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Agronomic Assessment of Zero Tilled Cowpea (*Vigna unguiculata* L) Grown with various Inputs under Konkan Condition

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Field experiment was conducted during *rabi* season of 2016-17 to investigate zero tilled cowpea (*Vigna unguiculata* L.) grown with various inputs under Konkan condition. The treatments comprised of absolute control (T_1), weed control (T_2), T_2 + recommended dose of fertilizers (RDF; 25:60:40 kg N:P:K ha^{-1}) (T_3), T_3 + bio-fertilizers (T_4), T_4 + micronutrients (T_5), T_5 + plant protection (T_6), T_6 + paclobutrazol (T_7), T_7 + one irrigation at pod filling stage (T_8). The treatment T_8 was found significantly superior for all the growth parameters, yield attributing characters, protein content, grain and straw yield followed by treatment T_7. However both the treatments remained statistically at par with each other, but found significantly superior over rest of the treatments. The significantly lowest grain and straw yield was recorded by treatment T_1 (absolute control) where no input was given to crop. Increase in grain yield due to treatments T_2, T_3, T_4, T_5, T_6, T_7 and T_8 over treatments T_1 was to the tune of 48.44, 64.20, 67.27, 71.09, 76.43, 76.84 and 82.26 per cent, respectively.

*(**Key words:** Inputs, Weed control, Zero tillage, Cow pea)*

Pulses have been referred as unique jewel of Indian crop husbandry. Pulses, the food legumes have been grown by farmers since millennia and these have contributed in providing nutritionally balanced food to the people of India. Pulses are the nature's precious gift to mankind. They provide not only nutritious food and feed but also improve soil health and crop productivity. Endowed with unique ability for nitrogen fixation, deep root system, lower water requirement, capacity to withstand drought, pulses constituent an important component of cropping system across the nation. Pulses are considered to be an important group of crops in conserving natural resources such as soil, water and nutrients. Water requirement of pulses are lower than cereals. Global water consumption of cereals is reported to be about 60% as against 4% in pulses. Pulses have ability to use water more efficiently than other crops due to their morphological and physiological feature. Besides economy in nitrogen use, pulses also help in increasing efficiency of other plant nutrients in cropping system.

Maharashtra ranks first in acreage and production of pulses followed by Madhya Pradesh, Uttar Pradesh, Rajasthan and Andhra Pradesh. The yield levels of pulses had remained low and stagnant, also area and total production. Number of districts harvesting more than 0.8 or 1 t ha^{-1} yield of *kharif* pulses had been very less (Anonymous, 2013). It was imperative to mention that the New Agriculture Technology (NAT) introduced during mid-sixties had increased the production of pulses from 50.82 million tonnes during 1950-51 to 265.64 million tonnes during 2013-14 with the increase in area from 97.32 million hectares to 125 million hectares. The contribution of pulses in India during 2014-15 was 17.16 million tonnes. The total production of pulses in Maharashtra was 13.92 million tonnes from an area of 11.62 million hectares (Anonymous 2014).

In present days of intensive cultivation, micronutrient deficiency is also pronounced. Therefore, it is necessary to study the micronutrient status and its response to pulses. Now-a days, almost attention is being given to the active role played by micronutrients, due to their wide ranging impact on nodulation and various physiological activities.

Application of nutrients through foliar spray demand less quantity of nutrients with rapid and efficient absorption. Foliar nutrients usually penetrate the cuticle of the leaf and enter the cells. Hence, foliar nutrition is recognized as an important method of fertilization in modern agriculture. Water management in cowpea is an important aspect of increasing the production. On the basis of recent scientific evidences, there is urgent necessity to work out the water need of the pulses. Cowpea gives better yield under optimum environment

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but slight change in environment can cause hormonal imbalance which results in abscission of assimilatory structures. Plant growth regulators check excessive vegetative growth and facilitate proper balance in source and sink which is essential to increase the yield of crops.

