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Performance of Cowpea [*Vigna Unguiculata* (L.) Walp] Under Organic Production System in Southern Dry Zone of Karnataka

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ABSTRACT

A field experiment was carried out during *kharif* 2013, 2014, 2015 and 2016 at Zonal Agricultural Research Station, V. C. Farm, Mandya to study the performance of cowpea under organic production system in red sandy loam soil. The results revealed that application of 100% N equivalent compost + recommended FYM (10 t/ha) + beejamrutha (seed treatment) + jeevamrutha (500 liter/ha) recorded significantly higher grain yield during all the years of experimentation (2056, 1987, 2108 and 2365 kg/ha, respectively) and also in their pooled data (grain yield 2129 kg/ha). This increased yield was attributed to more availability of nitrogen (289.5 kg/ha), phosphorus (40.5 kg/ha) and potassium (182.3 kg/ha) in the soil compared to other treatments. The benefit: cost ratio was higher with application of 100% N equivalent compost + jeevamrutha + beejamrutha (2.81). Soil chemical properties, *viz.* soil pH, organic carbon content and electric conductivity, were not influenced significantly by application of organic manures. However, there was an improvement in the soil chemical properties (289.5, 40.5 and 182.3 N, P_2O_5 and K_2O kg/ha, respectively) compared to initial soil data (229, 19.2 and 135 NPK kg/ha).

Key words: Beejamrutha, Compost, Cowpea, Economics, FYM, Jeevamrutha.

INTRODUCTION

Modern agriculture based on chemicals is not sustainable because of many problems such as loss of soil productivity from excessive erosion and associated plant nutrient losses, surface and ground water pollution from pesticides, fertilizers and sediments impending shortages of non-renewable resources and low farm income from high production costs. As a result, there is increasing awareness of the need for alternative agricultural systems. Although, chemical fertilizers are playing a crucial role to meet the nutrient requirement of the crop, persistent nutrient depletion is posing a greater threat to sustainable agriculture. Therefore, there is an urgent need to reduce the usage of chemical fertilizers and inturn to increase the usage of organics. Use of organic manures alone or in combination with chemical fertilizers, helps in improving physico-chemical properties of the soil and improves the efficient utilization of applied fertilizers resulted in higher seed yield and quality. Organic manures *viz*. compost, FYM, vermicompost, liquid organic manures *viz.* Jeevamrutha and help in the improvement of soil structure, aeration and water holding capacity of soil. Further, it stimulates the activity of microorganisms that makes the plant to get the macro and micro-nutrients through enhanced biological processes, increase nutrient solubility, alter soil salinity, sodicity and pH (Alabadan *et al*., 2009).

Cow pea (*Vigna unguiculata*) is most important among pulse crops. It is popularly called as vegetable meat as it plays an important role in Indian diet on account of high per cent of protein (23.14%) which is double than that of cereals. Traditionally in Karnataka especially in dry land area farmers or growing cowpea under natural farming without applying any synthetic fertilizers. But, the yield levels are too low. In recent years there was a growing demand for organic cowpea because of its health benefits. But, the standardization of nutrient management practices for organic cowpea production have not done so for. Keeping these facts in view, field study was planned with an objective to study the performance of cowpea under organic production system.

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MATERIALS AND METHODS

A field experiment was conducted during *kharif* 2013, 2014, 2015 and 2016 at Zonal Agricultural Research Station, V. C. Farm, Mandya (12° 34.3′N latitude, 76° 49.8′E longitude and at an elevation of 697 m above mean sea level. Soil of the experimental site was red sandy loam classified as *Alfisols*. Organic carbon, available nitrogen, phosphorus and potassium content of the soil were medium. The rainfall received during the crop growth period was 388 mm and

well distributed. The maximum and minimum temperature prevailed during crop growth period were within the crop cordial limits. The experiment was laid out in randomized complete block design (RCBD) with organic manures, beejamrutha and jeevamrutha, respectively. Thus, the 11 treatment combinations were replicated thrice and tried in RCBD.

Beejamrutha and Jeevamrutha formulations - preparation and application

The liquid organic formulations beejamrutha and jeevamrutha were prepared by following procedures given by Palekar (2006).

Beejamrutha

Beejamrutha was prepared by soaking 5 Kg of local cow dung in 20 liters of water and 50 g of lime in one liter water overnight. Next day morning squeeze cow dung into the lime soaked water and 10 liters of local cow urine was added to this by stirring thoroughly and adding lime solution and mix well.

