therefore, the multiple LSD test is conducted to find a significant difference between the parameters.

Table 6. Multiple Comparisions of Farmers' Premium, Gross Premium, Claims Reported and Claims Paid under PMFBY

(Mean Difference in Lakh Rupees)

(I) Parameters	(J) Parameters	Mean Difference (I-J)	Std. Error	Significance
Farmers' Premium	Gross Premium	-1911510.000*	194814.036	.000*
	Claims Reported	-1432923.333*	194814.036	.000*
	Claims Paid	-1343801.000*	194814.036	.000*
Gross Premium	Farmers' Premium	1911510.000*	194814.036	.000*
	Claims Reported	478586.667*	194814.036	.040*
	Claims Paid	567709.000*	194814.036	.019*
Claims Reported	Farmers' Premium	1432923.333*	194814.036	.000*
	Gross Premium	-478586.667*	194814.036	.040*
	Claims Paid	89122.333	194814.036	NS
Claims Paid	Farmers' Premium	1343801.000*	194814.036	.000*
	Gross Premium	-567709.000*	194814.036	.019*
	Claims Reported	-89122.333	194814.036	NS

*** The mean difference is significant at the 0.05 level; NS - Non-significant.**

There is a significant difference between farmers' premium and other parameters. It indicates that farmers' premium is significantly less compared to the gross premium, claims reported, and claims paid (Table 6). Also, it is recorded that there is a significant difference between gross premium and other factors. It implies that gross premium is significantly more than farmers' premium, claims reported, and claims paid under PMFBY. It is also observed that there is no significant difference between the claims reported and claims paid.

RWBCIS

Table 7. Farmers' Premium, Gross Premium Claims Reported and Claims Paid under RWBCIS **(Rs. in Lakhs)**

Year	Farmers' premium	AGR %	Goss premium	AGR (%)	Claims Reported	AGR (%)	Claims paid	AGR %
2016-17	40408	---	163178	---	165837	---	165829	---
2017-18	45964	13.75	236322	44.82	187465	13.04	187182	12.88
2018-19	56842	23.67	289156	22.36	325656	73.72	265621	41.91
Grand total	143214	---	688656	---	678958	---	618632	---

Source : Agricultural Statistics at a Glance, DES, 2019; **Note:** Gross premium includes farmers premium plus central and state governments' share of the premium.

It is observed that from 2016-17 to 2018-19,farmers' premium, gross premium, claims reported, and claims paid have positively been increased (Table 7). In 2017-18 the AGR of the gross premium was highest,which is 44.82 percent compared to all of the others. However, in the year 2018-19, the AGR of claim reported has highly been increased by 73.72 percent compared to the previous year's growth rate;by this, it has become the highest one among the farmers' premium, gross premium, and claims paid under the RWBCIS. In 2017-18 the AGR of the gross premium is increased higher than farmers' premium, but in 2018-19 the farmers' premium is increased (23.67 percent) than the gross premium (22.36 percent).

Table 8 illustrates the ANOVA results. Since the calculated p-value 0.016* is lesser than the 0.05 significance level; therefore, the research hypothesis is accepted, and the null hypothesis is rejected. Consequently, it can be inferred that there is a significant difference among the means of farmers premium, gross premium, claims reported, and claims paid under the RWBCIS. However, which parameter significantly differs from other parameters is not being identified from the ANOVA test. Therefore, the multiple LSD test is conducted to find a significant difference among the parameters.

Table 8. Comparision of Farmers' Premium, Gross Premium, Claims Reported and Claims Paid under RWBCIS

Groups	Sum of Squares	df	Mean Square	F value	Significance
Between Groups	68265626806.667	3	22755208935.556	6.343	0.016*
Within Groups	28701638457.333	8	3587704807.167		
Total	96967265264.000	11			

Table 9. Multiple Comparisions of Farmers' Premium, Gross Premium, Claims Reported and Claims Paid under RWBCIS

(Mean Difference in Lakh Rupees)

(I) Parameters	(J) Parameters	Mean Difference (I-J)	Std. Error	Significance
Farmers' Premium	Gross Premium	-181814.000*	48906.065	.006*
	Claims Reported	-178581.333*	48906.065	.006*
	Claims Paid	-158472.667*	48906.065	.012*
Gross Premium	Farmers' Premium	181814.000*	48906.065	.006*
	Claims Reported	3232.667	48906.065	NS
	Claims Paid	23341.333	48906.065	NS
Claims Reported	Farmers' Premium	178581.333*	48906.065	.006*
	Gross Premium	-3232.667	48906.065	NS
	Claims Paid	20108.667	48906.065	NS
Claims Paid	Farmers' Premium	158472.667*	48906.065	.012*
	Gross Premium	-23341.333	48906.065	NS
	Claims Reported	-20108.667	48906.065	NS

*** : The mean difference is significant at the 0.05 level; NS - Non-significant**

There is a significant difference between farmers' premium and other parameters. It indicates that farmers' premium is significantly less compared to the gross premium, claims reported, and claims paid (Table 9). Also, it is recorded that there is no significant difference between the gross premium and claims reported and claims paid. It is also found that there is no significant difference between claims reported and claims paid under RWBCIS.

CONCLUSION

It was observed that the coverage of farmers under both the schemes was increased in 2018-19 despite a decrease in 2017-18; this has shown the acceptance level of the schemes by farmers in India. In the comparative analysis, it has been observed that farmers' premium is significantly lesser than the gross premium, claims reported, and claims paid under both the schemes.Therefore, farmers are benefited under both the schemes. Accordingly, farmers have received more money in the form of indemnity against their premium. Under PMFBY, the gross premium is significantly more than farmers' premium, claims reported, and claims paid.On the contrary, under RWBCIS,the difference

between gross premium and claims reported and claims paid is statistically insignificant. It implies that the insurance companies are more benefited by receiving premium during the study period under PMFBY than RWBCIS. Since many states have raised the complaints against some insurance companies for non-payment and delayed payment of claim amount under the schemes (The Economic Times, 2020), it is recommended that the government has to limit the number of insurers; who are making use of the schemes as cash cows and it is better to give permission only to social concerned and non-profit motive insurers to offer the schemes.

Recently, GoI approved the guidelines for the reduction in the share of the central government's premium subsidy except to the North Eastern States for the schemes. It could create a financial burden to the state governments since the schemes are optional to them; there are possible chances to withdraw from the schemes by the states. It can create a difference in the socio-economic welfare of farmers of different states in India.Therefore, it is suggested that policymakers have to reconsider the decision. Subsidised crop insurance schemes have been helping financially to the enrolled farmers for their agriculture risk management. It gives moral stimulation to the farmers to continue farming even after crop failures. With all of these benefits, the government is reasonable to proceed with the subsidised crop insurance schemes in India.

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Research Note
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EFFECT OF LAND CONFIGURATION AND COW DUNG MANURE ON MAIZE PERFORMANCE IN MINNA, SOUTHERN GUINEA SAVANNA ZONE OF NIGERIA

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Crop yield is adversely affected in the southern Guinea Savanna zone of Nigeria due to the low nutrient and organic matter status of the soils in this agro-ecological zone. The soils found in this zone are mostly coarse-textured (sandy in nature) and are prone to short periods of dryness that result from erratic rainfall pattern in this zone. The potential for crop and soil productivity is quite high considering the vast land area available for crop production in the southern Guinea Savanna zone. Nottidge *et al.* (2005) reported that low crop yields in the southern Guinea Savanna zone are due to low soil fertility, especially low nitrogen and organic matter content.

