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Effect of Organic Manures, Biofertilizers and Cow Urine on NPK Content and Uptake by Clusterbean (*Cyamopsis tetragonoloba* L.) and Fertility Status of Soil

Snehal K. Ghoya[1], Mukesh Kumar[2*] and C.K. Patel[3]
[1]PG Scholar, Department of Agricultural Chemistry and Soil Science, C.P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar (Gujarat), India.
[2]Assistant Professor (Soil Science), Department of Natural Resource Management, College of Horticulture, Sardarkrushinagar Dantiwada Agricultural University, Jagudan (Gujarat), India.
[3]Associate Research Scientist, Centre for Natural Resources Management, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar (Gujarat), India.

(Corresponding author: Mukesh Kumar)*
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ABSTRACT: After green revolution, it becomes a practice in agriculture to get maximum production by using more chemical fertilizers and synthetic agrochemicals irrespective of its impact on soil health and environment. Keeping these facts into consideration, a field experiment was conducted during the *kharif* season of the year 2021 at Agronomy Instructional Farm, CPCA, SDAU, Sardarkrushinagar. The experiment was laid out in randomized block design with three replications. Thirteen treatments comprises different organic sources *viz.*, T_1: 100% RDF through chemical fertilizers (control), T_2: 100% RDN through castor cake (CC), T_3: 100% RDN through poultry manure (PM), T_4: 100% RDN through neem cake (NC), T_5: 75% RDN through CC + biofertilizers (NPK), T_6: 75% RDN through PM + biofertilizers (NPK), T_7: 75% RDN through NC + biofertilizers (NPK), T_8: 75% RDN through CC + 5% cow urine, T_9: 75% RDN through PM + 5% cow urine, T_{10}: 75% RDN through NC + 5% cow urine, T_{11}: 75% RDN through CC + biofertilizers (NPK) + 5% cow urine, T_{12}: 75% RDN through PM + biofertilizers (NPK) + 5% cow urine and T_{13}: 75% RDN through NC + biofertilizers (NPK) + 5% cow urine. The results revealed that an application of treatment T_{12} was recorded significantly higher N and P content in seed and stover. Accordingly, an application of same treatment (T_{12}) was recorded significantly higher N, P and K uptake by seed and stover. Therefore, treatment T_{12} was also recorded maximum available N and P_2O_5 and organic carbon content in soil at after harvest. Thus, it concludes that the application of 25% reduced level of RDN through poultry manure along with biofertilizers and cow urine spray improves the concentration of nutrients (NPK) in produce of clusterbean and also enhance their post-harvest availability in soil thereby sustained soil fertility (T_{12}).

Keywords: Poultry manure, Castor cake, Neem cake, Cow urine, Biofertilizers, NPK content and uptake, Available NPK.

INTRODUCTION

Clusterbean commonly known as *guar* in India and belongs to the family *Leguminoseae*. It is also known as one of the most important commercial crops of arid and semi-arid region. It is an important drought resistant crop suited to dry farming areas and cannot withstand under excessive moisture or water logging conditions. It has been established as high-valued cash crop in the arid and semi-arid regions due to its drought hardiness and large amount of usage and has occupied a special place in the commercial scene because of its gum. Among dryland crops, *guar* occupies an important place in the national economy because of its industrial importance mainly due to rich source of gum content in seed. The seed of clusterbean contains about 30 to 33 per cent gum in endosperm (Lee *et al.,* 2004). Clusterbean gum is used in textiles, paper, petroleum, pharmaceuticals, food processing etc. The use of *guar* gum has increased tremendously, as it is the natural absorbent. India occupied top position in the world trade for *guar* gum.

