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Effect of various cow-based bio-enhancers and botanicals on soil fertility after harvest, nutrient content and uptake by organic cowpea (*Vigna unguiculata* L.)

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Abstract
An experiment was conducted on medium black calcareous clayey soil to evaluate some cow-based bio-enhancers and botanicals for organic cultivation of cowpea (var. GC-6) during summer-2019 at Junagadh Agricultural University, Junagadh. The experiment comprising randomized block design with twelve treatments and three replications. The results revealed that next to 100% RDF, application of FYM @ 4 t/ha + Biofertilizers (*Rhizobium* @ 30 ml/kg seed + PSB @ 3 L/ha + KSB @ 3 L/ha) and *Panchagavya* as foliar spray @ 3% at 30 and 45 DAS + FYM @ 2 t/ha found significantly higher in terms of P content in seed, NPK content in stover and NPK uptake by organic cowpea. Whereas, the content of N and K in seed were significantly higher under FYM @ 4 t/ha + Biofertilizers (*Rhizobium* @ 30 ml/kg seed + PSB @ 3 L/ha + KSB @ 3 L/ha), followed by RDF through chemical fertilizers, *Panchagavya* as foliar spray @ 3% at 30 and 45 DAS + FYM 2 t/ha and *Jeevamrut* @ 500 L/ha with irrigation at sowing, 30 and 45 DAS + FYM 2 t/ha. While higher organic carbon and available NPK after harvest of the cowpea were recorded under the treatment of FYM @ 4 t/ha + Biofertilizers (*Rhizobium* @ 30 ml/kg seed + PSB @ 3 L/ha + KSB @ 3 L/ha), followed by FYM @ 4 t/ha and *Jeevamrut* @ 500 L/ha with irrigation at sowing, 30 and 45 DAS + FYM 2 t/ha.

Keywords: Cowpea, *Vigna unguiculata*, *Panchagavya*, *Jeevamrut*, seaweed extract, banana sap, organic farming

Introduction
The important pulses grown in India are red gram, green gram, black gram, cowpea, moth bean, chickpea, peas *etc*. In India, cowpea [*Vigna unguiculata* (L.) Walp] is grown as catch crop, intercrop, mixed crop and green manure crop. Cowpea belongs to family Papilionaceae and sub family Fabaceae. It is a minor pulse cultivated mainly in arid and semi-arid tracts of Rajasthan, Karnataka, Kerala, Tamil Nadu, Maharashtra and Gujarat. Cowpea contributes to the improvement of soil fertility by the atmospheric nitrogen fixation in the soil (60-70 kg N/ha to the subsequent crop) in association with symbiotic bacteria under favourable conditions. India is predominantly an agricultural country and green revolution has brought a significant change in Indian agriculture. The achievements were mainly due to use of high yielding varieties, fertilizer responsive crop cultivars and increased fertilizer use. However, over emphasis on chemical farming has led to deterioration of soil health resulted in decline in productivity. Sustained production strategies often involve application of organic sources.

With increased awareness on organic farming among the farming community, they are using of many organic formulations in crop production. Number of cow-based bio-enhancers like *'Jeevamrut'*, *'Panchagavya'*, *etc*. have been developed in different organic farming systems by innovative organic growers/associations and NGOs (Yadav, 2010) [7]. *Panchagavya* and *Jeevamrut* are two organic products which have received wide spread attention and acceptability among organic farming practitioners. Application of cow-based bio-enhancers, botanicals, organic manures and bio fertilizers such as *Panchagavya*, *Jeevamrut*, banana sap, seaweed extract, Farm yard manure and *Rhizobium*, PSB and KSB has led to a decrease in the use of chemical fertilizers and has provided high quality products free of harmful agrochemicals for human safety.

Materials and Methods

A field experiment titled "The effect of various cow-based bio-enhancers and botanicals on growth, yield and quality of organic cowpea (*Vigna unguiculata* L.)" was carried out at Certified Organic Farming Plot of Instructional Farm, College of Agriculture, JAU, Junagadh during the summer season of the year 2018-19. The soil of the experimental plot was clayey in texture and slightly alkaline in reaction as well as medium in available nitrogen, low in available phosphorus and medium in available potash.

