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Integrated nutrient management for seed production in cowpea [*Vigna unguiculata* L.]

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Abstract
An experiment on integrated nutrient management for seed production in cowpea was conducted with treatments T1 (RDF), T2 (RDF + lime), T3 (75% RDF + lime), T4 (75% RDF +25% FYM), T5 (75% RDF +25% vermicompost), T6 (75% RDF+25% FYM + lime), T7 (75% RDF + 25 % vermicompost + lime), T8 (50% RDF + 25% FYM+ 2 foliar spray), T9 (50 % RDF + 25% vermicompost +2 foliar spray), T10 (50% RDF +25% FYM + lime + 2 foliar spray), T11 (50% RDF +25% vermicompost + lime+ 2 foliar spray). It was observed that the number of pods per plant was highest in T7 (18.67) followed by T5 (16.67), length of pod was highest with T1(26.36 cm) followed by T6 (26.32 cm), dry weight of pod per plant was highest in T7 (32.67 g) followed by (32.03 g) in T4, number of seeds per plant was highest in T7 (190.67) followed by T6(180.00) and dry weight of pods per plot was highest in T7 (2010.5 g) followed by T6 (2008.6 g). However, the seed yield per plot was maximum in T7 (1656.00 g) followed by 1505.52 g in T6 and the seed yield per hectare was highest in T7 (18.21 q/ha) followed by 16.56 q/ha in T6 and 15.32 q/ha in T4 and the lowest seed yield of 13.95 q/ha was obtained in T1. It was observed that T7 produced the highest yield of 18.21q/ha followed by T6 (16.56 q/ha) which were significantly higher than the rest of the treatments. It can be concluded that application of 75% RDF along with either vermicompost or with FYM and application of lime produced a good environment supporting very good growth of cowpea to produce significantly higher seed yield.

Keywords: Cowpea, Vermicompost, Foliar Spray, Seed Yield

Introduction
Cowpea (*Vigna unguiculata* L. Walp.) is one of the most important pulse crop among the various grain legumes. Grain legumes are considered to be the most important source of protein in tropical and sub-tropical countries, where diets in general are deficient in protein. Pulses contain a high percentage of quality protein nearly three times as much as cereals. They also provide substantial quantities of minerals and vitamins to the diet. Cowpea is called as vegetable meat due to high amount of protein in grain with better biological value on dry weight basis. The factors attributed for low yields of pulses in India as compared to the world productivity are non-availability of quality seeds of improved and short duration varieties, growing of pulses under marginal and less fertile soil with low inputs and without pest and disease management, growing of pulses under moisture stress, unscientific post-harvest practices and storage under unfavourable conditions. Hence, there is a scope for improving the production potential of this crop by use of organic, inorganic and bio-fertilizers. 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 the sustainable agriculture. Therefore, there is an urgent need to reduce the usage of chemical fertilizers and in turn increase in the usage of organics which needed to check the yield and quality levels. Use of organics alone does not result in spectacular increase in crop yields, due to their low nutrient status (Subba Rao and Tilak, 1977) [17]. Therefore, the aforesaid consequences have paved way to grow cowpea using organic and inorganic fertilizer along with biofertilizer. Quality seed production in cowpea and seed availability is a felt need among the farmers. In view of such circumstances systemic research efforts are to be integrated to find out an optimum combination of organic nutrients viz., FYM, vermicompost, lime with different doses of chemical inorganic fertilizers in cowpea under coastal agro climatic zones of Odisha to standardize a best combination to get more seed yield.