The productivity of clusterbean is low due to several factors, *viz.* cultivation under rainfed condition and light textured soils that are having very low organic carbon content, multi-nutrient deficiencies like nitrogen, phosphorus and micronutrients like zinc, iron etc. and non awareness of the improved varieties and technologies among the farmers. For enhancement of production and productivity of *guar* seed needs the adoption of scientific production technologies with better nutrient management practices. The sources of nutrients are a chemical fertilizer that's very expensive as compared to organic manures. The chemical based farming have also harmful effects such as accumulation of excessive amount of nitrate in the water, contamination with heavy metals, deposition of phosphate along with nitrate in the aquatic ecosystems, presence of pesticidal residues in various food stuffs. Organic manure improves soil conservation, soil ecology and the environment, addition of organic manures improve crop productivity and soil biological activity (Saritha *et al*., 2013). Organic manures *viz*., FYM, vermicompost, poultry manure and oilcakes help in improvement of soil structure, aeration and water holding capacity of soil (Joshi *et al.,* 2016).

Organic farming approach is one of the ways towards soil sustainability, human health and environment also. Poultry manure is an important source of nutrients which plays direct role in plant growth. Besides major nutrients, poultry manure also contains traces of micronutrients which are generally not supplied by the commercial fertilizers but essential for plant growth. It is established that it is an excellent source of organic manure which increases nutrient uptake of the plants.

Cow urine is the liquid manure contains essential nutrients like nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, uric acid, amino acids enzymes, cytokinins *etc*. (Bhadauria, 2002; Devasena and Sangeetha 2021). The application of cow urine through foliar spray helps to correct the nutrient deficiency and improves the plant growth. The uric acid present in the urine acts as fertilizer and hormone. It has antibacterial, antiviral and antifungal properties.

Among the concentrated organic manures, caster cake is widely used due non-edible oil cake for animal feed. It contains a toxic alkaloids ricinine and ricin. Castor cake contains 5.5 to 5.8 per cent N, 1.8 to 1.9 per cent P_2O_5 and 1.0 to 1.1 per cent K_2O (Kolay, 2007). Castor cake has good manurial value which favoured to modify the growth and yield attributes resulted into significant positive correlation with yield of crop (Sujathamma *et al*., 2003). Neem cake is also non-edible oil cake that obtained from cold pressing of neem tree kernels. It acts as a natural fertilizer with pesticidal properties. Neem cake also reduce alkalinity in soil, as it produces organic acids on decomposition (Rajesh and David 2017). Being totally natural, it is compatible with soil microbes, improves the rhizopheremicroflora and hence ensures fertility of the soil. Biofertilizers play a significant role in fixing atmospheric nitrogen, production of growth promoting substances and make phosphorus and potassium available to the plants. Inoculation of seed with *Rhizobium* increase yield due to more nitrogen fixation and better utilization by plants. Several strains of phosphate solubilizing bacteria and fungi as well as potassium solubilizing microorganisms are isolated (Nautiyal *el al*., 2000; Sane and Mehta 2015). The mechanism of these microorganisms involves in secretion of organic acids which lower the pH and increase the availability of sparingly soluble phosphorus sources and also solubilize the fixed potassium in soil. Biofertilizers have shown positive interaction with organic manures in legume crops.

Assessment of the role of organic sources of nutrients to harness their effect in enhancing crop yield. Organic manures and biofertilizers have become an essential because of increasing cost of chemical fertilizers, sustain soil fertility and overcome adverse effect of chemical fertilizers on the soil health, ecology and environment.

MATERIALS AND METHODS

The experiment was carried out in open field condition during *kharif* season of the year 2021 at the Agronomy Instructional Farm, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Banaskantha (Gujarat), India. The university is located in North Gujarat Agro-climatic Zone IV of the Gujarat state.

The experiment was laid out in randomised block design with three replications. Total thirteen treatments were evaluated under the study *viz.,* T_1: 100% RDF through chemical fertilizers (control), T_2: 100% RDN through castor cake (CC), T_3: 100% RDN through poultry manure (PM), T_4: 100% RDN through neem cake (NC), T_5: 75% RDN through CC + biofertilizers (NPK), T_6: 75% RDN through PM + biofertilizers (NPK), T_7: 75% RDN through NC + biofertilizers (NPK), T_8: 75% RDN through CC + 5% cow urine, T_9: 75% RDN through PM + 5% cow urine, T_{10}: 75% RDN through NC + 5% cow urine, T_{11}: 75% RDN through CC + biofertilizers (NPK) + 5% cow urine, T_{12}: 75% RDN through PM + biofertilizers (NPK) + 5% cow urine and T_{13}: 75% RDN through NC + biofertilizers (NPK) + 5% cow urine. Clusterbean variety Gujarat Guar 2 was taken and sown at spacing 45 cm × 10 cm.