Twelve treatments comprising Absolute control (T_1), 100% RDF (T_2), *Panchagavya* as foliar spray @ 3% at 30 and 45 DAS (T_3), *Panchagavya* as foliar spray @ 3% at 30 and 45 DAS + FYM @ 2 t/ha (T_4), *Jeevamrut* @ 500 L/ha with irrigation at sowing, 30 and 45 DAS (T_5), *Jeevamrut* @ 500 L/ha with irrigation at sowing, 30 and 45 DAS + FYM @ 2 t/ha (T_6), Banana sap as foliar spray @ 1% at 30 and 45 DAS (T_7), Banana sap as foliar spray @ 1% at 30 and 45 DAS + FYM @ 2 t/ha (T_8), Seaweed extract as foliar spray @ 3.5% at 30 and 45 DAS (T_9), Seaweed extract as foliar spray @ 3.5% at 30 and 45 DAS + FYM @ 2 t/ha (T_{10}), FYM @ 4 t/ha + Biofertilizers (*Rhizobium* @ 30 ml/kg seed + PSB @ 3 L/ha + KSB @ 3 L/ha (T_{11}), FYM @ 4 t/ha (T_{12}) in randomized block design with three replications. Control and 100% RDF treatments were taken outside the organic plot.

Preparation of *Panchagavya*

For the preparation of *Panchgavya* a wide mouth plastic container was taken. It was cleaned and sundried for one or two days to sterilize it. First the cow dung (7 kg) and ghee (1 kg) were mixed thoroughly in the container using a wooden stick. It was stired in clockwise and anti-clockwise direction in a rhythmic motion twice in a day, once in the morning and once in the evening. The container was covered with using thick cloth to protect it from insects. This mixture wad leaved for three days it was kept away from direct sunlight and rain. After 3 days cow urine (10 litres) and water (10 litres) were mixed and kept it for 15 days with regular mixing both in morning and evening hours. After 15 days cow milk (3 L), cow curd (2 L), tender coconut water (3 L), jaggery (3 kg) and well ripened banana (12 nos.) were mixed. *Panchagavya* was ready after 30 days. This is diluted @ 300 ml/10 L water and sprayed.

Preparation of *Jeevamrut*

Jeevamrut was prepared by mixing 10kg *desi* cow dung, 10L cow urine, 2kg jaggery, 2 kg pulse flour (gram, pigeon pea, greengram, cowpea or blackgram) and hand full of soil collected from rhizosphere of Banyan tree. All these were mixed thoroughly and volume was made up to 200 lit. The mixture was stirred well. Kept in shade covered with wet jute bag. The solution was regularly stirred three times in the morning, afternoon and evening for continuously 9 days and it was used for soil application.

Results and discussion

Effect on nutrient content

Significantly the highest N and K content in seed were recorded under the treatment FYM @ 4 t/ha + Biofertilizers (*Rhizobium* @ 30 ml/kg seed + PSB @ 3 L/ha + KSB @ 3 L/ha (T_{11}), which was at par with 100% RDF (T_2), *Panchagavya* as foliar spray @ 3% at 30 and 45 DAS + FYM @ 2 t/ha (T_4) and *Jeevamrut* @ 500 L/ha with irrigation at sowing, 30 and 45 DAS + FYM @ 2 t/ha (T_6) in most of the cases. Content of P in seed was significantly highest with 100% RDF (T_2), yet it remained statistically comparable to the treatments FYM @ 4 t/ha + Biofertilizers (*Rhizobium* @ 30 ml/kg seed + PSB @ 3 L/ha + KSB @ 3 L/ha (T_{11}), *Panchagavya* as foliar spray @ 3% at 30 and 45 DAS + FYM @ 2 t/ha (T_4) and Banana sap as foliar spray @ 1% at 30 and 45 DAS + FYM @ 2 t/ha (T_8). Significantly the highest NPK content in stover were recorded under the treatment 100% RDF (T_2), yet it remained statistically comparable to the treatments FYM @ 4 t/ha + Biofertilizers (*Rhizobium* @ 30 ml/kg seed + PSB @ 3 L/ha + KSB @ 3 L/ha (T_{11}) and *Panchagavya* as foliar spray @ 3% at 30 and 45 DAS + FYM @ 2 t/ha (T_4). However, the Absolute control (T_1) registered significantly the lowest N, P and K content by seed and stover.

