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Effect of chemical fertilizer, organic manure and bio-fertilizer on NPK content, uptake and quality of summer cowpea (*Vigna unguiculata* L. Walp)

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Abstract
A field experiment was conducted during summer season of the year 2018 on loamy sand soil at College Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand to evaluate the effect of chemical fertilizer, organic manure (Castor cake, Vermicompost and FYM) and bio-fertilizers (*Rhizobium* and PSB) on nutrient content, nutrient uptake and quality of summer cowpea (*Vigna unguiculata* L. Walp). Significantly higher nitrogen and phosphorus content and uptake by seed was recorded under treatment T_2 (RDF 20-40-00 NPK kg ha^{-1}). Whereas, highest potassium content and uptake by seeds was registered under treatment T_8 (FYM @ 4 t ha^{-1} + PSB @ 5 mL kg^{-1} seed). Significantly higher nitrogen and phosphorus content and uptake in haulm also recorded under treatment T_2 (RDF 20-40-00 NPK kg ha^{-1}). Moreover, higher content of potassium in seed and haulm was noted with treatment T_8 (FYM @ 4 t ha^{-1} + PSB @ 5 mL kg^{-1}). Significantly higher protein content was recorded under the treatment T_2 (RDF 20-40-00 NPK kg ha^{-1}). The application of FYM @ 4 t ha^{-1} +PSB @ 5 mL kg^{-1} seed i.e. treatment T_8 remained at par with the treatment T_2 (RDF) with 22.30% protein content.

Keywords: Cowpea, castor cake, FYM, vermicompost, *Rhizobium*

Introduction
Among various pulses, cowpea have its origin from India and Ethiopia and is widely grown all over the world. Botanically, cowpea belongs to the family leguminosae and sub family fabaceae. It is a warm season, annual herbaceous legume. Plants are often categorized as erect, prostrate or creeper. Throughout India, cowpea is cultivated for its long green pods as vegetables and also provide foliage as green manure and fodder. In organic farming system, cowpea is one of the most essential vegetable crop as it fixes atmospheric nitrogen up to 240 kg/ha and leaves about 60 to 70 kg residual nitrogen for succeeding crops. Cowpea serves as a dual purpose food at both green shell and dry stage. It is also grown for hay and silage pasture and also as a source of protein, especially of lysine in the staple cereal diets of farming communities. In the current context with the advancement in the knowledge, technology and concern about the ecosystem, more emphasis is being given to the alternative sources of nutrients than fertilizers alone for maintaining the sustainability of environment. In view of this liquid biofertilizers and various organics supplements are also being focused along with chemical fertilizers. Organic manure *viz*., FYM, vermicompost, poultry manure and oilcake helps 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) [1]. In addition to this, the organic manures help in improving the use efficiency of inorganic fertilizers (Singh & Biswas, 2000) [7]. The seed inoculated with *Rhizobium* increase the number of rhizosphere and enhance microbiological activities. In view of the fact narrated above, the need based research program was planned.

Material and Method
A field experiment was conducted at College Agronomy Farm, B.A College of Agriculture, Anand Agricultural University, Anand (Gujarat) during summer season of the year 2018. The soil of experimental site was loamy sand in texture, having low in organic carbon and available nitrogen (124.85 kg ha^{-1}), medium in available P_2O_5 (29.23 kg ha^{-1}) and high in available K_2O (286.76 kg ha^{-1}). Cowpea variety Gujarat cowpea 4 (GC 4) was used as a test crop in the study.

The experiment was arranged in randomized block design with four replications, consisting of twelve treatments T_1: No fertilizer (control), T_2: RDF 20-40-00 kg ha^{-1} (NPK), T_3: Castor cake @ 0.5 t ha^{-1}, T_4: Vermicompost @ 1 t ha^{-1}, T_5: FYM @ 4 t ha^{-1}, T_6: Castor cake @ 0.5 t ha^{-1} + PSB @ 5 mL kg^{-1} seed, T_7: Vermicompost @ 1 t ha^{-1} + PSB @ 5 mL kg^{-1} seed, T_8: FYM @ 4 t ha^{-1} + PSB @ 5 mL kg^{-1} seed, T_9: *Rhizobium* @ 5 mL kg^{-1} seed + PSB @ 5 mL kg^{-1} seed, T_{10}: Castor cake @ 0.25 t ha^{-1} + *Rhizobium* @ 5 mL kg^{-1} seed + PSB @ 5 mL kg^{-1} seed, T_{11}: Vermicompost @ 0.5 t ha^{-1} + *Rhizobium* @ 5 mL kg^{-1} seed + PSB @ 5 mL kg^{-1} seed and T_{12}: FYM @ 2 t ha^{-1} + *Rhizobium* @ 5 mL kg^{-1} seed + PSB @ 5 mL kg^{-1} seed, each plot being 3.60 m × 5.00 m. Chemical fertilizer were applied through urea and DAP as per treatment. Organic manure comprising of castor cake and FYM were applied well in advance for proper decomposition whereas, vermicompost was applied on the day of sowing. The seeds were inoculated with respective strains of *Rhizobium* and PSB according to the treatment. Crop was harvested in second week of May. The data recorded during the course of investigation were subjected to statistical analysis as per method of analysis of variance (Panse and Sukhatme, 1978). Cowpea was sown on 21st February with seed rate of 25 kg ha^{-1}.