Material and Methods
The field experiment entitled was carried out during Rabi season of the year 2016-17 in the Vegetable Demonstration Plot of the Department of Vegetable Science, College of

Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha. The trial was conducted in RBD with three replications and eleven treatments. The treatments are T1 (RDF), T2 (RDF + lime), T3 (75% RDF + lime), T4 (75% RDF +25% FYM), T5 (75% RDF +25% vermicompost), T6 (75% RDF+25% FYM + lime), T7 (75% RDF + 25 % vermicompost + lime), T8 (50% RDF + 25% FYM+ 2 foliar spray), T9 (50 % RDF + 25% vermicompost +2 foliar spray), T10 (50% RDF +25% FYM + lime + 2 foliar spray), T11 (50% RDF +25% vermicompost + lime+ 2 foliar spray). [Recommended Dose of Fertilizer i.e. 40: 60: 60 kg NPK ha-1, lime @ 5q/ha was applied. Calculated amount of FYM and vermicompost were applied as per treatments. Foliar spray with NPK (19-19-19) @ 7.5 g/l was done as per the treatment.]

The seed of cowpea variety Kashi Kanchan, was collected from IVRI, Varanasi. Kashi Kanchan is a promising cow pea variety released from IIVR, Varanasi. This verity can be grown round the year provided there is mild winter during December and January. This variety is bushy and do not require staking with profuse fruiting. Good, healthy and bold seeds were selected and sowing was done after land preparation of the main field on lines giving 50 cm × 20 cm spacing in each plot of 3 m × 2.5m length and width.

Decomposed compost, well sieved vermicompost were purchased and applied in time as per treatment. FYM and vermicompost were applied before sowing of seeds. The recommended dose of fertilizer is 40:60:60 kg NPK ha^{-1} was applied through Urea, SSP (Single Super Phosphate), and MOP (Muriate of potash). The total amount of phosphorous and half of nitrogen as well as half of potash were applied as basal dressing before sowing the seeds in the rows. Thirty days after sowing, half of nitrogen and half of potash was applied as top dressing during hoeing, as per the treatment schedule. The soluble fertilizer (19:19:19 N: P: K) was sprayed as per the treatment schedule. All other recommended package of practices were followed throughout the research work. From each treatment ten number plants selected randomly were tagged for recording various biometric observations. The mean of the ten plants was considered for further analysis. The observations on various growth and yield parameters were recorded from the selected plants. The border plants were excluded while selecting the sample plants. Growth parameters like plant height, number of branches per plant, leaf area, leaf weight, fresh weight of the root per plant, dry weight of the root per plant, number of root nodules and phenological parameters like days to 1st flowering and days to 50% percent flowering along with yield parameters like number of pods per plant, average fresh weight of pod, pod length, pod circumference, number of seeds per pod, weight of fresh seeds per pod, dry weight of pod per plant, no of seeds per plant, number of pods harvested per plot, dry pod weight per plot, seed yield per plot, seed yield per hectare and b:c ratio were recored during the crop growth and after harvest period.

Analysis of variance (ANOVA) was carried out on mean values separately for each character adopting standard analysis of variance technique for RBD design (Panse and Sukhatme, 1985) [7]. The analysis of variance for each of the character was carried out with the mean value of data collected from sample plants from each plot and the mean average data was used for the total variance into components due to replication, treatment and error.

Results and Discussions

The plant height was taken on both 60th days and also on 90th day during the period of experiment. From the data, it was observed that lowest plant height of 39.89 was in T1 (RDF) and highest plant height 48.25 was recorded with T7 (75% RDF+25%VC+ Lime). However, plant height of 87.83 was found with T10 (50% RDF + 25% FYM +Lime + 2 foliar spray) and 112.74cm was with T4 (75% RDF + 25% FYM). The increase in plant height in different treatment did not show any systematic expression. Sharma *et al*. (2015) [12] recorded maximum plant height with vermicompost 5 T/ha whereas Menon *et al*. (2010) [6] reported increase in plant height due to application of inorganic fertilizers and FYM in Bhagya Laxmi variety of cowpea.

The number of branches per plant did not showed any significant effect due to various combinations of treatments. It was 8.80 in T7 (75% RDF + 25% VC + Lime) and 6.53 in T1 (RDF). Increase in number of branches due to vermicompost application was reported by Sharma *et al*. (2015) [12] and Das *et al*., 2011 [1] in Cowpea with 75% RDF with other organic manure combination.