The recommended dose of NPK 20:40:00 kg ha^{-1} were used for treatment application. Organic manures were applied well in advance as per treatments as basal application. Chemical fertilizers urea and superphosphate were used for N and P, respectively and applied as basal application in treatment T_1. Biofertilizers *viz*., *Rhizobium* was applied as seed treatment @ 20 ml kg^{-1} seed, whereas PSB and KSM each were applied as soil application @2.5 L ha^{-1}. Foliar spray of 5 per cent cow urine was applied as per treatment at 30 and 50 DAS. Quantity of organic manures (castor cake, neem cake and poultry manure) were calculated on the basis of nitrogen content in them (Waranke and Barber 1974).

The soil samples were collected 0-15 cm depth with the help of *khurpi* and spade before sowing and after harvest of crop and processed for further analysis. The air dry and sieved soil samples were analyzed as per methods suggested by Jackson (1973) *viz*., potentiometric method for pH, conductivity meter for EC, Walkley and Black's rapid titration method for organic carbon, while alkaline $KMnO_4$ method for available nitrogen (Subbiah and Asija 1956), Olsen's method for available phosphorus (Olsen *et al.*, 1954) and neutral ammonium acetate extraction and flame photometric method for available potassium (Jackson, 1973), however, mechanical composition of soil was analyzed using international pipette method suggested by Piper (1966) of initial soil sample were used. The experimental plot soil was loamy sand in texture with mildly alkaline in reaction (pH 7.53) and free from any kind of salinity hazard (EC 0.14 dSm^{-1}). The soil was low in organic carbon (0.29%) and available nitrogen (148.36 kg ha^{-1}) and medium in available phosphorus (45.38 kg P_2O_5 ha^{-1}) and potassium (251.49 kg K_2O ha^{-1}) status.

The representative dry plant samples (seed and stover) were analysed for N, P and K contents using micro-Kjeldahl method, vandomolybdo phosphoric acid and flame photometric method, respectively (Jackson, 1973). Data was statistically analyzed using the procedure described by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Effect on nutrient content in seed and stover at harvest.

The data pertaining to the nitrogen, phosphorus and potassium content in seed and stover of clusterbean as influenced by organic manures, biofertilizers and cow urine spray are presented in Table 1.

Nitrogen content. Data showed that significantly maximum N content in seed (4.10%) and stover (1.59%) were found with treatment T_{12} (75% RDN through PM + biofertilizers + 5% cow urine). However, itwas remained statistically at par with treatmentsT_{13} (75% RDN through NC + biofertilizers + 5% cow urine), T_6 (75% RDN through PM + biofertilizers), T_7 (75% RDN through NC + biofertilizers), T_{11} (75% RDN through CC + biofertilizers + 5% cow urine), T_5 (75% RDN through CC + biofertilizers) and T_1 (100% RDF through chemical fertilizers) with respect to N content in seed. Similarly, it was found at par with treatments T_{13} (75% RDN through NC + biofertilizers + 5% cow urine), T_{11} (75% RDN through CC + biofertilizers + 5% cow urine), T_6 (75% RDN through PM + biofertilizers), T_7 (75% RDN through NC + biofertilizers), T_5 (75% RDN through CC + biofertilizers), T_1 (100% RDF through chemical fertilizers) and T_3 (100% RDN through poultry manure)with respect to N content in stover. This might be attributed to *Rhizobium* have helped in increasing the availability of N in soil. PSB enhanced the availability of phosphorus to plants, which might have utilized by the crop in greater root development and nodulation that in turn resulted in higher nitrogen fixation in root nodules. Thus, increased availability of nitrogen and phosphorus might have resulted in greater uptake by plant for proper development and ultimately increased their content and uptake in seed and straw. Similarly, Khan *et al.* (2017) reported that inoculation of cowpea seed with *Rhizobium* + PSB had significantly increased nitrogen and phosphorus contents and uptake in seed and straw in comparison to no inoculation. These results are in line with the findings of Singh *et al.* (2014) in clusterbean and Singh *et al.* (2016) in blackgram.