In *Konkan* region of Maharashtra, pulses are mainly grown in *rabi* season in rice field after harvest of rice crop both on residual moisture as well as under irrigation. The cultivation of cowpea in rice fallows is reported to be more profitable than horse gram and mustard (Kadrekar, 1990). The average productivity of pulses in *Konkan* is found to be very low. One among various pulses, which are liked by *Konkan* people is cowpea. The reasons for the low yield of cowpea grown on residual moisture in zero tilled condition are that cowpea receives no irrigation at critical growth stages during hot weather. Another cause for low yield of cowpea is lack of use of critical inputs. Therefore, to exploit high yielding potential of cowpea on residual moisture, better management of these aspects needs to be emphasized.

The present investigation on "Agronomic assessment of zero tilled cowpea (*Vigna unguiculata* L.) grown with various inputs under *Konkan* condition" during *rabi* season, was carried out on variety *Konkan Sadabahar* in the year 2016-2017 with objectives to assess the effect of various inputs on growth, yield and quality of cowpea and to work out economics of various inputs.

MATERIALS AND METHODS

The field experiment was conducted during *rabi* season of 2016-17 at Agronomy Farm, College of Agriculture, Dapoli, Dist. Ratnagiri (M.S.). The experiment was laid out in randomized block design. There were eight treatments which were replicated thrice. The treatments mainly comprised of absolute control (T_1), weed control (2 hand weedings) (T_2), T_2 + RDF (T_3), T_3 + bio-fertilizers (T_4), T_4 + micronutrients (T_5), T_5 + Plant protection (T_6), T_6 + Paclobutrazol (T_7), T_7+ one irrigation at pod filling stage (T_8).

Cowpea genotype Konkan Sadabahar released by Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri (M.S.) is used in this experiment. The quantity of recommended fertilizer dose (25:60:40 kg N:P:K ha^{-1}) was applied in each plot before sowing. Under zero tillage condition, the fertilizers were applied uniformly to the whole plot in the holes dibbled earlier at the spacing of 30 x 15 cm. Fertilizers was uniformly mixed and it was applied 3-4 cm below the seed to avoid direct contact with fertilizers. The calculated value of N, P_20_5 and K_20 were applied through urea, single super phosphate and muriate of potash, respectively. The seeds used for sowing were treated with biofertilizers *viz*; *Rhizobium* and PSB @ 25 g each kg^{-1} of seeds, before sowing in order to enhance biological nitrogen fixation. After fertilizer application, the seeds were sown in the holes dibbled. Two to three seeds were dibbled at each spot at about 5cm depth. One irrigation was applied as per the treatments at pod filling stage to the respective plots by flexi pipe, as small bunds were raised around each respective treatment plot. Immediately, after harvesting of *kharif* rice existing weeds were controlled by applying non selective translocated herbicide Glyphosate 41% SL @ 2 kg a.i. ha^{-1}. Hand weeding operation was carried out to the respective treatment plots. Foliar application of Paclobutrazol @ 50 ppm at 60 DAS (pod filling stage) was done as per treatment. The multinutrient (Amrashakti) solution (N, P, K, S, Zn, Cu, B and Mo content 4.6, 0.7, 4.0, 5.4, 2.1, 2.5, 2.0 and 1.3% respectively) was sprayed @ 500 litres ha^{-1} of water on crop. First spraying was done 35 DAS and second spraying at 45 DAS. Plant protection measures against various pests were under taken by spraying cypermethrin and phosphamidon @ 0.1 and 0.03% respectively for control of aphids and pod borer during period of experimentation. In order to assess the effect of different inputs on the growth and development of cowpea crop, periodical observations were recorded.