In an increasingly expanding population with a resultant scarcity of land for arable crop production, continuous cultivation of available land may be a key option for food security. However, continuous cultivation of already fragile agricultural lands gives rise to soil nutrient depletion. The challenge of continuous cropping is further aggravated by overgrazing and removal of crop residues after harvest with little or no application of chemical fertilizers which are often costly and inaccessible to most farming communities. These problems often reduce the productive capacity of both soil and crops (Uwah *et al.,* 2014). Thus, it may be necessary to take advantage of soil and crop management practices that would not only maintain favourable soil physical and chemical conditions, but would also replenish the depleted soil nutrients necessary for increased crop yield.

Application of organic manures is beneficial for improvement of soil physical condition as they work as amendments as well as a source of nutrients essential for enhancement of crop growth and increased yields. Amos *et al.* (2015) and Udom *et al.* (2007) noted that cow dung manure produced good crop growth and higher yield because of its ease of mineralization. Furthermore, organic manures reduce soil bulk density, improve moisture storage, increase organic matter content and enhance concentration of essential nutrients. Management strategies that would favour sustainable crop productivity which maintain soil fertility at reduced cost and increased crop yield are to be worked out.

Land configuration is the modification of the soil surface into various shapes or forms and sizes by employing tillage practices. The emphasis is usually on the configuration or shape of the soil surface irrespective of the type of tillage and tillage implement used. Hence, several researchers have referred to land

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configuration as planting or sowing methods, land configuration practices and land shaping methods (Chiroma *et al.,* 2006; Haque *et al.,* 2002; Deshmukh *et al.,* 2016). Major land configuration practices are ridges (open or tied), furrows, raised bed, broad bed furrows and mounds or heaps. Deshmukh *et al.* (2016) reported poor crop growth and lower yield resulted from sowing on flat bed without any appropriate land configuration. These planting methods are aimed at pulverizing and gathering the top soil to provide a favourable environment for crop growth and enhanced yields. This arises from the fact that most of the soil nutrients and organic matter are concentrated in the upper soil layer. According to Chiroma *et al.* (2008), water use efficiency and nutrient availability to crops are increased under land configuration practices. The effectiveness of any crop management practice (nutrient application, irrigation and crop variety) is determined mainly by land configuration. Therefore, identifying a suitable land configuration practice is essential for proper growth and development of particular crops. The objective of this study was to determine the influence of sowing methods and cow dung manure on the performance of maize.

Field trials were conducted during the growing seasons of 2014 and 2015 at the Teaching and Research Farm of Federal University of Technology, Minna (latitude 9^0 31' N and longitude 6^0 26' E, at 208 m above mean sea level). Minna is located in the southern Guinea savanna zone of Nigeria. Minna has a sub-humid climate with a mean annual rainfall of 1,300 mm and a mean temperature of about 30^0C (Ojanuga, 2006). Rainfall commences in April and ends in October every year. The soils are developed from basement complex rocks, and are mostly sandy in texture.

The treatments were land configuration (ridge, flat and mound) and cow dung manure application rate (0 tons ha^{-1}, 5 tons ha^{-1} and 10 tons ha^{-1}). There were nine treatment combinations altogether arranged in a randomized complete block design and replicated four times.

The experimental plots (4m x 4 m each) were marked out and levelled after ploughing. The net plot was 4 m^2. The various forms of land configuration were constructed followed by the application of cow dung manure. Three to four seeds of 'Oba super 1' maize variety were sown at a spacing of 0.75 m between rows and 0.50 m within rows. Thinning of maize seedlings to two plants per stand was carried out at two weeks after planting (WAP). NPK fertilizer was applied at the recommended rate (90:30:30 kg ha^{-1}). Due to the sandy nature of the soil, nitrogen was applied in split doses at two and six WAP. Weeds control was done manually at two and fiveWAP. Maize cobs were harvestedat physiological maturity (12 WAP), sun-dried for about two weeks and threshed. Plant height was recorded at seedling emergence, vegetative growth, tasseling and maturity stages. Grain yield, stover yield, cob length and cob weight were recorded after crop harvest.

Land configuration had significant ($P \leq 0.05$) influence on plant height at all the stages of crop growth except at vegetative growth stage. Planting on mounds or heaps produced significantly tallest (35.4 cm) maize plants at the seedling emergence stage, but this

Table 1. Effect of land configuration and cow dung manure on plant height (cm) of maize

	Crop growth stages											
	Seedling emergence			Vegetative growth			Tasseling			Maturity		
Treatment	2014	2015	Com-bined	2014	2015	Com-bined	2014	2015	Com-bined	2014	2015	Com-bined
Land configuration (A)												
Ridge	37.0b	28.5a	32.7a	82.1a	108.6a	95.4a	160.2a	210.6a	185.4	167.7a	228.4a	198.0a
Flat	40.0b	28.5a	34.2a	84.5a	107.7a	96.1a	160.8a	214.0a	187.4a	171.2a	230.1a	200.6a
Mound	46.1a	24.7b	35.4a	90.7a	95.2a	93.0a	172.6a	193.8b	183.2a	180.1a	211.8b	195.9a
SE±	2.6	1.7	1.7	6.0	6.1	4.4	8.9	8.1	5.9	8.1	6.9	5.2
Cow dung rate (B)												
0 t ha^{-1}	35.8b	24.1b	30.0b	75.8b	82.9c	79.3c	155.6a	192.0b	173.8b	163.4a	209.9b	186.6b
5 t ha^{-1}	42.3a	26.9b	34.6a	86.8b	103.5b	95.2b	167.9a	208.3ab	188.1a	176.8a	224.4a	200.6a
10 t ha^{-1}	45.0a	30.6a	37.8a	94.7a	125.1a	109.9a	170.1a	218.2a	194.1a	178.8a	235.9a	207.4a
SE±	2.6	1.7	1.7	6.0	6.1	4.4	8.9	8.1	5.9	8.1	6.9	5.2
Interaction A x B	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means with different letter(s) on the same column are significantly different at 0.05 level of probability; NS: Not significant

Table 2. Effect of land configuration and cow dung manure on yield parameters and kernel yield of maize

	Grain yield (kg ha^{-1})			Stover yield (kgha^{-1})			Cob length (cm)			Cob weight (g/4 m^2)		
Treatment	2014	2015	Com-bined	2014	2015	Com-bined	2014	2015	Com-bined	2014	2015	Com-bined
Land configuration (A)												
Ridge	4,944a	3,019a	3,981a	9,833a	4,031a	6,932a	13.4a	13.6a	13.5ab	1,306a	684a	995a
Flat	5,083a	2,727a	3,905a	10,694a	4,031a	7,363a	12.9a	12.9a	12.9b	1,306a	592a	949a
Mound	6,278a	2,921a	4,600a	12,778a	3,990a	8,384a	13.5a	14.0a	13.7a	1,556a	632a	1,094a
SE±	617	270	335	1,203	192	627	0.4	0.5	0.3	171	52	88
Cow dung rate (B)												
0 t ha^{-1}	4,708b	2,396b	3,552b	10,472a	3,938a	7,205a	13.6a	12.4b	13.0b	1,306a	560b	933a
5 t ha^{-1}	5,236ab	2,926ab	4,081b	10,583a	3,938a	7,260a	12.6b	13.8a	13.2b	1,361a	629ab	995a
10 t ha^{-1}	6,361a	3,345a	4,853a	12,250a	4,177a	8,214a	13.6a	14.2a	13.9a	1,500a	721a	1,110a
SE±	617	270	335	1,203	192	627	0.4	0.5	0.3	171	52	88
Interaction A x B	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means with different letter(s)on the same column are significantly different at 0.05 level of probability; NS: Not significant

trend was not sustained throughout the stages of crop growth(Table 1). Ridge planting method gave rise to significantly tallest plants, while the mound sowing method produced significantly shortest plants at both tasseling and maturity stages of crop growth. Rate of application of cow dung manure significantly affected the plant height throughout the cropping season (Table 1). Plant height increased with cow dung manure application throughout the crop growth periods. Irrespective of rate of cow dung manure applied, its applications produced the tallest plants, whereas, the shortest plants were produced when cow dung manure was not applied. In this study, the production of tallest plants resulting from the application of 10 tons ha^{-1} of cow dung compared to 0 and 5 tonsha^{-1} application rates attests to the fact that, increasing cow dung application rate will improve crop growth

Land configuration had significant influence on cob length only (Table 2). Mound planting method resulted in longer cobs than flatbed planting, whereas, both mound and ridge planting methods were on par with each other.Difference in cob length due to ridgeand flat planting method was also not significant. Cow dung manure application rate significantly influenced the grain yield, cob length and cob weight. These yield indices increased with cow dung manure application rate. Application of 10 tons ha^{-1} resulted in significantly highest grain yield, cob length and cob weight, while these yield parameters were significantly lowest with zero application of manure.