Phosphorus content. The analysed data showed that different treatments have their significant effect on phosphorus content in seed and stover. Application of 75% RDN through PM + biofertilizers + 5% cow urine (T_{12}) gave maximum P content in seed (0.354%) and stover (0.185%), which was at par with treatmentsT_6 (75% RDN through PM + biofertilizers), T_3 (100% RDN through poultry manure) and T_1 (100% RDF through chemical fertilizers). It might be due to poultry manure having rich in P for its fast mineralization rate and PSB can change unavailable forms of phosphorus into available forms that can be easily assimilated by plant leads to increase in content of phosphorus. These finding in close agreement with the results of Rathore *et al.* (2007) in clusterbean, Singh *et al.* (2016) in blackgram and Khan *et al.* (2017) in cowpea.

Potassium content. The data revealed that the different organic sources did not exhibit their significant influence on potassium content in seed and stover of clusterbean.

Effect on nutrient uptake by seed and stover at harvest

The data pertaining to the nitrogen, phosphorus and potassium uptake by seed and stover of clusterbean as influenced by organic manures, biofertilizers and cow urine spray are presented in Table 2.

Nitrogen uptake. The significantly maximum N uptake in both seed (43.59 kg ha^{-1}) and stover (45.47 kg ha^{-1}) was recorded under treatment T_{12} (75% RDN through PM + biofertilizers + 5% cow urine) and but it was at par with treatmentsT_6 (75% RDN through PM + biofertilizers), T_3 (100% RDN through poultry manure) and T_{13} (75% RDN through NC + biofertilizers + 5% cow urine) with respect to N uptake by seed. While, it was remained at par with the treatments T_6 (75% RDN through PM + biofertilizers), T_3 (100% RDN through poultry manure) and T_1 (100% RDF through chemical fertilizers) regarding N uptake by stover. This might be due to significantly higher nitrogen content in seed and stover as well as seed and stover yield ultimately led to higher nitrogen uptake. Malav *et al.* (2018) conducted a field experiment under organic farming on fenugreek and who reported that the application of 50% RDN through CC + *Rhizobium* + PSB was found significant maximum uptake of nitrogen by straw (18.32 and 21.47 kg ha^{-1}). These results corroborated the findings of Singh *et al.* (2015) in greengram, Khan *et al.* (2017) in cowpea and Manohar *et al.* (2018) in clusterbean.

Phosphorus uptake. The significantly higher P uptake by seed (3.76 kg ha^{-1}) was recorded under treatment T_{12} (75% RDN through PM + biofertilizers + 5% cow urine) and remained statistically at par with treatments T_6 (75% RDN through PM + biofertilizers), T_3 (100% RDN through poultry manure) and T_1 (100% RDF through chemical fertilizers).Similarly, significantly higher P uptake by stover (5.33 kg ha^{-1}) was also obtained under treatment T_{12} and remained statistically at par with treatments T_6 and T_3. This might be due to significantly higher phosphorus content in seed and stover as well as seed and stover yield ultimately led to higher phosphorus uptake. Similarly, Munda *et al.* (2015) observed that PSB biofertilizer treated plot had higher uptake of phosphorus over control. In the same way, Malav *et al.* (2018) conducted a field experiment under organic farming on fenugreek and who stated that the application of 50% RDN through CC + *Rhizobium* + PSB was recorded significant maximum uptake of phosphorus by seed (3.49 and 4.51 kg ha^{-1}). These results supported the findings of Singh *et al.* (2015) in greengram, Khan *et al.* (2017) in cowpea and Manohar *et al.* (2018) in clusterbean.