RESULTS AND DISCUSSIONS

Yield attributing characters

The yield contributing characters studied were number of developed pods plant^{-1}, number of grains pod^{-1}, length of pod and test weight (100 grain weight). The variations caused by different treatments are presented in Table 1. Data showed that mean number of pods per plant was 10.14. The treatment weed control (2 hand weedings) + RDF + bio-fertilizers + micronutrients + plant protection + paclobutrazol + one irrigation at pod filling stage (T_8) recorded highest number of developed pods per plant (12.26) over rest of the treatments except weed control (2 hand weedings) + RDF + bio-fertilizers + micronutrients + plant protection + paclobutrazol (T_7) and weed control (2 hand weedings) + RDF + bio-fertilizers + micronutrients + plant protection (T_6) which were at par with each other.

Different inputs significantly influenced the number of grains per pod of cowpea. Treatment weed control

(2 hand weedings) + RDF + bio-fertilizers + micronutrients + plant protection + paclobutrazol + one irrigation at pod filling stage (T_8) recorded significantly highest number of grains (12.07) per pod over rest treatments. However, the lowest number of grains per pod was found in treatment T_1 (control).

Scrutiny of data presented in Table 1 reveal that, pod length (cm) of cowpea was significantly influenced due to various treatments under study. The length of pod (cm) was significantly higher in treatment T_8 (9.88) over rest of the treatments. Different inputs significantly influenced the test weight (100 grains) of cowpea. The treatment T_8 recorded significantly highest 100 grain weight (8.52 g) except the treatments T_7 and T_6 which were at par with each other. However, the lowest test weight (7.21 g) was observed in treatment T_1 (control).

The grain yield per unit area in cowpea is a function of yield attributes of an individual plant *viz*., number of developed pods per plant, number of grains per pod, pod length and test weight. Highest values were observed in case of the treatment of adoption of all inputs (T_8). The increased yield attributes might be due to increased growth and development parameters which ultimately resulted in increased yield. These findings are close conformity with those of Zaghloul *et al.* (2015), Dhane *et al.* (2010), Balachandran *et al.* (2005) and Shinde *et al.* (1991).

Yield

Data pertaining to grain and stover yield of cowpea as influenced by different treatments are presented in Table 1. The mean grain and stover yield was observed to be 0.65 and 1.27 t ha^{-1}, respectively. Various treatments significantly influenced the grain yield of cowpea. The treatment T_8 recorded significantly higher grain yield (1.12 t ha^{-1}) over rest of the treatments followed by treatments T_7, T_6, T_5, T_4, T_3 and T_2 in that descending order of significance. However, the lowest grain yield was recorded in treatment T_1 (control). The per cent increase in grain yield due to various treatments indicated that the treatment T_8 recorded highest per cent (82.26%) increase in grain yield over control followed by T_7 (76.84%), T_6 (76.43%), T_5 (71.09%), T_4 (67.27%), T_3 (64.20%) and T_2 (48.44%).

Assessment of impact of different inputs indicated that, reduction in the grain yield of cowpea due to various inputs was to the tune of 16.67% due to weed control, 15.14% due to RDF, 4.66% due to bio-fertilizers, 7.17% due to multinutrient solution, 13.89% due to plant protection, 1.34% due to paclobutrazol and 23.39% due to one irrigation. Various treatments significantly influenced the stover yield of cowpea. The treatment T_8 recorded significantly highest stover yield (2.22 t ha^{-1}) which was significantly superior over rest of the treatments. The treatment T_7 and T_6 were at par with each other and significantly superior over remaining treatments. However, treatment T_5 recorded minimum stover yield followed by treatment T_4, T_3, T_2 and T_1 in that descending order of significance. However the lowest stover yield was recorded in treatment T_1 (control).

Significantly highest values of grain and stover yield were recorded due to the treatment T_8, where adoption of all inputs was given to the crop followed by treatment T_7. The increase in grain and stover yield was due to increase in growth characters like plant height, number of branches per plant, number of pods per plant and dry matter accumulation due to adoption of all inputs given to the crop. The better plant growth and improved yield attributes finally led to higher grain and stover yields. These results confirm with the findings of Marimuthu *et al.* (2015), Dhane *et al.* (2010) and Sarkar *et al.* (1998).