Jeevamrutha

Jeevamrutha was prepared by mixing 10 kg of cow dung, 10 liter of cow urine, 2 kg of local jaggery, 2 kg of pigeon pea flour and hand full of soil collected from farm. All these were put in 200 liter capacity plastic drum and mixed thoroughly and volume was made up to 200 liters. The mixture was stirred well in clock wise direction and kept in shade covered with wet jute bag. The solution was regularly stirred clockwise in the morning, afternoon and in the evening continuously for 10 days and it was used for soil application. Jeevamrutha was applied when the soil was wet near the root zone of the crop as per the treatments.

The seeds were soaked with beejamrutha over night and then dried under shade before sowing. The manures were supplied in the form of FYM, compost (prepared by using cattle shed waste) and vermicompost (prepared by using cattle shed waste and crop residues). The nutrient content of FYM was 0.5% N, 0.2% P and 0.5% K, compost was 0.58% N, 0.32% P and 0.52% K and vermicompost was 1.13% N, 0.678% P and 1.13% K. The recommended dose of the FYM and compost were applied as basal dose 20 days before sowing. After 30 days after sowing, vermicompost was applied as top dress @ 1250kg/ha and Jeevamrutha was sprayed after 30 days after sowing @ 500 liters/ha. Standard package of practices were adopted. Growth, yield parameters and yield were measured and estimated using standard procedures.

Short duration (95 – 100 days) variety of Cowpea - KBC – 2 was used for the field experiment. Cowpea crop was sown with seed rate of 30 kg $ha^{-1}$and seeds were sown at spacing of 45 cm and seed to seed spacing of 15 cm (45 cm X 15 cm). Irrigation was provided at 10-15 days interval depending on the stage of crop and soil condition. Necessary aftercare operations were followed as per the recommendations. No major pest and disease incidences were noticed during crop growth. The five plants were selected randomly in net plot area and used for taking observations on growth and yield parameters at regular intervals. Market price of inputs prevailing at the time of their use was considered for working out of cost of cultivation. The gross return was calculated on the basis of market price of the produce at the time when the produce was ready for sale. Net returns (Rs. ha^{-1}) were calculated by deducting the cost of cultivation from the gross income. Experimental data collected was subjected to statistical analysis by adopting Fisher's method of Analysis of Variance (ANOVA) as outlined by Gomez and Gomez (1984). Critical Difference (CD) values were calculated whenever the 'F' test was found significant at 5 per cent level.

RESULTS AND DISCUSSION

Application of different levels of organic manures in combination with beejamrutha and jeevamrutha has recorded significantly higher growth parameters. Application of 100% N equivalent compost + recommended FYM + Beejamrutha + Jeevamrutha recorded higher plant height, number of branches, number of leaves, leaf area and leaf area index (74.7 cm, 10.1, 27.48, 1210.7 cm^2 and 2.69, respectively in their pooled data) compared to other organic treatments (Table 1 and 2).

This increase in plant height and number of branches per plant may be due to higher dry matter production and its distribution to vegetative part and these higher growth parameters was mainly attributed to higher N availability throughout the crop growth period because of slow decomposition of organic matter and higher rhizobium nodules in the root. The similar result reported in increase in soybean growth parameters due to application of organics was reported by Jaybhay *et al.* (2015). Jeevamrutha application might also helps in solubilisation of nutrients in soil and absorption of nutrients and moisture in the same line as reported by Jidhu Vaishnavi and Jayakumar (2016), Yogananda *et al.* (2015) and Siddappa *et al*. (2016).

In the present investigation, application of 100% N equivalent compost + recommended FYM + Beejamrutha + Jeevamrutha recorded significantly higher grain yield (2129 kg ha^{-1} in their pooled data) with an increase in yield of 30.29 percent over other organic treatments. Similarly, significantly higher haulm yield (8611 kg ha^{-1} in their pooled data) was also recorded with 100% N equivalent compost + recommended FYM + Beejamrutha + Jeevamrutha with an increase of 37.61 per cent over other organic treatments.