Due to integrated nutrient management, there was significant difference in leaf area in various treatment which was only 120.84 cm^2 in T5 (75% RDF + 25% Vermicompost) and was 172.98cm^2 in T7 (75% RDF + 25% VC + Lime). Even though the increase in leaf area was more due to combine application of organic manure but the trend was not uniform in all the treatments. Ramana *et al*. (2011) [10] reported increase in leaf area due to 75% RDF+PSB in cowpea and also Lad *et al*. (2014) [5] in cowpea due to increase level of nitrogen during the trial.

The average fresh weight of trifoliate leaves of cowpea did not varied much because this character is somewhat a varietal character. The fresh weight of leaves varied from 2.88gm in T8 (50% RDF + 25% FYM +2 foliar spray) and 3.57 in T7 (75% RDF + 25% VC +Lime).

The fresh weight of different root ranged from 7.67 in T8 to 11.67 inT10. Similarly, the dry weight of roots ranged from 2.03 in T11 to 2.86 in T7 and T9. It was found that during experiment these two characters did not reflect similar trend in different treatments Kirmiti (2011) [4] also reported increase in root biomass in different variety of cowpea.

The number of root nodule per plant varied from 8.70 inT1 to 29.27 in T7. In T1 due to only RDF application the number of nodules were less as compared T7 which recorded highest number of nodules due to 75% RDF +Vermicompost +Lime application. Increase in nodule number per plant was also reported by Patel and Jadav (2010) [8], Singh *et al*. (2005) [15] and Khan *et al*. (2015) [3].

The days taken to first flowering was little delayed due to more winter during the experiment period. However, days to 1st flowering was 50.57 days in T1 (RDF) and flowering in T9 (50% RDF+ 25% VC + 2 foliar spray) was 41.33 day. It was found that only application of RDF took more days as compared to combination of nutrients in other treatments. There was significant difference in days to flowering when organic sources were taken as compared to only inorganic fertilizers. However, days to 50% flowering ranged from 69.67 in T8 (50% RDF + 25% FYM +2 foliar spray) to 73 days in T9 (50% RDF + 25% VC +2 foliar spray). Since the flowering behaviour is genetically controlled and also influenced by climate so, different treatment combination did not produce much variation as per days to first flowering and days to 50% flowering was concerned. Tiwari and Singh (2000) observed no significant difference in number of days

taken to 50% flowering due to fertilization. However, Satodiya (2015) [11] concluded that application of fertilizer resulted in significant decrease in days to flowering. However, Patel and Jadav (2010) [8] concluded that inorganic fertilizer along with Rhizobium seed in inoculation recorded earliness in flowering in Pusa Phalguni variety of cowpea.

The number of pods per plant varied from 11.33 to 18.67 and was found significantly differ indifferent treatments. The average weight of pod was 7.55 g in T3 (75 % RDF + Lime) to 8.95g in T6 (75% RDF + 25% FYM +Lime). It was found that there was not much variation in average pod weight and also pod length which was found to be 24.83 in T5 (75% RDF + 25% Vermicompost) to 26.36 in T1 (RDF). However, the circumference of pod varied from 2.63 in T3 (75 % RDF + Lime) to 2.81 in T2 (RDF +Lime). The number of seeds per pod ranged from 11.20 to 13.80. There was not much variation in length of pod and also the number of seeds per pod in various treatments. However, the fresh weight of seeds per pod was found to record 2.98 to 3.76g in T11 (50% RDF + 25% VC+Lime+1 foliar spray) and T7 (75% RDF + 25% VC + Lime) respectively. It was observed that number of pod and other pod characteristics record significant difference in many of the treatments. This type of observation had been reported by Ramana *et al*. (2011) [10] and Jat *et al*. (2013) [2] in pod length and number of seeds per pod and number of pods per plant. Prasad *et al*. (2012) [9] recorded increase in pod length and number of pods per plant due to inorganic fertilization along with bio fertilizer treatment. Similarly, result were also reported by Singh *et al*. (2011) [14] in French bean and Sharma *et al*. (2015) [12] in cowpea.