From the data presented in Table 1 it is clearly seen that among the seven important aspects (weed control, RDF, bio-fertilizers, micronutrients, plant protection, plant growth regulator and irrigation) one irrigation at pod filling stage was the major factor responsible for increasing grain and stover yield.

Quality studies

Data pertaining to protein content (%) in grain and stover as influenced by different treatments are presented in Table 1. The mean protein content in cowpea grain was 20.78 per cent. Various treatments significantly influenced the protein content in grain of cowpea. The treatment T_8 recorded significantly highest protein content (22.20%) over rest of the treatments followed by treatment T_7. Similarly, the protein content of the treatments *viz.*, T_6, T_5, T_4, T_3, T_2 and T_1 were in descending order of significance. However, the lowest protein content was recorded in treatment T_1 (control).

Mean protein content in cowpea stover was 6.64 per cent. Various treatments significantly influenced the protein content of stover of cowpea. The treatment T_8 recorded significantly highest protein content (7.75) in stover followed by treatments T_7, T_6, T_5, T_4, T_3 and T_2. The lowest protein content in stover was recorded in T_1 treatment.

Table 1. *Mean yield attributing characters, grain and stover yield (t ha^{-1}) and protein content (%) of cowpea as influenced by different treatments*

Treatments	No. of pods plant^{-1}	No. of grainspod^{-1}	Length of pod (cm)	Test weight (g)	Grain yield (t ha^{-1})	% Grain yield compared to 100% (T_8)	Grain Yield reduction due to various inputs (%)	(%) increase over T1 (control)	Stover yield (t ha^{-1})	Protein content (%)	
										Grain	Stover
T_1: Absolute control	5.56	6.16	5.03	7.21	0.20	17.74	–	–	0.39	18.47	0.93
T_2: T_1 + Weed control	8.65	9.28	6.10	8.35	0.38	34.41	16.67	48.44	0.96	19.41	7.18
T_3: T_2 + RDF	10.38	9.32	7.12	8.36	0.55	49.55	15.14	64.20	1.05	20.65	7.24
T_4: T_3 + Bio-fertilizers	10.46	9.45	7.16	8.41	0.61	54.21	4.66	67.27	1.15	20.74	7.36
T_5: T_4 + Multinutrient solution	10.56	9.54	7.18	8.41	0.69	61.38	7.17	71.09	1.30	21.13	7.43
T_6: T_5 + Plant protection	11.59	10.14	7.30	8.46	0.84	75.27	13.89	76.43	1.55	21.74	7.55
T_7: T_6+ Paclobutrazol	11.67	10.18	7.32	8.47	0.86	76.61	1.34	76.84	1.55	21.93	7.67
T_8: T_7 + One Irrigation	12.26	12.07	9.88	8.52	1.12	100.00	23.39	82.26	2.22	22.20	7.75
Mean	10.14	9.52	7.14	8.27	0.65	–	–	–	1.27	20.78	6.64
S.E.±	0.37	0.06	0.18	0.03	0.001	–	–	–	0.001	0.02	0.07
C.D. at 5%	1.12	0.18	0.54	0.08	0.002	–	–	–	0.004	0.08	0.02

Table 2 *. Mean nitrogen content (%), phosphorus content (%), potassium content (%)in grain, stover and their total uptake (kg ha^{-1}) by cowpea influenced by different treatments*