Significantly higher grain yield recorded with application of 100% N equivalent compost + recommended FYM + Beejamrutha + Jeevamrutha was due to better yield attributing characters like number of pods per plant, number of seeds per pod and test weight (27.5, 15.30 and 11.77 g, respectively in their pooled data) (Table 2 and 3). Increased yield attributes might be due to beneficial effect of jeevamrutha which has reflected in the form of higher plant height (74.7cm) with more number of branches per plant (10.1) and more number of leaves per plant (27.48) (Table 1) and finally more assimilating area for food production.

Table 1: Growth attributes of cowpea as impact on organic practices under different source of nutrients.

Treatment	Plant Height (cm)					Number of Branches					Number of leaves				
	2013	2014	2015	2016	Pooled	2013	2014	2015	2016	Pooled	2013	2014	2015	2016	Pooled
T_1	54.0	63.4	64.2	66.85	62.1	7.0	7.4	7.8	8.52	7.7	12.51	14.17	12.77	13.56	13.25
T_2	61.3	60.3	62.3	63.25	61.8	7.8	7.3	7.9	8.53	7.9	21.12	21.42	20.69	21.78	21.25
T_3	56.0	53.0	54.7	58.74	55.6	7.7	7.1	7.3	7.89	7.5	20.62	20.42	19.52	20.62	20.29
T_4	63.5	64.5	65.8	66.95	65.2	9.0	7.4	7.5	7.95	8.0	23.60	23.45	22.78	23.78	23.40
T_5	59.2	58.5	65.9	69.85	63.4	8.3	7.3	7.6	7.85	7.8	19.22	18.79	18.73	19.16	18.97
T_6	59.0	58.4	68.9	72.54	64.7	8.5	7.1	7.9	8.23	7.9	17.43	17.23	16.51	17.56	17.18
T_7	59.8	60.5	68.2	73.62	65.5	8.4	7.1	7.8	8.12	7.9	18.13	16.92	17.10	18.13	17.57
T_8	60.7	61.5	69.3	70.85	65.6	8.9	7.2	8.0	9.25	8.3	22.47	24.20	23.68	24.68	23.75
T_9	64.3	62.5	67.8	68.95	65.9	9.4	7.5	8.4	9.74	8.8	24.17	25.91	25.22	26.24	25.39
T_{10}	61.7	60.4	70.2	75.84	67.0	8.9	7.5	8.9	9.63	8.7	23.12	23.77	24.41	24.77	24.02
T_{11}	72.5	70.1	75.6	80.52	74.7	10.2	8.5	10.2	11.52	10.1	26.74	27.75	27.24	28.20	27.48
S.Em. ±	1.5	1.6	2.1	2.36	1.9	0.40	0.20	0.28	0.23	0.3	0.67	0.66	0.56	0.61	0.62
CD (P=0.05)	4.3	4.8	6.24	7.04	5.6	1.30	0.60	0.83	0.67	0.9	1.96	1.96	1.65	1.79	1.84

Table 2: Leaf area (cm^2 $plant^{-1}$), Leaf area Index and No. of pods $plant^{-1}$ of cowpea as impact on organic practices under different source of nutrients.

Treatment	Leaf area (cm^2)					Leaf area Index					No. of pods $plant^{-1}$				
	2013	2014	2015	2016	Pooled	2013	2014	2015	2016	Pooled	2013	2014	2015	2016	Pooled
T_1	507.6	516.8	538.4	538.5	525.3	1.13	1.15	1.20	1.20	1.17	18.9	20.5	21.36	23.52	21.1
T_2	811.1	814.2	806.2	814.2	811.4	1.80	1.81	1.79	1.81	1.80	19.3	22.1	23.69	25.89	22.7
T_3	676.4	673.1	674.9	678.0	675.6	1.50	1.50	1.50	1.51	1.50	19.1	22.2	24.50	26.74	23.1
T_4	837.9	836.4	837.5	839.8	837.9	1.86	1.86	1.86	1.87	1.86	24.1	22.1	24.60	25.61	24.1
T_5	663.3	661.3	661.8	664.8	662.8	1.47	1.47	1.47	1.48	1.47	19.4	19.1	20.30	21.35	20.0
T_6	520.9	519.2	519.1	522.4	520.4	1.16	1.15	1.15	1.16	1.16	21.3	17.7	18.50	19.85	19.3
T_7	597.1	595.3	597.0	598.6	597.0	1.33	1.32	1.33	1.33	1.33	20.8	18.2	19.60	22.36	20.2
T_8	818.5	851.8	852.2	858.5	845.3	1.82	1.89	1.89	1.91	1.88	23.3	20.8	23.50	25.68	23.3
T_9	1098.3	1069.0	1058.9	1102.2	1082.1	2.44	2.38	2.35	2.45	2.40	25	22.3	24.80	26.35	24.6
T_{10}	933.8	935.9	988.7	967.0	956.3	2.08	2.08	2.20	2.15	2.13	23.7	20.6	22.60	27.48	23.6
T_{11}	1159.9	1191.4	1232.1	1259.4	1210.7	2.58	2.65	2.74	2.80	2.69	26.3	25.3	28.00	30.52	27.5
S.Em. ±	39.3	30.5	34.7	37.9	35.6	0.09	0.07	0.08	0.08	0.08	0.8	0.5	0.59	0.62	0.6
CD (P=0.05)	115.9	90.1	102.3	111.9	105.0	0.26	0.20	0.23	0.25	0.23	2.3	1.6	1.74	1.85	1.9