The dry weight of pod per plant varied from 20.27 g to 32.67 g and there was significant difference in dry weight of pod per plant in different treatment. Similarly the number of seeds per plant also varied from 154.33 in T3 to 190.67 in T7. It was found that when dry weight of pods per plant was increased due to more number of seeds per pod, the total dry weight of seeds per plant was also increased. It was observed that 75% RDF + 25% VC + Lime application produced more seeds per plant.

The number of pods/plot varied from 659.00 in T9 to 858.67 in T7. It was observed that 50% RDF + 25% VC + 2 foliar spray produced least number of pods per plot. The vermicompost application in treatment combination produced better results for seed yield/ha. The dry weight of pods per plot varied from 1397.00 in T11 to 2010.50 in T7. Similar trend of numbers of pods per plant and dry weight of pod per plot was found in the same treatment indicating the effect of inorganic and organic matter producing this trend.

The dry seed yield per plot was 1268.42g in T1 and 1656.00 in T7. Similarly, the dry seed yield per hectare was lowest i.e. 13.95 Q/ha in T1 as compared to 18.21 Q/ha in T7. Which reflect the similar trend in different treatment so far as yield and yield attributing characters were concerned. It can be found from the data that only inorganic manure with amendments do not produce high seed yield rather a combination of 75% RDF and other organic manures produced better results. This type of findings were also reported by Jat *et al*. (2013) [2], Prasad *et al*. (2012) [9], Singh *et al*. (2012) [13], Singh and Chauhan (2009) [16] and Sharma *et al*. (2015) [2]. Even though foliar spraying of soluble nutrient keep the plant healthy but due to 50% RDF in those treatment combination the yield and yield attributes characters were not found to be significantly influenced.

The result of the experiment revealed that cowpea crop when grown in Rabi season and if coincide with low temperature comes to flowering little late and once the diurnal temperature becomes moderate there is profuse flowering and fruiting with less incidence of diseases. Kashi Kanchan variety of cowpea responded well to inorganic and organic sources of plant nutrients better as compared to inorganic nutrients alone. However, with 50% RDF and 25% vermicompost or FYM with foliar spraying twice with soluble fertilizer could not produced desired yield as seen in treatment T7 when a combination of 75% RDF + 25% vermicompost + Lime was taken which produced height seed yield of 18.21 Q/ha. This combination also response well to yield attributing characters, and other growth parameters and quality of the seeds as well. The B: C ratio was also found to be best with this treatment.

So, it can be concluded that seed production of Kashi Kanchan variety of cowpea released from IIVR, Varanasi can be suitable taken under coastal agro climatic condition based on soil test report with 75% RDF + 25% vermicompost + lime to get good seed yield per hectare. However, the trial may be conducted over seasons at various localities to get more authentic result and seed production of Kashi Kanchan variety of cowpea as revealed from the experiment can be profitable done under Odisha agro climatic condition.

Table 1: Growth and phenological characters of cowpea as influenced by different treatments