Treatments	Grain		Stover		Total	Grain		Stover		Total	Grain		Stover		Total
	% N	N (kg ha^{-1})	% N	N (kg ha^{-1})	N uptake (kg ha^{-1})	% P	P (kg ha^{-1})	% P	P (kg ha^{-1})	P uptake (kg ha^{-1})	% K	K (kg ha^{-1})	% K	K (kg ha^{-1})	K uptake (kg ha^{-1})
T_1: Absolute control	2.96	5.86	0.94	3.67	9.53	0.24	0.47	0.11	0.44	0.91	1.03	1.98	1.86	7.29	9.32
T_2: T_1 + Weed control	3.11	11.93	1.15	10.96	22.89	0.28	1.08	0.13	1.22	2.30	1.06	4.16	2.03	19.32	23.37
T_3: T_2 + RDF	3.31	18.29	1.16	12.22	30.51	0.29	1.61	0.13	1.41	3.02	1.06	5.90	2.06	21.66	27.51
T_4: T_3 + Bio-fertilizers	3.32	20.09	1.18	13.55	33.63	0.30	1.79	0.14	1.54	3.43	1.08	6.51	2.08	23.82	30.32
T_5: T_4 + Multinutrient solution	3.36	23.01	1.19	15.52	38.53	0.30	2.02	0.14	1.58	3.82	1.09	7.44	2.10	27.62	34.74
T_6: T_5 + Plant protection	3.48	29.21	1.21	18.70	48.20	0.31	2.60	0.14	1.82	4.81	1.10	9.27	2.11	32.70	41.97
T_7: T_6+ Paclobutrazol	3.51	30.02	1.23	19.07	49.09	0.31	2.68	0.15	2.23	4.90	1.11	9.46	2.13	32.87	42.33
T_8: T_7 + One Irrigation	3.52	39.30	1.24	27.57	66.87	0.32	3.55	0.15	3.29	6.84	1.12	12.38	2.15	48.17	60.20
Mean	3.32	22.21	1.16	15.16	37.41	0.29	1.98	0.14	1.69	3.75	1.08	7.14	2.07	26.68	33.72
S.E.±	0.01	0.05	0.01	0.10	0.13	0.01	0.07	0.01	0.23	0.07	0.02	0.03	0.01	0.13	0.09
C.D. at 5%	0.02	0.16	0.03	0.30	0.38	0.04	0.21	0.02	0.71	0.20	0.05	0.09	0.02	0.40	0.26

The mean protein content (%) in cowpea differed significantly due to different inputs. Higher protein content in cowpea stover was found in treatment (T_8) due to application of irrigation, these results are similar to Gethe *et al.* (1996). However the lower protein content in grain and stover was found in treatment (T_1) i.e. control due to weed infestation. These results are similar with the results of Dhane *et al.* (2010) and Lalova and Lena (1983).

Nutrient content and uptake of cowpea

The nitrogen content in grain and stover of cowpea as affected by various treatments are presented in Table 2. The mean nitrogen content in grain of cowpea was 3.32 per cent. Nitrogen content in cowpea grain was influenced significantly by various treatments. Among the various treatments, nitrogen content in grain was significantly highest under treatment T_8 (3.52%) followed by treatment T_7 (3.51%) which were at par with each other. The treatment T_6 recorded significantly higher nitrogen content followed by T_5 than rest of the treatments. Treatments T_4 and T_3 were at par with each other. Similarly, the treatment T_2 recorded (3.11%) significantly higher nitrogen content than treatment T_1. However, the lowest nitrogen content was recorded in treatment T_1 i.e. control (2.69%).

The mean nitrogen content in stover was 1.16 per cent. Nitrogen content in stover was higher under T_8 treatment (1.24%) which was significantly higher over rest of the treatments except T_7 and T_6. Similarly the treatment T_5 to T_2 which were at par in that descending order and superior over treatment T_1. However the lowest nitrogen content in stover was found in treatment T_1 (control).

Data pertaining to the effect of different treatments on nitrogen uptake by cowpea grain, stover and their total are presented in Table 2. The mean value of nitrogen uptake by cowpea grain, stover and their total uptake was 22.21, 15.16 and 37.41 kg ha^{-1}, respectively. Nitrogen uptake in grain, stover and their total uptake by cowpea, were found to be significant, Among the different treatments, nitrogen uptake in grain, stover and their total were significantly highest under treatment T_8 (66.87%) which was significantly superior over rest of the treatments followed by remaining treatments in descending order of significance. However the lowest uptake of nitrogen was found in treatment T_1 (9.53%) i.e. control.