According to Deshmukh *et al.* (2016), poor crop growth and lower yield resulted from sowing on flat bed without any appropriate land configuration. Kiran *et al.* (2008) reported that plant height and total dry matter of sorghum increased with ridges and furrows than with the flat bed planting method. Ridges and furrows were observed to perform better due to higher soil moisture conservation. Management strategies that would favour sustainable crop productivity are those that maintain soil fertility and increase crop yield.

In conclusion, planting on the flat and on ridges, and application of 10 tons ha^{-1} of cow dung manure produced the tallest maize plants. Cow dung manure application rate @ 10 tons ha^{-1} resulted in the highest grain yield, cob length and cob weight. Therefore, application of cow dung as manure at 10 tons ha^{-1} has the potential for improving maize performance for sustainable food security.

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Research Note
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SPATIAL HEDONIC PRICE ANALYSIS OF DRY CHILLIES IN KARNATAKA

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Chilli (*Capsicum annum*), is an important spice crop valued for its diverse commercial uses. India, accounts for 36% of world's production and exports the chillies to over 90 countries in the world. Andhra Pradesh (composite) and Karnataka states are the leading producers in India with 57% and 12% share in Indian production, respectively. Dry chilli is mainly grown as rain fed crop in south India. Dried chilli powder is consumed directly as food due to its spicy taste. Besides direct consumption, the chillies are also used for the extraction of colour and oleoresins that are used in the manufacture of expensive cosmetics and dyes. Chilli varieties differ from each other in terms of their coloor, pungency and oleoresin content. Guntur variety is pungent, with the fruit being short, thick and red with ASTA colour value of 32.11 and the capsaicin content of 0.226%. The Guntur variety is primarily used for direct consumption. Byadgi variety has rich colour (ASTA colour value is 159.9) and mild spiciness(capsaicin content is 0.59% (Spices Board, 2020). Being a rainfed crop, the revenues from chilli cultivation are of high importance to farmers and the local economies of a particular state.

The price of dried chillies varied widely between Rs.38 to Rs.19,878 per q during the studybased on factors such as variety, quality, colour, and seasonality.Observation of price data suggests that prices in markets that are located geographically close tend to be similar. Agglomeration of markets, transportation costs, and other regional factors could result in regional price variation. Previous studies considered the effects of traditional factors such as colour, quality and seasonality on the prices. Spatial spillover effects and market specific effects were not previously explored. These unaccounted spillover effects could potentially bias the estimates of price functions. Also, these effects could be more practically relevant, as farmers could benefit by catering to these markets.

The objective of this study is to estimate the spatial hedonic model for chillies.It is hypothesized that price differs significantly between varieties and across markets even after controlling for quality characteristics. Hedonic price analysis treats a good(product) as a bundle of characteristics and explains the price of an item in terms of these quality characteristics. For Example, the consumer's willingness to pay for the chilli (powder) based on colouror pungency can be estimated by regressing the price of the item on the quantity of embodied characteristics. Besides the item's

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characteristics, location of markets could also influence the price. Prices in neighboring markets tend to be correlated and this correlation decreases with increasing distance between the markets.Buyers and sellers might consider markets in the vicinity as related. Low costs of transportation, storability of the produce can induce spatial spillover effects.To capture these spatial spillover effects, aspatial hedonic price function using Maximum Likelihood Estimators after Box-Cox transformation on the dependent variablewas estimated. Results from the model indicate statistically significant and positive spatial effects across markets.

Triplett (2006) provides an overview of the hedonic price methodology and a comparision of empirical price function specifications. Bhavani Devi *et al*. (2015) found statistically significant price volatility in chilli prices that differed across time and markets. Naidu *et al*. (2014) found evidence for seasonality in prices with highest amplitude in the month of March and lowest amplitude in the month of September.Srikala (2016) investigated for irregular variations in prices and have not found any irregularity in the price time series in their study. Shivashankar (2007) found that different markets offered dissimilar grades of chillies.Following the literature, a hedonic price model with variables measuring quantity, qualitative characteristics and seasonalityhas been specified.The spatial hedonic price function after Box Cox transformation is specified as in equation (1):

$$Y = \rho WY + X\beta + \varepsilon \quad (1)$$

Where, Y is log of Price, *W* represents spatial weights matrix; ρ_1 is spatial correlation parameter to be estimated; β represents the parameters to be estimated; *X* represents independent variables as described above. ε represents the random error component. Specification of Spatial weights matrices is of vital in spatial econometric models. Method such as exponential distance decay, inverse squared distance and inverse cubed distance are widely followed in the literature. Following the approach of Ponnaluru (2012), Spatial weights matrix *W* is specified using the exponential distance decay measure and is standardized to preserve the symmetry of the spatial weights matrices.

Market level panel data set published by Ministry of Agricultural Marketing, Govt. of Karnataka (Source: APMC *Krishimarata Vahini* website, Govt. of Karnataka) covering fifteen-years period from 2002 to 2017 is considered (the year of this study is 2019-20) and cross sectional, analytic study design is implemented. Dependent variable of the study is price (Table 2). The prices observed are nominal (Table 1). It could be noted that in general, higher mean prices occured in Managalore, Bangalore markets compared to other markets such as Byadgi. Chillies arrivals at the market also exhibit seasonality (Table 1). Peak season is from December to April each year accounting for over 82% of all arrivals. February and March with 22.7%, and 22% are the months with highest arrivals. June to October being lean period accounts for 10% of all arrivals. Arrivals quantity is treated as exogenous in this study, as the production is dependent on the planted

Table 1. Descriptive statistics and brief definitions of variables

Variable	Definition	Min.	Max.	Mean	SD
modalp	Nominal Price in Rupees (Rs/qtl). Mode of the price series realized during the trading day	38	19878	6059.8700	3258.1500
arrivals	Quantity of Chillies arriving at Market in quintals	0	63000	325.7615	1552.4600
byadgi	Dummy variable. Value = 1 if Variety is Byadgi, else 0	0	1	0.2567	0.4368
guntur	Dummy variable. Value = 1 if Variety is Guntur, else 0	0	1	0.1909	0.3930
local	Dummy variable. Value = 1 if Variety is Local, else 0	0	1	0.2511	0.4337
avg	Dummy variable. Value =1 if Grade is Average, else 0	0	1	0.5946	0.4910
medium	Dummy variable. Value =1 if Grade is Medium, else 0	0	1	0.0868	0.2816
small	Dummy variable. Value =1 if Grade is Small, else 0	0	1	0.0021	0.0460
large	Dummy variable. Value =1 if Grade is Large, else 0	0	1	0.0029	0.0541
mblr	Dummy variable. Value =1 if Market is Bangalore, else 0	0	1	0.3457	0.4756
mbdg	Dummy variable. Value =1 if Market is Byadgi, else 0	0	1	0.1637	0.3700
nov	Dummy variable. Value =1 if Month is November, else 0	0	1	0.0802	0.2716
dec	Dummy variable. Value =1 if Month is December, else 0	0	1	0.0955	0.2939
jan	Dummy variable. Value =1 if Month is January else 0	0	1	0.0949	0.2930
feb	Dummy variable. Value =1 if Month is February, else 0	0	1	0.0945	0.2926
mar	Dummy variable. Value =1 if Month is March, else 0	0	1	0.0975	0.2967
apr	Dummy variable. Value =1 if Month is April, else 0	0	1	0.0769	0.2664
sep	Dummy variable. Value =1 if Month is September, else 0	0	1	0.0728	0.2598

crop, which is done much ahead of marketing time, however, given the storability nature of the product, arrivals could be timed to follow higher prices. It is assumed in this study that storage period does not extend beyond a year. Major markets for dry chillies in Karnataka are Byadgi with a total of 74.6%, Bangalore 9.3%, Hubbali with a market share of 8.3% and all other markets with a share of 7.6%. Size, location and other regional characteristics of these markets can affect the price. These effects are captured by modeling spatial autocorrelation.