Table 3: Number of seeds plant^{-1}, 100 seed weight (g) and Haulm yield (Kg ha^{-1}) of cowpea as impact on organic practices under different source of nutrients.

Treatment	Number of seeds pod^{-1}				100 seed weight (g)				Haulm yield (Kg ha^{-1})			
	2013	2014	2015	2016	Pooled	2013	2014	2015	2016	Pooled	2013	2014	2015	2016	Pooled
T_1	11.06	11.33	11.40	11.73	11.38	11.07	11.04	11.09	11.10	11.08	5466	4650	5587	5785	5372
T_2	13.04	12.69	13.08	13.21	13.01	11.40	11.43	11.43	11.44	11.43	7358	7319	7458	7589	7431
T_3	12.96	12.67	13.02	13.16	12.95	11.34	11.34	11.38	11.36	11.36	6572	6074	6874	7158	6670
T_4	13.11	12.60	13.18	13.25	13.04	11.42	11.43	11.40	11.45	11.42	8109	7633	8236	8365	8086
T_5	12.20	12.49	12.38	12.49	12.39	11.29	11.30	11.31	11.32	11.30	7488	7475	7596	7745	7576
T_6	12.05	12.10	12.07	12.12	12.09	11.23	11.22	11.23	11.26	11.24	7782	7520	7895	7985	7796
T_7	12.20	12.27	12.20	12.28	12.24	11.26	11.23	11.25	11.28	11.26	7619	7753	7741	7895	7752
T_8	13.24	13.10	12.95	13.29	13.14	11.54	11.52	11.56	11.57	11.55	7879	6291	7968	8152	7573
T_9	13.60	13.49	13.93	14.02	13.76	11.69	11.70	11.70	11.72	11.70	8207	7665	8367	8456	8174
T_{10}	13.48	13.24	13.58	13.91	13.55	11.59	11.56	11.60	11.61	11.59	7908	7520	7652	7895	7744
T_{11}	14.79	15.35	15.37	15.70	15.30	11.74	11.78	11.77	11.80	11.77	8608	8420	8674	8741	8611
S.Em. ±	0.33	0.49	0.29	0.30	0.35	0.04	0.06	0.06	0.06	0.05	202.0	196.0	201.3	205.6	201.2
CD (P=0.05)	0.97	1.43	0.85	0.89	1.04	0.12	0.17	0.17	0.16	0.16	597.0	579.0	603.2	614.5	598.4

In the present study, the increase in grain yield and haulm yield of cowpea due to application of 100% N equivalent compost + recommended FYM + Beejamrutha + Jeevamrutha could be due to better availability of nutrients throughout the crop growth which might be the result of improved microbial activity in the soil. These findings are in accordance with Kasbe *et al.* (2009) and Dekhane *et al.* (2011) where in, it is reported that higher nutrient status of Jeevamrutha formulation resulted in profused growth in the form of higher dry matter accumulation and yield parameters. Whenever liquid manures are applied at regular intervals (2 to 3 times), they act as a stimulus in the plant system and in turn increase the production of growth regulators in the cell system and growth hormones which in turn might have enhanced the soil biomass, there by sustaining the availability and uptake of applied as well as native soil nutrients which ultimately have resulted in better growth and yield of crops. These findings are in conformity with the results of Sharma and Thomas, (2010); Reshma *et al*., (2018).