Potassium uptake. The significantly higher K uptake by seed (7.13 kg ha^{-1}) was recorded under treatment T_{12} (75% RDN through PM + biofertilizers + 5% cow urine). However, it was remained statistically at par with treatments T_6 (75% RDN through PM + biofertilizers) and T_3 (100% RDN through poultry manure). Similarly, significantly higher K uptake by stover (39.02 kg ha^{-1}) was also obtained under treatment T_{12} and remained statistically at par with treatment T_6. This might be due to significant higher seed and stover yield led to higher potassium uptake. Manohar *et al.* (2018) conducted a field experiment on *kharif* clusterbean and reported that the application of RDF + PSB and *Rhizobium* increase total uptake of N, P and K over RDF (20 kg N ha^{-1} and 40 kg P_2O_5 ha^{-1}). Similar findings were also reported by Singh *et al.* (2015) in greengram and Khan *et al.* (2017) in cowpea.

Effect on fertility status of soil at after harvest

The important soil properties *viz*. pH, EC, organic carbon, available N, P_2O_5 and K_2O of the experimental site were determined after harvest of clusterbean.

pH, EC and organic carbon. The analysis of soil samples after harvest of clusterbean crop did not reveal significant changes in pH and EC of soil due to different organic sources (Table 3).

The significantly higher organic carbon content in soil (0.328%) was recorded with the application of 75% RDN through PM + biofertilizers + 5% cow urine (T_{12}) over rest of treatments. Which was found at par with most of the treatments except treatments T_1, T_8, T_{10} and T_{12}. However, the lowest organic carbon content (0.271%) was found with the application of 100% RDF through chemical fertilizers (T_1). Application of higher dose of organic manures significantly improved organic carbon status over other treatments in present study could be due to fact that addition of organic manures increased organic matter to the soil which in turn increases organic carbon content in soil. The results are in agreement with the previous research work reported by Rajesh and David (2017).

Available nutrients in soil. The data presented in Table 3 revealed that significantly higher available nitrogen and phosphorus in soil after harvest of the crop (174.71 kg ha^{-1}) and (43.11 kg ha^{-1}), respectively were found under treatment T_{12} (75% RDN through PM + biofertilizers + 5% cow urine). While, it was remained statistically at par with treatments T_6 (75% RDN through PM + biofertilizers), T_3 (100% RDN through poultry manure), T_{13} (75% RDN through NC + biofertilizers + 5% cow urine), T_7 (75% RDN through NC + biofertilizers) and T_{11} (75% RDN through CC + biofertilizers + 5% cow urine)with respect to available nitrogen, similarly for available phosphorus in soil, it was found at par with treatments T_{13} (75% RDN through NC + biofertilizers + 5% cow urine), T_6 (75% RDN through PM + biofertilizers), T_1 (100% RDF through chemical fertilizers), T_{11} (75% RDN through CC + biofertilizers + 5% cow urine), T_3 (100% RDN through poultry manure) and T_7 (75% RDN through NC + biofertilizers). However, available K status in soil was found non-significant after harvest of crop. Significant increase in the available nitrogen and phosphorus status of soil after harvest of clusterbean through addition of organic manures with biofertilizers. This might be due to direct addition of N through organic manures and *Rhizobium* fix atmospheric nitrogen in to soil. *Rhizobium* and PSB further promotes other microbial activities, which helps in better nodulation and subsequence aid in increasing the availability of nitrogen. PSB transfer immobile phosphorus in to available form and thereby increase the availability of P_2O_5 in soil. These findings are in agreement with those reported by Khan *et al*. (2013) in cowpea and Singh *et al.* (2016) in blackgram.

The analysis of soil samples after harvest of clusterbean crop did not reveal significant changes in available potassium of soil due to different treatments.

Table 1: Effect of organic manures, biofertilizers and cow urine spray on nutrient content in seed and stover of clusterbean.