Different varieties of chillies could command different prices owing to the differences in their characteristics. *Kaddi* variety occupies a market share of 49.3%, with Guntur variety (24.5%), and *Byadgi* (6%). Dummy variables were specified to capture the price differences across these varieties. Grade of chillies is another important factor affecting price. It could be observed that *Average* grade accounts for 63% of total arrivals, *Medium* 24% and others grades such as *Large, FAQ,* and *small* account for remaining 11% of market share. It is hypothesized that the parameter estimates on these dummy variables are significantly different from each other.

Results from the spatially lagged dependent model are presented in Table 2. Parameter estimate on *arrivals* is positive and statistically significant. This could indicate that larger markets with more arrivals fetch higher prices compared to markets with lesser arrivals. This positive relationship between quantity and product price is as expected of an inverse supply function, however, caution must be exercised in the interpretation of this relationship, as the estimated model does not

Table 2. Parameter estimates from MLE estimation on spatial lagged dependent variable mode with data pooled across time and space under Box Cox transformation

Variable	Parameter Estimate	Pr > |t|
Intercept	131.934	<0.0001
Ln arrival	2.23	<0.0001
byadgi	1.288	0.0058
guntur	-19.003	<0.0001
local	-28.197	<0.0001
avg	31.975	<0.0001
medium	-15.694	<0.0001
small	-18.177	<0.0001
large	31.344	<0.0001
nov	5.511	<0.0001
dec	4.195	<0.0001
jan	3.534	<0.0001
feb	1.995	0.0003
mar	1.279	0.0176
apr	-3.06	0.0000
sep	1.567	0.0242
rho1	0.017	0.0016
Dependent Variable	Ln Price	
Loglikelihood value	-50631.77	
Kaddi variety with *FAQ* size is the base category for dummy variables		

contain enough information for identification as inverse supply function.Parameter estimate of intercept is 131.934, positive and statistically significant. This term captures the price behaviour ofreference category which is a *Hybrid* variety,and FAQ sized. Parameter estimate on *byadgi* is 1.288 positive and statistically significant. Parameter estimate on the variable representing *Guntur* variety is -19.003 negative and statistically significant. Parameter estimate on *Local* is -28.197, negative and statistically significant. These results indicate that *Byadgi* variety received a consistently higher price than among all the varieties;while, *Guntur* variety commands higher price than local variety. These price differences reflect the preferences of consumers and/or producers for these varieties.The findings of this analysis indicate that prices differ statistically significantly and are positively correlated across markets even after controlling for traditional factors.

Parameter estimates on quality of chilies were also statistically significant. Parameter estimate on *average* size is higher than the *medium* size. However, the parameter estimate of the variable *large* size is lesser than the estimate on the variable *average*. These results indicate that price differs significantly with size of chilies. Average sized chillies fetch statistically significantly higher prices compared to any other sized chillies (the price ordering is as: *Average* > *Large* > *medium*>*small*) and parameter estimates on month of sale were also statistically significant. Magnitude of the parameter estimates consistently decrease from November to April. Parameter estimate on variable representing *November* is highest and the estimate on variable representing *April* is smallest among all the months.Parameter estimate representing*September* is higher than most months. These results indicate that after controlling all other characteristics, prices are highest in November with a decline till April. This period corresponds to the peak arrivals with highest arrivals in the month of April. Compared to the peak period, the off-season (from April to November) prices are higher. These results are consistent with the economic behaviour of the markets.Spatial spillover effects due to sales at nearby locations are positive (as captured by the parameter estimate, Rho is 0.017, and statistically significant).Prices at markets located in a neighborhood are higher than the markets located far off from each other. This might be due to addition of shipping costs, and overlap of buyers across the neighbourhood markets.The results from the model could be used in designing optimum marketing policies. Furthermore, research in this area could explore the regional impacts of price formation.

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EFFECT OF FOLIAR SPRAY ON GROWTH AND YIELD PARAMETERS UNDER SALINITY CONDITIONS IN GREENGRAM

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Greengram is an important pulse crop of India having wide soil and climatic adaptability. The lowproductivity in greengram is mainly due to poor fertility status of the soil, nutrient deficiencies and flower shedding. The stress of salinity is one of the negative environmental factor that restrict greengram productivity in arid and semi-arid areas. Salt stress is significant abiotic stress that is harmful to the development and productivity of plants (Syeed *et al*., 2011). Salt toxicity inhibits plant growth and development and can also reduce water physiologically owing to serious salt deposits.

Salinity affects the plant at all growth stages but this effect varies with the growth stages and species. The major effect of salinity on plant growth has been attributed to osmotic inhibition of water availability, the toxic effect of ions and nutritional imbalance caused by such ions.Salt stress-induced low intracellular water potential and water scarcity around the root zone as a result of which roots did not receive enough water and nutrients for plant development (Nirmala *et al.,* 2015).To overcome all these problems under salinity conditions,application of plant growth regulators is one of the important ways to increase salt tolerance of plants.

Foliar applications of liquid fertilizer supply plant nutrients more rapidly than methods involving uptake by root due to seed/root treatment. Leaves, particularly those with thick cuticle, have low absorption rates.Foliar application of nutrients play a vital role in pulse production by stimulating root development, nodulation, energy transformation, various metabolic processes, translocationactivity in plants and pod setting, thereby increases the yield(Mohandoss and Rajesh, 2003).One of the major causes for low seed yield in pulses is due to high level of flower shedding. Foliar application of growth regulators constitutes one of the important technologies that cater to seed nutrition at the most vulnerable stage *i.e.,* seed filling. Significant increases in seed yield of different crops due to foliar application of nutrients and growth regulators have been reported. External application of growth regulators reduces the flowerdrop considerably and thereby increases the pod setting and seed yield (Abdel-Haleem and Mohammed, 2007).

