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

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ABSTRACT

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

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

INTRODUCTION

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

MATERIAL AND METHODS

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

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

RESULTS AND DISCUSSION

Effect of crop residue incorporation

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

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

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

Effect of time of sowing

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Effect of time of irrigation

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

Interaction effect

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

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

CONCLUSION

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

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