Results and Discussion

Effect on NPK content in seed and haulm

Data with respect to NPK content in seed and haulm as influenced by different treatments are presented in Table 1. Significantly higher nitrogen (3.79%) and phosphorus content (0.69%) in seed was obtained under treatment T_2 (RDF 20-40-00 NPK kg ha^{-1}). Whereas, the higher K content in seed (1.47%) was recorded with treatment T_8 (FYM @ 4 t ha-1 + PSB @ 5 mL kg^{-1} seed). The higher N content in seed was recorded with treatment T_2 (20-40-00 NPK kg ha^{-1}) may be attribute to greater availability of N under this treatment and its efficient and effective absorption by the root system and greater availability of nutrients in rhizosphere. The reason for the highest content of P in seed through application of RDF in form of chemical fertilizer may be probably because of higher P concentration in soil solution, which reflected in terms of higher content of P in seed. The findings are in close proximity with the findings of Khandelwal *et al.* (2012) [5] and Verma *et al.* (2015) [9]. The higher K content in seed was recorded with treatment T_8 (FYM @ 4 t ha-1 + PSB @ 5 mL kg^{-1} seed) may be due to improved nutritional status in plant parts under FYM application primarily seems to be on account of enrichment of these nutrients in soil, secondly it can be attributed to their efficient extraction per translocation in the plant system due to enhanced activities of roots on account of pivotal role of FYM on maintenance of better physico-chemical and biological properties of the soil. Similar results were published by Chaudhary *et al.* (2016) [2] in cowpea.

The data pertaining to the NPK content in haulm of cowpea as influenced by different treatments are presented in Table 1. The N and P content in haulm were significantly influenced by various treatments. From the results (Table 1), it was observed that higher N (1.97%) and P content (0.34%) in haulm was recorded under treatment T_2 RDF (20-40-00 NPK kg ha^{-1}). Whereas, the K (2.47%) content in haulm was recorded significantly higher under treatment T_8 (FYM @ 4 t ha^{-1} + PSB @ 5 mL kg^{-1} seed). The increase in N content in haulm with treatment T_2 RDF (20-40-00 NPK kg ha^{-1}) was quite obvious because under this treatment, chemical fertilizer supplied N which is in available and easily absorbable form resulted into more content of N in haulm. The higher removal of P with this treatment might be due to better development of root and shoot which ultimately resulted in higher content of P in haulm. These findings are in collaboration with the findings of Khandelwal *et al.* (2012) [5] and Yadav *et al.* (2017) [10]. The appraisal of data presented in Table 1 revealed that the difference in K content due to varied treatments was significant. The K content (2.47%) in haulm was recorded significantly higher under treatment T_8 (FYM @ 4 t ha^{-1} + PSB @ 5 mL kg^{-1} seed). The treatment T_8 (FYM @ 4 t ha^{-1} + PSB @ 5 mL kg^{-1} seed) recorded higher amount of K in haulm may be due to the integrated application of FYM and bio-fertilizer which must have provided K in extraction per translocation in the plant system owing to improved activities of roots on account of crucial role of FYM on maintenance of better physical, chemical and biological properties of the soil. The results are in close agreement with those reported by Chaudhary *et al.* (2016) [2] in cowpea.

Effect on NPK uptake by seed and haulm

Data presented in Table 2 indicated that NPK uptake by seed and haulm was significantly influenced by different treatments. Significantly higher nitrogen (36.88 kg ha^{-1}) and phosphorus uptake (6.75 kg ha^{-1}) by seed was obtained under treatment T_2 (RDF 20-40-00 NPK kg ha^{-1}). Whereas, the higher K uptake by seed (13.81 kg ha^{-1}) was recorded with treatment T_8 (FYM @ 4 t ha-1 + PSB @ 5 mL kg^{-1} seed). The reason behind the higher uptake of N is directly related with the yield and N content in seed. The treatment T_2 (RDF 20-40-00 NPK kg ha^{-1}) received maximum yield and N content in seed which would have resulted in overall higher N uptake. The findings are in close proximity with the findings of Khandelwal *et al*. (2012) [5] and Verma *et al*. (2015) [9]. The K content in seed as well as yield of the seed under this treatment is higher which resulted into higher uptake of K under this treatment. Similar results were published by Chaudhary *et al*. (2016) [2] in cowpea.