Improvement in yield and yield attributes might be due to stimulation in root growth by organic nutrients as well better absorption of water and nutrients due to soil application of Jeevamrutha which further also supported the synergistic and complementary effect of Jeevamrutha after fermentation which favors the higher yield. These findings were in line with those reported by Reshma *et al.* (2018), Avudaithai *et al.* (2010) and Kumar *et al*. (2011).

Higher net returns was worked out with 100% N equivalent compost + recommended FYM + Beejamrutha + Jeevamrutha @ 500 liter/ha (Rs. 63,225) followed by 100% N equivalent compost + beejamrutha + jeevamrutha @ 500 liter/ha (Rs. 62,525). The higher net return was mainly due to higher grain yield and haulm yield of cowpea in addition to lower cost of cultivation. The lower net returns was recorded under 75% N equivalent compost (Rs. 41,925) (Table 4) which was mainly due to lower grain yield. While, the highest cost of production was recorded in application of 100% N equivalent compost + FYM @ 10 t/ha + beejamrutha + jeevamrutha @ 500 liter/ha (Rs. 43,225). Hence, even though this treatment recorded highest seed yield and net returns but recorded lower B:C ratio (2.46) due to higher cost of cultivation. These results were in line with McBride and Catherine Greene (2009).

The analysis of soil physico-chemical properties *viz*. pH, EC and per cent OC were not influenced significantly at the end of the fourth crop cycle (Table 5). However, these parameters were enhanced greatly as compared to initial soil test values. In the present investigation, there was a significant difference among the different organic sources of nutrient with respect to soil available major nutrients. Application of 100% N equivalent compost + FYM 10 t/ha + Beejamrutha + Jeevamrutha registered significantly higher amount of soil available nutrients (289.3, 40.5 and 182.6 kg N, P_2O_5 and K_2O/ha, respectively) as compared to other. However, it was at par with application of 125% N equivalent compost + Beejamrutha + Jeevamrutha (285.6, 35.6 and

170.8 kg N, P_2O_5 and K_2O/ha, respectively).This was due to build up of more amount of organic carbon in the soil and which in turn enhanced the nutrient supplying capacity of the soil due to build up of more and more soil micro-organisms. Organic manures were indirectly improving the physical, chemical and biological properties of soils reported by Palaniappa and Siddeswaran (1994) and Neha chaudhary *et al.* (2016).

The uptake of major nutrients were significantly higher in application of 100% N equivalent compost + FYM @ 10 t/ha + beejamrutha + jeevamrutha @ 500 liter/ha (143.4, 26.3 and 97.4 kg NPK/ha) as compared to other treatments.

Table 4: Grain yield and Economics of cowpea as impact on organic practices under different source of nutrients.

Treatment	Grain yield (Kg ha^{-1})				Pooled data of 4 years				
	2013	2014	2015	2016	Pooled	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B: C ratio
T_1	1445	1416	1485	1589	1484	32275	74200	41925	2.30
T_2	1524	1711	1768	1851	1714	32900	85700	52800	2.60
T_3	1513	1633	1695	1785	1657	33525	82850	49325	2.47
T_4	1829	1588	1678	1863	1740	41600	87000	45400	2.09
T_5	1594	1517	1658	1796	1641	32875	82050	49175	2.50
T_6	1651	1429	1547	1645	1568	33500	78400	44900	2.34
T_7	1612	1521	1612	1815	1640	34125	82000	47875	2.40
T_8	1768	1740	1802	1963	1818	33900	90900	57000	2.68
T_9	1925	1864	1963	2015	1941	34525	97050	62525	2.81
T_{10}	1804	1797	1847	1958	1852	35150	92600	57450	2.63
T_{11}	2056	1987	2108	2365	2129	43225	106450	63225	2.46
S.Em. ±	46.0	38.0	41.2	40.6	41.4	-	-	-	-
CD (P=0.05)	135.0	111.0	122.3	121.0	122.3	-	-	-	-

T_1 - 75% N equivalent compost, T_2 - 100% N equivalent compost, T_3 - 125% N equivalent compost, T_4 - 100% N equivalent compost + Recommended FYM, T_5 - 75% N equivalent compost + Beejamrutha, T_6 - 100% N equivalent compost +Beejamrutha, T_7 - 125% N equivalent compost + Beejamrutha, T_8 - 75% N equivalent compost + Beejamrutha + Jeevamrutha, T_9 - 100% N equivalent compost + Beejamrutha + Jeevamrutha, T_{10} - 125% N equivalent compost + Beejamrutha + Jeevamrutha and T_{11} - 100% N equivalent compost + Recommended FYM + Beejamrutha + Jeevamrutha.