The phosphorus content in grain of cowpea as affected by various treatments are presented in Table 2. The mean phosphorus content in grain of cowpea was 0.29 per cent. Among different treatments, phosphorus content in grain was significantly highest under treatment T_8 (0.32%). The lowest phosphorus content in grain was found in treatment T_1 i.e. control (0.24%).

The phosphorus content in stover of cowpea as affected by various treatments are presented in Table 2. The mean phosphorus content in stover of cowpea was 0.14 per cent. Phosphorus content in stover was significantly highest under treatment T_8 which were at par with rest of the treatments except T_1. Furthermore, treatment T_1 *i.e.*, control recorded lowest phosphorus content in stover.

Data pertaining to the effect of different treatments on phosphorus uptake by cowpea grain, stover and their total are presented in Table 2. The mean value of phosphorus uptake by cowpea grain, stover and their total uptake was 1.98, 1.69 and 3.75 kg ha^{-1}, respectively. Phosphorus uptake in grain, stover and their total uptake in cowpea, was significantly influenced by various treatments. Phosphorus uptake in grain, stover and their total were significantly highest under treatment T_8 (6.84 kg ha^{-1}) than rest of treatments. The treatment T_7 and T_6 were at par with each other and significantly superior over remaining treatments. The treatments viz., T_5, T_4, T_3 and T_2 resulted in phosphorus content in descending order of significance. The treatment T_1 recorded significantly lowest phosphorus uptake in grain, stover and their total uptake by cowpea.

The potassium content in grain of cowpea as influenced by various treatments are presented in Table 2. The mean potassium content in grain of cowpea was 1.08 per cent. Potassium content in grain of cowpea was significantly influenced by various treatments. K content in grain was significantly highest under treatment T_8 (1.12%) over rest of the treatments except T_7, T_6, T_5 and T_4 which were at par with each other. The treatments T_3, T_2, and T_1 which were at par with each other. However the lowest potassium content was found in treatment T_1 i.e. control.

The potassium content in stover of cowpea as affected by various treatments are presented in Table 2. The mean potassium content in stover of cowpea was 2.07%. Potassium content in stover of cowpea was significantly influenced by various treatments.

Potassium content in stover was significantly higher under treatment T_8 (2.15%) over rest of the treatments except the treatment T_7. The treatment T_6 and T_5 which were at par with each other and significantly superior than rest of the treatment and treatment T_4 and T_3 were at par with each other. In treatment T_3 significantly highest potassium content in stover was recorded over T_2 and T_1 treatments. Lowest potassium content in stover of cowpea was observed in treatment T_1 *i.e.*, control.

The data pertaining to the effect of different treatments on potassium uptake by cowpea grain, stover and their total are presented in Table 2. The mean value of potassium uptake by cowpea grain, stover and their total uptake was 7.14, 26.68 and 33.72 kg ha^{-1}, respectively. Potassium uptake in grain, stover and their total uptake in cowpea, was significantly influenced by various treatments. Potassium uptake in grain, stover and their total were significantly highest under treatment T_8 (60.20 kg ha^{-1}) than rest of the treatments. The treatments *viz.*,T_7, T_6, T_5, T_4, T_3, T_2 and T_1 recorded significantly higher potassium uptake in that descending order of significance.

The increased N, P and K contents in grains and stover, nutrient uptake in grains and stover and total uptake by crop might be due to recommended dose of fertilizers, irrigation, weed management. Due to this, there was a least competition of weeds for nutrients. These results are similar to those of Komal *et al.* (2015).