Perusal of data presented in Table 2 revealed that NPK uptake by haulm of cowpea as influenced by different treatments. The highest N (25.43 kg ha^{-1}) and P (4.43 kg ha^{-1}) uptake by haulm was observed under treatment T_2 (RDF 20-40-00 NPK kg ha^{-1}). Whereas, the K (29.62 kg ha^{-1}) uptake by haulm was recorded significantly higher under treatment T_8 (FYM @ 4 t ha^{-1} + PSB @ 5 mL kg^{-1} seed). Treatment receiving RDF in respect to N uptake by haulm indicated conspicuous differences from various treatment because the N content and haulm yield under this particular treatment is high which together succeed in giving higher N uptake in haulm. Uptake is the product of nutrient content in haulm and haulm yield, ascribed to this fact it is evident that P uptake in haulm is higher under (RDF) owing to higher P content in haulm and haulm yield. The results are in close agreement with those given by Dekhane *et al.* (2011) [4], Khandelwal *et al*. (2012) [5] and Yadav *et al.* (2017) [10]. The close observation of the set of data tabulated (Table 2) state that significantly highest K uptake by haulm (29.62 kg ha^{-1}) was found under the treatment T_8 (FYM @ 4 t ha^{-1} + PSB @ 5 mL kg^{-1} seed) and the lowest K uptake (9.30 kg ha^{-1}) was given by treatment T_1 (control). As we observe that the K content and seed yield in treatment T_8 (FYM @ 4 t ha^{-1} + PSB @ 5 mL kg^{-1} seed) is higher and when this content is multiplied with the yield it's obvious that it will give higher value of K uptake in haulm under this particular treatment. The result is in closely related with the findings of Chaudhary *et al*. (2016) [2] in cowpea.

Effect on protein content in seed

The data pertaining to protein content in seed as influenced by different treatments are presented in Table 2. Significantly higher protein content (23.70%) was recorded under the treatment T_2 (RDF 20-40-00 NPK kg ha^{-1}). The application of FYM @ 4 t ha^{-1} +PSB @ 5 mL kg^{-1} seed i.e. treatment T_8 remained at par with the treatment T_2 (RDF) with 22.30% protein content. Increase in protein content in seed might be due to the fact that higher nitrogen content in seed is directly associated to higher availability of nitrogen to plants. Higher nitrogen in seeds is directly responsible for higher protein content because it is a primary component of amino acid which constitute the basis of protein content. Another reason for the increase in the protein content might be due to fact that cowpea is a leguminous crop and the application of phosphatic fertilizer must have activated the microbial population responsible for root nodulation and efficient nodulation which must have enhanced nitrogen fixation by the plant and ultimately increased the protein content. The results are in close conformity with those of Chauhan *et al*. (2016) [3] and Singh *et al.* (2018) [8].

Table 1: Effect of chemical fertilizer, organic manure and bio-fertilizers on NPK content and uptake by seed of cowpea