Treatment		Plant height (cm)		No. of branches (90 DAS)	Leaf area (cm^2)	Fresh weight of leaves (g)	Days to 1st flowering	Days to 50 % flowering	Fresh weight of root (g)	Dry weight of root (g)	No. of nodules/ plant
		60 DAS	At harvest								
T_1	RDF	39.89	108.67	6.53	129.59	2.89	50.67	71.33	8.33	2.06	8.70
T_2	RDF + lime	43.86	95.33	7.13	134.14	3.43	46.20	69.67	10.33	2.43	20.83
T_3	75% RDF + lime	42.29	110.32	6.93	148.95	3.02	46.27	70.67	9.67	2.70	21.40
T_4	75% RDF + 25% FYM	45.79	112.74	7.27	142.01	3.10	48.00	69.67	11.00	2.63	26.73
T_5	75% RDF + 25% vermicompost	47.23	101.13	7.47	120.84	3.07	47.00	72.33	11.33	2.52	27.70
T_6	75% RDF + 25% FYM + lime	47.50	109.04	8.60	168.78	3.53	43.67	71.33	9.33	2.53	28.23
T_7	75% RDF +25% vermicompost +lime	48.25	108.32	8.80	172.98	3.57	44.67	72.67	10.67	2.86	29.27
T_8	50% RDF + 25% FYM + 2 foliar spray	45.25	96.93	7.73	137.20	2.88	47.30	69.67	7.67	2.10	17.57
T_9	50% RDF + 25% vermicompost + 2 foliar spray	43.14	103.04	7.80	128.94	3.52	41.33	73.00	9.33	2.86	15.13
T_{10}	50% RDF + 25% FYM + lime + 2 foliar spray	44.70	93.94	7.73	160.23	3.03	46.33	71.67	11.67	2.41	12.90
T_{11}	50% RDF + 25% vermicompost + lime + 2 foliar spray	47.01	87.78	6.87	125.08	3.53	46.00	70.67	8.33	2.03	16.43
	CEm (±)	3.92	8.03	0.64	6.50	0.22	2.65	2.25	0.84	0.21	1.85
	CD (0.05)	11.56	23.67	1.88	19.16	0.65	7.82	6.63	2.48	0.60	5.46
	CV (%)	15.08	13.57	14.67	7.92	11.72	9.96	5.48	14.88	14.17	15.69

Table 2: Yield and yield attributing characters of cowpea as influenced by different treatments

Treatment		No. pods / plant at harvest	Weight of fresh pod (g)	Pod length (cm)	Pod girth (cm)	Dry weight of pods/ plant (g)	No. of pods/ plot	Pod weight/ plot (g)	No. of seeds/ pod	Weight of seeds/ pod (g) (fresh)	No. of seeds/ plant	Seed yield/ plot (g)	Seed yield (q/ha)
T_1	RDF	8.80	26.36	2.64	24.47	155.67	1401.13	13.00	667.33	1268.42	13.95	3.13	14.00
T_2	RDF + lime	8.37	26.04	2.81	30.60	175.33	1631.30	13.20	741.33	1365.65	15.30	3.25	14.67
T_3	75% RDF + lime	7.55	25.77	2.63	27.11	154.33	1486.71	13.80	764.67	1302.60	14.32	3.28	15.33
T_4	75% RDF + 25% FYM	8.60	25.90	2.69	32.03	170.67	1544.80	12.90	671.67	1393.26	15.32	3.51	15.67
T_5	75% RDF + 25% vermicompost	8.02	24.83	2.63	29.00	183.00	1858.32	13.60	834.33	1391.59	15.35	3.57	16.67
T_6	75% RDF + 25% FYM + lime	8.95	26.32	2.68	30.30	180.00	2008.60	12.40	837.33	1505.52	16.56	3.61	16.33
T_7	75% RDF + 25% vermicompost +lime	8.42	25.20	2.72	32.67	190.67	2010.50	13.50	858.67	1656.00	18.21	3.76	18.67
T_8	50% RDF + 25% FYM+ 2 foliar spray	8.27	25.57	2.65	30.00	164.67	1638.00	12.47	768.32	1335.84	14.69	3.75	15.67
T_9	50% RDF + 25% vermicompost + 2 foliar spray	8.25	25.05	2.64	29.03	175.00	1464.45	11.90	659.00	1323.40	14.55	3.05	14.67
T_{10}	50% RDF + 25% FYM + lime + 2 foliar spray	8.08	26.28	2.76	24.33	161.00	1728.05	12.93	751.33	1277.90	14.05	3.62	12.33
T_{11}	50% RDF + 25% vermicompost + lime + 2 foliar spray	6.07	25.03	2.68	20.27	160.33	1397.00	11.20	659.00	1371.02	14.56	2.98	11.33
	CEm (±)	0.69	0.88	0.11	1.57	12.45	122.32	0.37	40.17	80.77	0.92	0.16	1.36
	CD (0.05)	2.04	2.58	0.34	4.62	36.73	36.60	1.10	118.49	238.23	2.71	0.48	4.00
	CV (%)	14.44	5.91	7.41	9.64	12.68	12.83	5.04	9.39	10.13	10.53	8.41	15.53

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