The effect of different treatment on available nitrogen, phosphorus and potassium status (kg ha^{-1}) of soil after harvest of cowpea are presented in Table 3. The availability of nutrients in the soil after harvest of cowpea was significantly influenced by different treatments. Nitrogen was significantly more available in soil under treatment T_8 (318.90 kg ha^{-1}) followed by T_7 over rest of the treatments. The treatments viz., T_6 and T_5, T_5 and T_4, and T_3 which were at par with each other and significantly superior over rest of the treatments. Availability of N in soil was significantly highest under T_8 (318.90 kg ha^{-1}). Availability of phosphorus in the soil after harvest of cowpea was significantly influenced by different treatments. The availability of Phosphorus, was significantly more in soil under the treatment T_8 (15.50 kg ha^{-1}) followed by treatment T_7, T_6, T_5 and T_4 treatments in descending order of significance. Similarly, the treatment T_3 and T_2 which was at par and significantly superior over T_1 *i.e.*, control which recorded lowest available phosphorus content in soil. Availability of nutrients in the soil after harvest of cowpea was significantly influenced by different treatments. The availability of K was significantly more in soil under the treatment T_8 (253.20 kg ha^{-1}) than rest of the treatments. In treatments *viz.*, T_7 to T_1 the available potassium in soil was in descending order of significance.

Significantly highest available N, P and K in soil was found in case of the treatment T_8 over rest of the treatments, due to the fact recommended dose of fertilizers and irrigation was applied to the crop. As a result nutrient availability was higher in these treatments. These findings are in close conformity with Subhendu *et al.* (2005).

Table 3. *Mean available nitrogen, phosphorus and potassium content (kg ha^{-1}) in soil after harvest of cowpea as influenced by different treatment*

Treatments	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
T_1: Absolute control	291.44	12.13	215.67
T_2: T_1 + weed control	304.15	13.20	218.13
T_3: T_2 + RDF	308.00	13.44	220.13
T_4: T_3 + bio-fertilizers	309.14	13.91	223.14
T_5: T_4 + multinutrient solution	310.37	14.13	225.12
T_6: T_5 + plant protection	311.33	14.54	248.00
T_7: T_6 + paclobutrazol	313.42	15.15	250.00
T_8: T_7 + one Irrigation	318.90	15.50	253.20
Mean	308.35	14.00	231.67
S.E.±	0.53	0.09	0.24
C.D. at 5%	1.60	0.28	0.72

Table 4. *Mean soil moisture content (%) from two layers of soil as influenced by different treatments*

TR.	INITIAL	15 DAS	30 DAS	45 DAS	60 DAS (B) DAS	60 (A) DAS	AT HARVEST	INITIAL	15 DAS	30 DAS	45 DAS	60 (B) DAS	60 (A) DAS	AT HARVEST
	0-15 cm depth							15-30 cm depth						
T_1	27.15	26.42	24.98	22.15	20.49	20.49	19.83	28.62	28.37	27.57	24.51	21.73	21.73	20.40
T_2	27.15	26.39	24.94	22.12	20.43	20.43	19.73	28.62	28.36	27.50	24.38	21.54	21.54	20.20
T_3	27.15	26.34	24.85	21.97	20.25	20.25	19.51	28.62	28.31	27.38	24.20	21.33	21.33	19.93
T_4	27.15	26.37	24.87	22.02	20.32	20.32	19.60	28.62	28.32	27.41	24.26	21.41	21.41	20.04
T_5	27.15	26.33	25.01	22.22	20.59	20.59	19.93	28.62	28.40	27.61	24.55	21.77	21.77	20.45
T_6	27.15	26.40	24.96	22.13	20.45	20.45	19.77	28.62	28.36	27.62	24.42	21.60	21.60	20.26
T_7	27.15	26.45	24.83	21.92	20.18	20.18	19.43	28.62	28.29	27.34	24.15	21.27	21.27	19.86
T_8	27.15	26.34	24.88	21.92	20.40	26.84	24.78	28.62	28.30	27.38	24.22	21.36	28.91	26.57

Soil moisture studies

The soil moisture contents at depth of 0-15 and 15-30 cm recorded at 15 days interval, before and after irrigating the crop for the treatment T_8 are summarized in Table 4.