Table 5: Impact of organic manures on soil chemical properties after the harvest of fourth crop.

Treatment	pH	EC (dSm^{-1})	OC (%)	Soil available nutrients (Kg ha^{-1})			Nutrient uptake (Kg ha^{-1})		
				N	P_2O_5	K_2O	N	P	K
T_1	7.52	0.325	0.415	232.5	20.5	143.2	100.7	17.6	62.8
T_2	7.32	0.351	0.412	246.8	26.8	155.6	112.3	18.4	65.9
T_3	7.28	0.349	0.421	255.3	35.4	158.7	122.7	20.1	71.8
T_4	6.75	0.343	0.420	275.8	32.6	176.9	106.8	18.4	78.5
T_5	7.81	0.328	0.426	242.3	25.8	135.8	116.8	20.56	71.7
T_6	7.41	0.342	0.428	245.8	30.2	145.6	124.4	21.04	78.4
T_7	7.15	0.350	0.432	275.6	25.6	156.3	116.9	22.23	81.7
T_8	7.12	0.332	0.436	252.3	28.7	133.5	132.5	22.43	85.7
T_9	7.10	0.351	0.459	278.9	25.9	152.6	136.7	24.5	90.4
T_{10}	7.01	0.361	0.468	285.6	35.6	170.8	142.4	25.9	93.9
T_{11}	6.75	0.372	0.452	289.5	40.5	182.3	143.4	26.3	97.4
S.Em. ±	0.32	0.019	0.095	8.12	0.86	8.89	4.48	0.89	5.02
CD (P=0.05)	NS	NS	NS	23.12	2.412	26.02	13.45	2.66	15.05

Initial soil chemical properties: Bulk density: 1.32 g/cc;Soil pH: 6.85; OC: 0.36; Electrical conductivity: 0.338 dSm^{-1}; Soil Available N: 229 kg/ha, P_2O_5: 19.2 kg/ha and K_2O: 135 kg/ha.

T_1 - 75% N equivalent compost, T_2 - 100% N equivalent compost, T_3 - 125% N equivalent compost, T_4 - 100% N equivalent compost + Recommended FYM, T_5 - 75% N equivalent compost + Beejamrutha, T_6 - 100% N equivalent compost +Beejamrutha, T_7 - 125% N equivalent compost + Beejamrutha, T_8 - 75% N equivalent compost + Beejamrutha + Jeevamrutha, T_9 - 100% N equivalent compost + Beejamrutha + Jeevamrutha, T_{10} - 125% N equivalent compost + Beejamrutha + Jeevamrutha and T_{11} - 100% N equivalent compost + Recommended FYM + Beejamrutha + Jeevamrutha.

However, it was on par with 125% N equivalent compost + beejamrutha + jeevamrutha @ 500 liter/ha (142.4, 25.9 and 92.9 kg NPK/ha) and 100% N equivalent compost + beejamrutha + jeevamrutha @ 500 liter/ha (136.7, 24.5 and 90.4 kg NPK/ha). These results are in line with earlier findings of Kiran *et al.* (2015), Arun kumar *et al.* (2014) and Neha chaudhary *et al.* (2016).

Thus, combined application of different levels of organic manures, jeevamrutha and beejamrutha resulted in better growth and yield attributes resulting into 30.29 per cent increased grain yield in cowpea. Organic manures and liquid organic formulations can effectively and efficiently be used to get higher grain yield in cowpea. Hence, this study has shown the advantages with organic manures and organic liquid formulations and thus they can be exploited extensively in crop production.

CONCLUSION

Combined application of organic manures, jeevamrutha and beejamrutha @ 100% N equivalent compost + FYM @ 10 t/ha + beejamrutha + jeevamrutha @ 500 liter/ha resulted in better growth attributes and contributed for improved fertility status of soil in terms of soil available N, P_2O_5 and K_2O 289.5, 40.5 and 182.3 kg/ha, respectively. It has resulted in 30.29 percent increased grain yield over application of 75% N equivalent compost.

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