Seed germination, stem elongation, plant extension and reproductive growth are influenced by gibberellins. GA_3 application also counteracts the adverse effects of NaCl salinity on the relative content of water, leakage of electrolytes and the content of Chl. Exogenous GA_3 also increases the content of sugar and

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Table 1. Effect of foliar spray on growth characters of green gram cv. CO 6

Treatments	Plant height (cm)	Number of branches per plant	Number of leaves per plant	Leaf Area Index	Number of clusters per plant
Control	23.88	1.53	16.08	23.18	2.08
Salicylic acid	26.80	5.98	23.35	27.21	4.60
Triacontanol	24.63	3.65	18.93	25.38	3.20
GA_3	28.70	6.88	27.03	29.12	5.52
SED	1.405	0.380	0.901	0.0895	0.2095
CD@5%	3.175	0.850	2.036	0.179	0.419

Table 2. Effect of foliar spray on physiological parameters and yield characters of green gram cv. CO 6

Treatments	Number of pods per plant	Number of seeds per pod	Hundred seed weight (g)	Chlorophyll content (mg/g)	Relative water content (%)	Harvest Index (%)
Control	6.10	5.05	3.225	1.61	11.27	78.72(62.52)
Salicylic acid	10.95	7.16	4.225	2.30	12.34	84.57(66.89)
Triacontanol	9.05	6.05	4.175	2.08	12.22	79.76(63.26)
GA_3	12.75	8.07	5.165	3.21	13.37	87.63(69.40)
SED	0.3914	0.202	0.0670	0.1260	0.1520	0.8265(0.6375)
CD@5%	0.884	0.458	0.134	0.2520	0.3040	1.6530(1.2750)

Note : Figures in Parantheses indicate arc sign transformed values

Table 3. Effect of foliar spray on resultant seed quality of green gram cv. CO 6

Treatments	Rate of germination	Germination (%)	Root length (cm)	Shoot length (cm)	Fresh weight (g/plant)	Dry weight (g/plant)	Vigour Index
Control	4.09	81(64.20)	11.19	19.24	3.062	1.052	2124
Salicylic acid	4.57	87(68.28)	11.64	19.63	3.177	2.032	2514
Triacontanol	4.26	85(67.73)	11.52	19.44	3.125	2.020	2330
GA_3	4.72	93(75.91)	13.12	19.65	3.257	2.045	2579
SED	0.0670	2.8065	0.9161	0.5991	0.0210	0.0200	5.969
CD@5%	0.134	5.613	1.9972	1.3061	0.042	0.040	11.938

soluble protein, while the content of Chl remained unchanged.Keeping this in view, the study was conducted in green gram cv.CO 6 variety to determine the effect of foliar spray on crop growth performance, seed yield and seed quality of green gram under salinity condition.

The seeds of green gram cv. CO 6 procured from the National Pulse Research Center, Vamban were used for the field trial conducted during rabi, 2017 under dryland condition.The treatment include foliar sprays *viz.,*Salicylic acid(100ppm), Triacontanol (100ppm), GA_3 (100ppm) and control. The experiment was laid out in a randomized block design and the treatments were replicated five times.The recommended package of practices for green gram was followed uniformly for all the treatments. Five plants were selected randomly (irrespective of replication label) and the following observations were recorded such as plant height, number of branches, number of leaves, leaf area index, number of clusters, number of pods per plant, number of seeds per pod, chlorophyll content, relative water content, fresh weight, dry weight, hundred seed weight (ISTA, 2013) and harvest index. Furthermore, the resultant seeds were analysed under laboratory condition for seed germination, rate of germination (Maguire, 1962). Shoot length, root length, dry matter production and vigour index(Abdul-Baki and Anderson, 1973).

Crop growth and Seed yield: The results on foliar spray treatments revealed that crop plants sprayed with GA_3 @100ppm recorded higher values in all growth and yield parameters, followed by salicylic acid when compared to other treatments. Greengram seeds sprayed with GA_3 showed the highest performance for the growth and yield attributing traits *viz.,* plant height (28.7cm), number of branches (6.88), number of leaves (27.03), leaf area index (29.12), number of clusters (5.52) (Table1), number of pods per plant (12.75), number of seeds per pod (8.07) and hundred seed weight (5.165 g) (Table 2) when compared to other treatments and control. This might be due to the application of GA_3 which improves nutrient uptake from the soil(Rahman *et al.,* 2018).The above higher yield attributes obtained with a foliar spray of GA_3, might be because of the maximum net photosynthetic rate in leaves and better translocation of photosynthates and metabolites (nutrients,*etc.*). Similar findings were reported by Sankar Ganesh *et al*.(2013) in different varieties of greengram.

Foliar application of Gibberellic acid avoided the reduction of IAA and cytokinin levels in salt-stressed plants resulting in the better cell division in root apical meristem, thus, enhancing yield and productivity of plants (Hayat *et al.,* 2010). The application of gibberellic acid to greengram plants under salt condition showed the beneficial effect which could be due to its influence on translocation of CO_2 assimilation into the seeds and enhancement of photosynthetic rate due to increased chlorophyll content.Karlidag *et al.*(2009) have reported similar findings.By decreasing ionic and osmotic stress and stimulating plant growth, gibberellic acid on salt-treated crops induces salt tolerance in crops.

Physiological parameters: Greengram sprayed with GA_3recorded the highest value for certain physiological traits *viz.,*chlorophyll

content (3.21), relative water content (13.37) and harvest index (87.63%) when compared to other treatments and control. GA_3 application increases the above physiological parameters as reported by Khan *et al.*(2003) under salinity condition in green gram.GA_3 delays senescence, improves growth and development of chloroplast and intensifies photosynthetic efficiency which could be evident from the increased chlorophyll content (Baliah *et al.,* 2018). The foliar application of GA_3 may increase the leaf diffusive resistance and lower transpiration rates and protects relative water content. Low yield attributing characters under control (salt stress conditions) might be due to the thickness of the assimilate conducting pathway is reduced and leaves start behaving as sinks rather than sources. This causes inhibition of assimilating movement towards developing reproductive organs, which might be the reason for observing a decrease in growth parameters. On the other hand, adverse effects of high salinity were alleviated by the hormone treatment, primarily by rejuvenation of the sink potential and enhancement of the duration or rate of dry mass accumulation in developing duration or rate of dry mass accumulation in developing reproductive organs (Tiwari and Lal, 2018).

Seed quality of harvested seeds:The resultant seeds obtained from greengram plants given with foliar spray of GA_3 at flowering stage exhibited the highest germination percentage (93), rate of germination (4.72), root length (13.12 cm), shoot length (19.65 cm), fresh weight (3.257 g), dry matter production (2.045 g) and the vigour index (2579) (Table 3) when compared to all other treatments and control. This might be due to the role of applied plant growth regulators in improving the nutrient uptake from the soil and subsequently increasing the plant growth of salt-stress plants.

The beneficial effect of GA_3foliar spray on resultant seed quality might be due to its effective translocation of CO_2 assimilation into the seeds that leads to increased seed metabolites (evident from higher 100 seed weight) and their digestion by the release of hydrolytic enzymes due to increased aminoacid content by GA_3application(Costa *et al.,* 2011). The application of gibberellins increase the seed germination proportion by attributing the actual fact that they increase the aminoacid content within the embryo and cause the discharge of hydrolytic enzyme needed for digestion of endospermic starch once seeds renew growth at germination.

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EFFECT OF PRESERVATIVE SOLUTION ON VASE LIFE AND FLOWER QUALITY OF GERBERA (G*erbera jamesonii*) VAR. DOUBLE DUTCH

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Gerbera is one of the important cut flower crop of India occupied a premier position in the cut flower industry. It is a dwarf herbaceous perennial cut flower which is being cultivated for the long productive period and for its beautiful colours. It is cultivated in poly houses for commercial production and also in the flower bed in gardens.In recent years, significant growth in gerbera cultivation has taken place in India has been accompanied by due to its preference among the consumers and potential in market. Many preservative solutions were introduced to increase the quality and vase life of cut flowers. Plant growth regulator application has brought out many changes in growth and flowering in gerbera. The use of regulators in extending vase life of flowers is also proven for many other cut flower crops. Vase life and membrane stability of the cut spike of gladiolus have been improved with the use of benzyl adenine (BA) (Jafarpour *et al*., 2015). Gerbera being a soft stemmed plant responds well to growth regulators for prolonged vase life. A number of microorganisms are found to contaminate the flowers as well as the vase solution. Among them, *Bacillus pumilus*, an endophyte is found within the flowers. This bacterium is one of the most common in the endophytic microbial community, where it is a contaminant in the symptomless tissue of flowers which cause browning symptoms in the flower and leads to minimal vase life (Sharma *et al*., 2018). Hence, the experiment was laid out to determine the response of gerbera to various preservative solutions and the vase life and flower quality during 2018-19. Preservative solutions *viz.,*Sucrose (4% and 6%), 8 HQC (200 ppm and 250 ppm),BA (100 ppm and 200 ppm) and silver nitrate (25 ppm and 50 ppm) each with two doses along with a control were prepared and used for the study. Freshly harvested gerbera flowers were kept in the containers of each solution which are replicated thrice under completely randomized design.