Initial soil moisture was 27.15 per cent. At 15 DAS mean soil moisture content of all treatments were in range of 26.33 to 26.42 per cent. At 30 DAS mean soil moisture content of all treatments were in range of 24.83 to 25.01 per cent. At 45 DAS mean soil moisture content of all treatments were in range of 21.92 to 22.22 per cent. At 60 DAS and at harvest, treatment T8 recorded highest moisture per cent which was 26.84 per cent and 24.78%, respectively and these were greater than rest of the treatments due to the application of irrigation.

Initial soil moisture in 15-30 cm soil depth was 28.62 per cent. At 15 DAS mean soil moisture content of all treatments were in range of 28.29 to 28.40 per cent. At 30 DAS mean soil moisture content of all treatments were in range of 34 to 27.62 per cent. At 45 DAS mean soil moisture content of all treatments were in range of 24.15 to 24.55 per cent. At 60 DAS, treatment T_8 was irrigated due to which the soil moisture per cent increased from 21.36 per cent to 28.91 per cent and at harvest also the moisture per cent of treatment T_8 (26.57%) was greater than rest of the treatments due to the application of irrigation.

Economics of the treatment

The cost of cultivation, gross return, net returns and benefit cost ratio obtained from different treatments are presented in Table 5. The mean total cost of cowpea cultivation was Rs. 18222.78 ha^{-1}. Cost of cultivation was significantly higher under treatment T8 (Rs. 27369.52 ha^{-1}) followed by T_7 (24958 ha^{-1}). Similarly treatment T_6 recorded maximum cost of cultivation than treatments *viz*., T_5, T_4, T_3, T_2 and T_1 in that descending order. However, the lowest cost of cultivation was in treatment T_1 (absolute control).

The mean gross return from zero tilled cowpea was Rs. 28726.58 ha^{-1}. The treatment T8 recorded significantly highest gross returns (Rs. 49104.00 ha^{-1}) than the rest of the treatments, followed by treatment T_7 which was also superior than remaining treatments in that descending order of significance. However the lowest net return was found in treatment T_1 (Rs.8704 ha^{-1})

The mean net returns of cowpea was Rs. 10462.03 ha^{-1}. Net return was found significantly maximum with the treatment T_8 (Rs. 21621.25 ha^{-1}) which was profitable followed by treatments viz., T_6, T_7, T_5, T_4, T_3 and T_2. However the lowest net return was found in treatment T_1 (Rs. 509 ha^{-1}).

The mean value of B:C ratio was 1.53. The B:C ratio was found significantly maximum with the treatment T_8 (1.79) followed by treatment T_2 (1.66). It was observed that the treatment (T_8) gave significantly the highest net monetary returns Rs. 21621 ha^{-1} and gross return Rs. 49104 ha^{-1}. The B:C ratio of cowpea was also higher in treatment T_8 (1.79) followed by treatment T_2 (1.66). These results are in similar line with the result of Yadav *et al.* (2014) and Chandegara *et al.* (1998).

Table 5. *Cost of cultivation, gross return, net return and B:C ratio of cowpea as influenced by different treatments*

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
T_1: Absolute control	7979	8704	509	1.09
T_2: T_1 + weed control	10394	17290	6897	1.66
T_3: T_2 + RDF	15317	24224	8907	1.58
T_4: T_3 + bio-fertilizers	17441	26490	9050	1.51
T_5: T_4 + multinutrient solution	19723	30000	10276	1.52
T_6: T_5 + plant protection	22601	36700	14099	1.62
T_7: T_6 + paclobutrazol	24958	37300	12343	1.49
T_8: T_7 + one Irrigation	27370	49104	21621	1.79
Mean	18222.78	28726.58	10462.03	1.525
S.E.±	–	0.248	76.59	–
C.D. at 5%	–	0.752	232.31	–

To get highest grain and stover yield of cowpea during *rabi* hot weather season, the crop should be cultivated by zero tillage with, weed control + RDF + bio-fertilizers + micronutrients + plant protection + paclobutrazol + one irrigation at pod filling stage. This package of practices results in highest net return (Rs. 21621 ha^{-1}) and benefit cost ratio (1.79).

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