Treatments		Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	NPK content in seed			NPK uptake by seed		
				N Content (%)	P Content (%)	K Content (%)	N Uptake (kg ha^{-1})	P Uptake (kg ha^{-1})	K Uptake (kg ha^{-1})
T_1	Control	747	922	3.04	0.45	0.99	20.35	3.36	7.35
T_2	RDF (20-40-00 NPK kg ha^{-1})	972	1362	3.79	0.69	1.10	36.88	6.75	10.73
T_3	Castor cake @ 0.5 t ha^{-1}	825	1052	3.20	0.51	1.22	26.59	4.25	10.04
T_4	Vermicompost @ 1 t ha^{-1}	824	1034	3.18	0.53	1.22	26.21	4.37	10.06
T_5	FYM @ 4 t ha^{-1}	825	1078	3.23	0.54	1.24	26.45	4.43	10.26
T_6	Castor cake @ 0.5 t ha^{-1} + PSB @ 5 mL kg^{-1} seed	848	1096	3.27	0.54	1.27	27.68	4.58	10.74
T_7	Vermicompost @ 1 t ha^{-1} + PSB @ 5 mL kg^{-1} seed	842	1081	3.24	0.55	1.31	27.40	4.60	11.03
T_8	FYM @ 4 t ha^{-1} + PSB @ 5 mL kg^{-1} seed	942	1201	3.59	0.55	1.47	32.59	5.39	13.81
T_9	*Rhizobium* @ 5 mL kg^{-1} seed + PSB @ 5 mL kg^{-1} seed	784	979	3.13	0.48	1.10	24.62	3.75	8.51
T_{10}	Castor cake @ 0.25 t ha^{-1} + *Rhizobium @ 5* mL kg^{-1} seed + PSB @ 5 mL kg^{-1} seed	812	997	3.17	0.48	1.13	25.72	3.92	9.18
T_{11}	Vermicompost @ 0.5 t ha^{-1} + *Rhizobium* @ 5 mL kg^{-1} seed + PSB @ 5 mL kg^{-1} seed	800	994	3.16	0.50	1.17	25.10	3.99	9.35
T_{12}	FYM @ 2 t ha^{-1} + *Rhizobium* @ 5 mL kg^{-1} seed + PSB @ 5 mL kg^{-1} seed	818	1000	3.18	0.50	1.21	25.62	4.12	9.92
S.Em. ±		42	56	0.14	0.02	0.05	1.56	0.29	0.60
C.D. at 5%		121	163	0.41	0.06	0.14	4.48	0.82	1.73
C.V.%		10.06	10.59	8.77	7.97	7.82	11.48	12.84	11.90

Table 2: Effect of chemical fertilizer, organic manure and bio-fertilizers on protein content, NPK content and uptake by haulm of cowpea

	Treatments	Protein content (%)	NPK content in haulm			NPK uptake by haulm		
			N Content (%)	P Content (%)	K Content (%)	N Uptake (kg ha^{-1})	P Uptake (kg ha^{-1})	K Uptake (kg ha^{-1})
T_1	Control	19.00	1.62	0.10	1.01	14.93	0.92	9.30
T_2	RDF (20-40-00 NPK kg ha^{-1})	23.70	1.97	0.34	1.13	25.43	4.43	15.38
T_3	Castor cake @ 0.5 t ha^{-1}	19.98	1.71	0.25	2.22	18.01	2.64	23.31
T_4	Vermicompost @ 1 t ha^{-1}	19.88	1.72	0.26	2.31	17.74	2.61	23.87
T_5	FYM @ 4 t ha^{-1}	20.20	1.72	0.26	2.32	18.51	2.80	25.08
T_6	Castor cake @ 0.5 t ha^{-1} + PSB @ 5 mL kg^{-1} seed	20.45	1.81	0.30	2.31	19.86	3.27	25.34
T_7	Vermicompost @ 1 t ha^{-1} + PSB @ 5 mL kg^{-1} seed	20.26	1.82	0.30	2.37	19.72	3.24	25.67
T_8	FYM @ 4 t ha^{-1} + PSB @ 5 mL kg^{-1} seed	22.30	1.87	0.31	2.47	23.62	4.01	29.62
T_9	*Rhizobium* @ 5 mL kg^{-1} seed + PSB @ 5 mL kg^{-1} seed	19.55	1.63	0.11	1.12	15.94	1.08	10.95
T_{10}	Castor cake @ 0.25 t ha^{-1} + *Rhizobium* @ 5 mL kg^{-1} seed + PSB @ 5 mL kg^{-1} seed	19.83	1.64	0.13	1.14	16.32	1.28	11.33
T_{11}	Vermicompost @ 0.5 t ha^{-1} + *Rhizobium* @ 5 mL kg^{-1} seed + PSB @ 5 mL kg^{-1} seed	19.75	1.67	0.17	2.20	16.60	1.68	21.84
T_{12}	FYM @ 2 t ha^{-1} + *Rhizobium* @ 5 mL kg^{-1} seed + PSB @ 5 mL kg^{-1} seed	19.85	1.70	0.19	2.21	16.97	1.94	22.13
S.Em. ±		0.89	0.04	0.01	0.06	1.10	0.16	1.28
C.D. at 5%		2.57	0.12	0.03	0.18	3.08	0.46	3.69
C.V.%		8.74	4.89	7.93	6.63	11.50	12.77	12.64

Conclusions

In the view of the results obtained from the present investigation, it can be concluded that, for securing higher protein content, nutrient content and uptake in the seed and haulm of cowpea, the crop should be fertilized either with recommended dose of fertilizer (20-40-00 kg NPK ha^{-1}) in form of chemcal fertilizer or apply FYM 4 t ha^{-1} along with PSB 5 mL kg^{-1}seed.

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