Observations on vase life, fresh weight, flower diameter, solution uptake and quality parameters such as membrane stability index and ornamental index were recorded once in three days and statistically analysed. The membrane stability index was calculated by taking the percentage of leachates suggested by Leopold *et al.* (1981). In this method, a uniform sample size (25 cm^2) was taken and kept in 25 ml distilled water for two hours and the initial OD value was observed at 273nm using spectrophotometer. Then, it was boiled for 10 minutes. The final value was observed at 273nm. Ornamental value index of the plants in each treatment were calculated by visually assessing the compactness of the

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flower, turgidity, texture, colour and freshness of the flowers and over all look following the ten-point hedonic scoring technique.

Significant results were obtained on the effect of preservative solution on the flower quality of gerbera (Table 1).The data pertaining to the vase life of gerbera showed significant variations. Maximum vase life (12.28 days) was observed in those plants treated with 8-HQC @ 250 ppm(T_4)which is followed by 11.2 days observed in flowers kept in sucrose @ 6% (T_2). The lowest vase life was observed in control (T_9) with 6.28 days. The positive influence of 8-HQC in extending the vase life of gerbera had been attributed to its antibacterial property (Soad *et al.,*2011). According to Banaee *et al.* (2013), the chelating properties of the quinoline compounds/esters probably chelated the metal ions of enzymes active in creating the stem blockage. HQC also acidifies the water and influence the flower longevity. Many researchers found that the microorganisms present in the cut end of the stem and also in water, plug the cut end of the stem which blocks the uptake of water. This may cause flower wilting which is one of the main postharvest disorders leading to stem break that occurs 10cm below thecapitulum (Shabanian *et al.,* 2018). Besides this, blockage of xylem vessels due to bacterial or microorganisms accumulation is another contributing factor leading to quality loss. This blockage can be culminated in water uptake deficiency and water loss showed that some bacteria from vase water could elevate ethylene production (Jalili Marandi *et al*., 2011). This preservative solution prevents the bacterial growth in the cut end which enhances water conductivity of the solution. Application of antibacterial compounds as the vase solution inhibits vascular blockage and increase water uptake (Shanan, 2012).

The data on flower weight was observed once in three days *viz*., 3rd,6th and 9th day. Maximum flower weight (112.4 g, 105.8 g and 100.5 g) was observed in T_4 (8-HQC @ 250 ppm) followed by T_3 (8-HQC @ 200 ppm) with 110.5 g, 103.9 g and 98.6 g on 3rd,6th and 9th day of observation, respectively. The minimum flower weight (93.2 g, 86.6 g and 81.3 g) was observed under control (T_9) at all the three stages of observations. Highest flower diameter (12.3 cm, 10.5 cm and 8.51 cm) was observed in T_4 (8-HQC @ 250 ppm) in all the three days of observation. This was followed by T_3 (8-HQC @ 200 ppm) which recorded 12.2 cm, 10.5 cm and 8.51 cm on 3rd,6th and 9th day of observation respectively. However, the lowest flower diameter (9.65 cm, 7.87 cm and 5.82 cm) was recorded under control T_9 on 3rd,6th and 9th day of observation respectively.The favourable effect of 8-HQC on floral characters might be due to sufficient availability of restorable substrate which reduced microbial activity and increased absorption of solution.

The data pertaining to the solution uptake showed maximum values (22.4 ml, 16.0 ml and 7.72 ml) in the flowers treated with 8-HQC @ 250 ppm(T_4) in all the three stages of observations, respectively. This was followed by T_3 (8-HQC @ 200 ppm) which recorded 20.7 ml, 14.33 ml and 6.05 ml in 3rd, 6th and 9th day of observation, respectively. However, the lowest uptake was observed under T_9-Control which recorded 9.33 ml, 3.93 ml and decreased after 6thday of observation. Among the preservative solutions, maximum solution uptake was recorded with 8-HQC and sucrose in both the dosages acidified

Table1.Effect of preservative solution on vase life and flower quality of gerbera (*Gerbera jamesonii*) var.Double Dutch

Treatments	Vase Life (days)	Fresh weight (g)			Flower diameter (cm)			Solution uptake (ml)			Membrane stability index (%)			Ornamental index
		Day 3	Day 6	Day 9	Day 3	Day 6	Day 9	Day 3	Day 6	Day 9	Day 3	Day 6	Day 9	
T_1-Sucrose @ 4 %	8.89	105.3	98.7	93.4	10.7	8.99	6.94	20.0	13.6	5.35	71.4	65.6	56.2	9.68
T_2-Sucrose @ 6 %	11.16	105.9	99.3	94.0	10.7	8.94	6.89	20.1	13.7	5.47	73.9	68.1	58.7	9.21
T_3- 8HQC @ 200 ppm	10.18	110.5	103.9	98.6	12.2	10.4	8.35	20.7	14.3	6.05	76.1	70.3	60.9	9.23
T_4- 8HQC @ 250 ppm	12.28	112.4	105.8	100.5	12.3	10.5	8.51	22.4	16.0	7.72	78.3	72.5	63.1	9.75
T_5- BA @ 100 ppm	8.19	103.2	96.6	91.3	10.1	8.34	6.29	14.9	8.53	1.25	63.2	57.4	48.0	6.32
T_6- BA @ 200 ppm	8.26	103.1	96.5	91.2	10.2	8.44	6.39	15.2	8.78	1.21	65.0	59.2	49.8	7.66
T_7- AgNo3 @ 25 ppm	9.41	107.7	101.1	95.8	10.9	9.2	7.15	17.9	11.5	3.27	67.3	61.4	52.1	8.18
T_8- AgNo3 @ 50 ppm	8.92	108.3	101.7	96.4	11.4	9.65	7.6	18.3	11.9	3.64	67.9	62.1	52.7	8.32
T_9-Control	6.28	93.2	86.6	81.3	9.65	7.87	5.82	9.33	3.93	1.22	60.3	54.4	45.1	4.15
SEd.	0.48	0.73	0.89	0.83	0.06	0.07	0.06	0.74	0.78	0.63	0.72	0.58	0.48	0.03
CD(at 5%)	0.98	1.48	1.80	1.68	0.13	0.14	0.13	1.48	1.58	1.26	1.44	1.18	0.98	0.07

the holding solution, which results in greater solution uptake by flower. Similar results were obtained in tuberose (Wang *et al*., 2014; Meman and Mabhi,2006).

All the preservative solutions enhanced the membrane stability index which leads to better vase life in all the preservative solution treatments. Maximum membrane stability index (78.3%, 72.5 % and 63.1 %) was observed under the treatment T_4(8-HQC @ 250 ppm) which is followed by T_3 (8-HQC @ 200 ppm) with 76.2 %, 70.3 % and 60.9 %) in 3rd, 6th and 9th day of observations, respectively. The lowest membrane stability index (60.3 %, 54.4 % and 45.1 %) was observed in control (T_9) at all three stages of observations. In the study, membrane stability index has been found to be reduced in control treatment. The treatment with 8-HQC @ 250 ppm (T_4) improved membrane stability index that led to better flower vase life. Similar effects on membrane stability index have been reported in Gladiolus with BA and GA3 (Singh *et al*., 2008).