Treatments	Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)	
	Seed	Stover	Seed	Stover	Seed	Stover
T_1	3.68	1.45	0.339	0.173	0.626	1.208
T_2	3.42	1.35	0.302	0.155	0.655	1.213
T_3	3.61	1.44	0.347	0.182	0.657	1.230
T_4	3.46	1.34	0.305	0.158	0.656	1.217
T_5	3.78	1.48	0.308	0.159	0.661	1.303
T_6	3.96	1.54	0.350	0.179	0.666	1.320
T_7	3.92	1.51	0.307	0.163	0.662	1.313
T_8	3.02	1.36	0.289	0.149	0.638	1.250
T_9	3.24	1.37	0.301	0.151	0.640	1.277
T_{10}	3.11	1.38	0.298	0.147	0.639	1.263
T_{11}	3.87	1.55	0.309	0.162	0.665	1.343
T_{12}	4.10	1.59	0.354	0.185	0.672	1.357
T_{13}	4.04	1.57	0.312	0.160	0.666	1.340
S.Em.±	0.16	0.06	0.01	0.01	0.01	0.04
C.D. (P = 0.05)	0.45	0.17	0.035	0.019	NS	NS

Table 2: Effect of organic manures, biofertilizers and cow urine spray on nutrient uptake by seed and stover of clusterbean.

Treatments	Nitrogen uptake (kg ha^{-1})		Phosphorus uptake (kg ha^{-1})		Potassium uptake (kg ha^{-1})	
	Seed	Stover	Seed	Stover	Seed	Stover
T_1	34.75	37.84	3.21	4.46	5.89	31.28
T_2	29.43	30.75	2.60	3.54	5.66	27.63
T_3	35.89	38.23	3.45	4.82	6.55	32.57
T_4	30.07	30.90	2.66	3.67	5.71	28.12
T_5	33.65	33.23	2.74	3.58	5.88	29.21
T_6	40.28	42.68	3.57	4.98	6.77	36.64
T_7	34.36	36.60	2.69	3.91	5.80	31.78
T_8	23.19	29.02	2.22	3.18	4.89	26.56
T_9	27.32	30.96	2.51	3.41	5.35	28.84
T_{10}	24.67	30.20	2.35	3.20	5.05	27.62
T_{11}	34.25	36.44	2.72	3.80	5.88	31.58
T_{12}	43.59	45.47	3.76	5.33	7.13	39.02
T_{13}	35.71	37.46	2.73	3.81	5.87	32.01
S.Em.±	2.75	2.62	0.21	0.27	0.39	2.10
C.D. (P = 0.05)	8.03	7.64	0.61	0.78	1.13	6.12

Table 3: Effect of organic manures, biofertilizers and cow urine sprayon pH, EC and organic carbon in soil after harvest of clusterbean.

Treatments	pH	EC (dS m$^{-1)}$	Organic carbon (%)	Available nutrients in soil (kg ha^{-1})		
				N	P_2O_5	K_2O
T_1	7.62	0.133	0.271	152.04	41.69	246.75
T_2	7.56	0.128	0.313	159.31	37.30	253.22
T_3	7.54	0.132	0.324	166.50	40.84	256.20
T_4	7.57	0.131	0.322	161.79	38.19	254.18
T_5	7.61	0.128	0.307	159.89	38.78	251.43
T_6	7.55	0.131	0.326	172.20	41.99	257.35
T_7	7.59	0.130	0.318	163.81	40.10	253.41
T_8	7.58	0.127	0.293	154.82	36.95	245.99
T_9	7.61	0.130	0.305	159.00	39.48	252.84
T_{10}	7.59	0.127	0.288	156.12	37.75	248.62
T_{11}	7.58	0.132	0.319	162.70	41.20	255.50
T_{12}	7.52	0.135	0.328	174.71	43.11	259.99
T_{13}	7.59	0.132	0.318	165.40	42.38	258.68
S.Em.±	0.102	0.003	0.009	4.36	1.07	8.10
C.D. (P = 0.05)	NS	NS	0.026	12.73	3.11	NS

CONCLUSIONS

It can be concluded that the application of 75% RDN through PM + biofertilizers (NPK)+ 5% cow urine spray increase the NPK content and uptake by seed and stover of clusterbean and also enhance their availability in soil as well as sustain soil fertility.

FUTURE SCOPE

The research work can be helpful to researchers for further investigation and also may be useful to crop growers for selection of suitable combination of organic sources of nutrients to sustained the soil fertility.

Conflicts of Interest. None.

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