The data on ornamental index showed that those flowers treated under 8-HQC @ 250 ppm (T_4) recorded maximum score (9.75) which is on par with the treatment T_1 (Sucrose @ 4%) with 9.68 %. However, lowest score (4.15) was observed in those flowers kept under control (T_9). Sucrose is a main source of energy and good respiratory substrate for the maintenance of osmotic potential while 8-HQC helped in controlling harmful bacteria and prevented bacterial plugging of water conducting tissues and thereby increased useful life of gerbera stalk. The increase in longevity of flower due to sucrose might be due to the role of applied sugars in delaying senescence. However, the poor vase life recorded under control might be due to the poor absorption of water and multiplication of bacteria and blockage of uptake of the water.

It could be concluded that 8-HQC (Hydroxy Quinoline Chloride) @ 250 ppm can be used as vase solution to enhance the vase life of gerbera var. double dutch flowers for around 12 days with higherquality for marketing purpose.

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CASE STUDY OF FARMER PRODUCER COMPANIES IN CAUVERY DELTA REGION

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Farmer Producer Organisation (FPO) is a legal entity where farmers from the same geographical cluster engaging in the production of similar crops will aggregate themselves for achieving economies of scale and sharing the benefit/profit among the members of the organization (NABARD, 2015). Farmer Producer Company (FPC) is a mixture of professional management and mutual benefit among the shareholders who are farmers.Sankri and Ponnusamy (2015) identified essential processes for the formation of FPC such as promotion, motivation, capacity building, training, exposure visits, and stakeholder meetings.

The Government can frame the criteria for selecting the FPO based on an objective business plan for potential growth through policy implication for providing needed assistance (Michalek *et al*., 2018) and ensuring the FPC information available to interested parties for learning from each other (Trebbin, 2014).

Farmers started showing interest in FPOs due to government initiatives. Besides, donors and NGOs support this institution for achieving good bargaining power, capacity building, and participating in a competitive global market (Trebbin, 2014). Participation in FPO by small farmers could be increased by charging a low entry fee (Ito*et al*., 2012). Farmer Company runs the risk of facing the various challenges which may prevent it from remaining effective and competitive in the local system (Jain and Narnaware, 2018). Hence, FPOs require resource institute support for better performance and sustainability in India (Singh *et al*., 2018). Small Farmers Agribusiness Consortium (SFAC) is the association and Government wing assisting 902 FPOs as of September 30th, 2019 and 8.84 lakhs farmers were benefited(GoI, 2019).

The previous studies dealt with the impact of producer organisation membership and effectiveness (Michalek *et al*., 2018), the role of PO in connecting the farmers with small landholding to the modern retail chain in India (Trebbin, 2014), factors influencing the members' participation in cooperative at China (Ito *et al*., 2012), sustainability of FPOs in India (Singh *et al*., 2018), factors influencing the Farmer Collectives performance (Jain and Narnaware, 2018).Specific questions have remained unanswered about FPCs in India.

As the establishment of FPCs in the Cauvery Delta region has commenced only from the year 2014, it is still in the nascent stage. An attempt is made to understand the reach

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and initial challenges faced by FPCs in the region. For this, an in-depth interview is conducted with CEOs of five selected FPCs in the area with the objectives (a) to explore the status of the management structure of FPC soperating in the Cauvery Delta Region (b) to analyse the challenges faced by FPCs(c) to understand FPCs management with respect to adopting modern agricultural marketing channels.The study was conducted at Thanjavur, Thiruvarur, and Nagapattinam districts of Tamil Nadu.The study is mainly based on personal interview with the management of the FPCs, hence, descriptive and empirical. Out of the twelve FPOs officially functioning in these districts, five FPCs were considered for this purpose. The CEO and Managing Directors were interviewed and data is collected from October to November 2019.The secondary data was collected from the official website of NABARD and SFAC and Government reports during the period 2015-2019.

Status of the Management Structure of Farmer Producer Companies

All the Farmer Producer Companies in the selected Cauvery delta region were registered under the Companies Act, 2013. The Authorized Capital of FPCs documented in the Memorandum of Association(MoA) is INR. 10,00,000 only. However,management can increase it by passing a special resolution in the meeting and communicating with the Registrar of Companies(RoC). The average equity capital contributed by the producers(farmers) is INR. 10,00,000 (INR. 1000/farmer).

It is found that FPCs were established in the Cauvery delta region starting from the year 2014. During 2014, two FPCs were formed at Thanjavur and Thiruvarur district. One FPC in Thiruvarur district in 2016 and one FPC is recently included in Nagapattinam district. Rajarajacholan and Veerachozhan FPC have increased their authorized capital and the members had also exceeded above 1000. Recently formed Mayiladuthurai Kamban Collective FPC Ltd. has 910 members. The majority of FPC deals with more than two crops, and all the management is trading paddy as common produce. (Table 1)

Only farmers are eligible to become members of the FPCs, and interested farmers should contribute INR is 1000 as share capital (10 shares @ INR is 100). It revealed that every member should subscribe ten shares except Veerachozhan FPC which specified that members should contribute INR 500 only (5 shares). This restriction is imposed to avoid concentration of the decision making power in the hands of the few members.

Twenty interested farmers from the local area can integrate themselves to formulate the Farmer Interested Group (FIG). A Cluster of five FIG can be formed as Farmer Help Group (FHG) which will account for 100 members. Finally, a collection of ten FHG can be created as a Farmer Producer Company.Persons with professional skills are likely to be appointed as employees of the FPC, designated as Chief Executive Officer (CEO). The CEO will be performing his duties and responsibilities as instructed by the Board of Directors(BoDs), Resource Institute (RI), Producer Organisation

Table 1. Details of the selected FPCs in the Cauvery delta region

Name of the FPC	Incorporation Date	No. of Members	Crops Dealt
Rajarajacholan FPC Ltd., Thanjavur district	07-10-2014	1033	Blackgram and Paddy
Thiruvarur FPC Ltd., Thiruvarur district	03-09-2014	1000	Paddy, Pulses and Cotton
Karikalan Pulses FPC Ltd., Thiruvarur district	06-01-2016	1000	Blackgram and Paddy
Veerachozhan FPC Ltd., Nagapattinam District	19-10-2015	1044	Paddy and Pulses
Mayiladuthurai Kamban Collective FPC Ltd., Nagapattinam District	10-07-2018	910	Paddy, Blackgram, Green Gram, Groundnut, Cotton and Coconut

Source: Primary data, 2019

Promoting Institution (POPI), and supporting government agencies such as NABARD, SFAC, etc.

For selecting BoDs, an open ballot system is adopted for appointing eligible candidates for the post of Director. Respondents have stated the following as the primary criteria for choosing a BoD. i. representative nature, ii. analytical skills, iii. knowledge, iv. leadership skills, v. responsible in his/her action, vi. the capability of developing a marketing strategy for selling farm output and vii. good contact among the shareholders. The age of the majority of the BoDs among selected FPCs is ranging between 50-60 years. Retired Government and private sector employees (progressive farmers) showed interest in working as BoDs compared to other categories of farmers. This is because they wish to help the farmers to get the best price for their commodity and many of them do not expect remuneration for attending the meetings. The personal interview with the representatives showed that 25 percent of the BoDs were appointed based on the convenience of the FPC, apart from voting. As per the norms framed by SFAC, the Producer Company should have a minimum of five BoDs for its functioning. Four out of the five selected FPCs have more than or equal to nine BoDs. Thiruvarur FPC ltd. has only six BoDs, out of which five are females and one male Director. The composition of male BoDs is comparatively higher than females in other FPCs selected for the study.

As per Fig.1., 85 percent of members of Veerachozhan FPC and 99 percent of

members of Mayiladuthurai FPC are having cultivatable land up to 2 ha. In other FPCs, marginal and small farmer members ranged from 50 percent to 70 percent.Karikalan FPC has 50 percent of members having landholding between 2 to 4 ha. Medium and Large farmers becoming a member of FPC is rare because they have direct access to the market, good bargaining power, fetching fair price for output, etc. In this study, hardly a few members were found to be holding land above 5 ha. Only Veerachozhan FPC had 14 percent of members who fell under the medium and large farmer category. In the case of Rajarajacholan FPC, a few members are landless farm labourers.

Challenges faced by FPCs in Cauvery Delta Region

Out of five FPCs, only Karikalan FPC has its processing unit and is involved in the value addition process.Thiruvarur FPC hasan association with FHG for the value addition of products. The remaining three FPCs have an objective of doing value addition in the future. All the FPCs are currently involved in purchasing output from members, and the major collected part is sold to intermediaries at a little higher price.FPC's retail shop sells agri inputs to members at a reasonable price. Though the main objective of FPC is to eliminate the middlemen and connect the final consumer to the producers (GoI, 2014), none of the selected FPC has achieved this objective.The efficient functioning of the FPCs has to be significantly improved to fulfill the above purpose.The sustainability of FPC sentirely depends on involving in value addition of products so that the profit can be increased and eventually be shared among the members. Only then there will be overwhelming participation of farmers in FPCs activities.

Table 2. Number of Board of Directors in Farmer Producer Companies

Name of the FPC	No. of Board of Directors				Total
	Male	%	Female	%	
Rajarajacholan Farmer Producer Company Ltd.	7	77.78	2	22.22	9
Thiruvarur Farmer Producer Company Ltd.	1	16.67	5	83.33	6
Karikalan Pulses Farmer Producer Company Ltd.	8	72.73	3	27.27	11
Veerachozhan Farmer Producer Company Ltd.	11	91.67	1	8.33	12
Mayiladuthurai Kamban Collective Farming Producer Company Ltd.	7	77.78	2	22.22	9

Source: Primary data, 2019

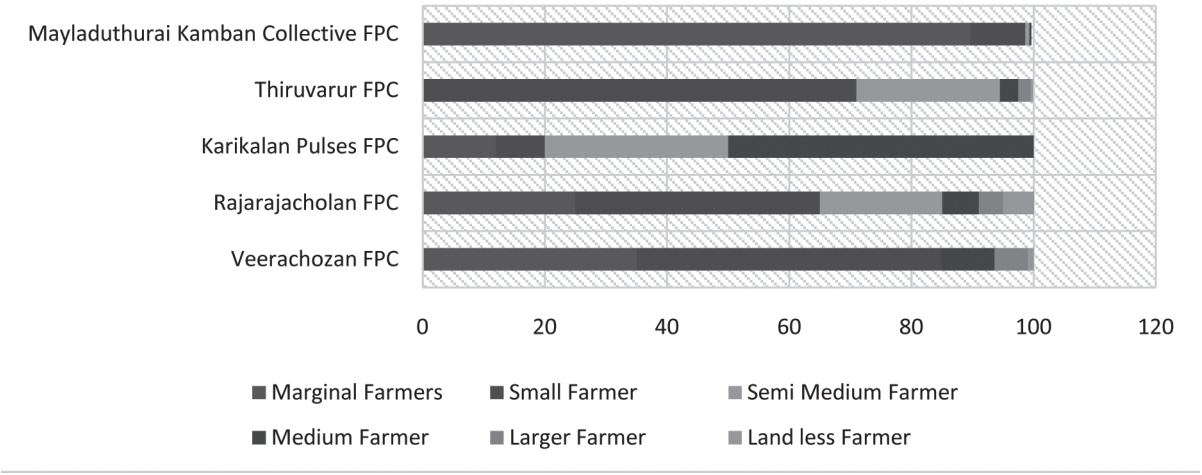

Fig. 1. Members landholding pattern of five FPCs (Primary data, 2019)

During the discussion, it is found that almost all decisions in the selected FPCs were taken by the BoDs of FPCs, without the consent of members.The annual general meeting is the only platform for members' participation in the decision-making process. Lack of involvement of members seems to have de-motivated them from participating in the FPC activities and they seem to have lost interest. Communication gap exists between the members, and the management which needs to be reduced for improving the efficiency of the FPCs.

The number of employees in FPCs is ranged from one to three.It is found that the CEO performing majority of work in FPC,including the accountant work. Furthermore, it is found that the work pressure of the CEOs is high as the responsibility of all the departments of the FPCs is handled. The salary package for CEOs is ranging from INR 20,000 per month to INR 30,000 per month. If SFAC supports the FPC, the CEO salary will be paidby SFAC for three years. After the grant period, FPCs have to pay a compensation at a lower rate of INR 20,000 to CEOs which is a draw back and CEOs may leave the job.

The CEO and BODs are aware of every activity of the company, but members wouldknow the status only once a year (AGM). Most of the members are illiterate and are unable to access modern technology like a smartphone. To provide livelihood opportunities for the members and their family activities like loading and unloading of the goods, jobs associated with the undersupply chain, lower level office clerk post, etc. can be offered to the shareholders' family members, who are desperate for jobs. By this, the members will gain knowledge about the activities performed in FPC. In the future, they may willingly involve in the activities for the common benefit of the FPC.

It is observed that despite being a member of FPC, most of the shareholders(members) are selling the commodity to local traders rather than selling to FPC. Few shareholders are not loyal to the FPC as per their agreement due to financial indebtedness, need for immediate payment, risk-averse, etc.A few other

Table 3. Membership of FPCs in Modern Agricultural Marketing Channels

Particulars	Rajaraja-cholan FPC Ltd.	Thiruvarur FPC Ltd.	Karikalan Pulses FPC Ltd.	Veerachozhan FPC Ltd.	Mayiladuthurai Kamban Collective FPC Ltd.
Member of e-NAM	No	No	Yes	Yes	Yes
Member of Mandi	No	Yes	Yes	No	No
Participated in e-auction	No	No	Yes	No	No
Commodity Exchange	No	No	No	No	No
Marketing using Android Apps	No	No	Yes	No	No

Source : Primary data, 2019

drawbacks or challenges identified in the process are that there is more than one shareholder from the same house; main reason being little cluster accessiblity for FPC's membership, accumulating of 1000 shareholders for obtaining benefits from nodal agencies. This may lead to inefficiency and spoil the primary intention of starting FPC for improving the livelihood ofthefarming community. Besides, lack of adequate infrastructure facility, insufficient working capital to carry out routine business transactions, etc. are the other major obstacles faced by the FPCs.

Participation of FPCs in Modern Agricultural Marketing Channels

It is observed that Karikalan Pulses FPC and Veerachozhan FPC are members of e-NAM.Thiruvarur FPC and Karikalan Pulses FPC are members of Mandi(APMC), and e-auction is performed only by Karikalan Pulses FPC in the selected region. None of the FPCs were engaged in futures trading through commodity exchanges (Table 3).

Karikalan Pulses FPC Ltd. utilizes-NAM, APMC, e-auction, and android apps from modern agricultural marketing channels to sell members' commodities. However, other FPCs are yet to adapt to contemporary developments in marketingagriculturalcommodities.The FPC's management expressed that mandi (APMC) infrastructure facilities are unsatis-factory and should be improved in the near future. Only Karikalan Pulses FPC is using Android Apps for selling members farm output to interested parties. This is found to reduce the transaction cost substantially. Overall, it is found that all the five FPCs have a keen interest in adopting modern agricultural marketing channels for selling the output directly to the consumers.

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