Nutrient accumulation in plants is a function of nutrient concentration and dry matter accumulation. The cow urine rich in uric acid, a source of nitrogen was readily soluble in liquid form one of the important compounds in *Panchagavya* was readily available to the plants directly influencing the nitrogen content of leaves. The increased supply of plant nutrients with sources of foliar application in plant available form might have increased the accumulation of dry matter concomitantly by affecting the ramification of roots favorably. The increased dry matter in above ground parts favors translocation of more carbohydrate towards developing roots. Increased allocation of food material to roots in turn enhanced the root volume and thereby concomitantly increased uptake of more plant nutrients. The present findings are in accordance with those reported earlier (Patel, 2012; Kumavat *et al*., 2013; Choudhary *et al.*, 2017) [6, 5, 3].

Effect on nutrient uptake

Significantly the highest N, P and K uptake by crop (Table 1) were recorded under RDF through chemical fertilizers, but it was statistically at par with the treatment FYM @ 4 t/ha + Biofertilizers (*Rhizobium* @ 30 ml/kg seed + PSB @ 3 L/ha + KSB @ 3 L/ha and *Panchagavya* as foliar spray @ 3% at 30 and 45 DAS + FYM @ 2 t/ha in most of the cases. However, the Absolute control (T_1) registered significantly the lowest N, P and K uptake by seed, straw and crop.

Among the different cow-based bio-enhancers and botanicals treatments, the highest highest N, P and K uptake by crop were observed with the treatment of *Panchagavya* as foliar spray @ 3% at 30 and 45 DAS + FYM 2 t/ha, followed by *Jeevamrut* @ 500 L/ha with irrigation at sowing, 30 and 45 DAS + FYM 2 t/ha due to quick build-up of soil micro flora and fauna which has consequently increased the enzymatic activity and helped in mineralization, solubilisation of native and applied nutrients and making them available in the soil for plant uptake and 500 L *Jeevamrut* might have added some quantity of nutrients in the soil. The present findings are in accordance with those reported earlier (Patel, 2012; Kumavat *et al*., 2013; Choudhary *et al.*, 2017) [6, 5, 3].

Nutrient status of soil after harvest of the crop

Post-harvest soil fertility analysis revealed that cow-based bio-enhancers and botanicals treatments significantly affected the available nitrogen, available phosphorus, available potash and organic carbon (Table 1) in the soil. Significantly the highest available nitrogen, phosphorus, potash and organic carbon were recorded with application of FYM @ 4 t/ha + Biofertilizers (*Rhizobium* @ 30 ml/kg seed + PSB @ 3 L/ha + KSB @ 3 L/ha, which remained statistically equivalent to FYM @ 4 t/ha and *Jeevamrut* @ 500 L/ha with irrigation at sowing, 30 and 45 DAS + FYM @ 2 t/ha over the treatment control.

The bio fertilizers have important role in improving nutrient supplies to soil and also have long term impact without any adverse effects and the FYM is considered a store house of almost all essential nutrients required for plant growth and also improves the soil environment by way of improving the

physico-chemical properties of soil. Thus, on addition of FYM with biofertilizer, the available nutrient status of soil increases considerably due to mineralization of native soil as well as its own nutrient contents. In case of organic carbon, it was possible because of enrichment of soil with organic matter resulting in stable aggregation and favourable pore geometry in soil, ultimately reduced the bulk density and also, increased organic carbon by direct addition of organic matter through FYM. Similar results were also reported by Ali *et al.* (2011) [1], Boraiah *et al.* (2015) [2] and Javiya (2019) [4].

Table 1: Effect of different treatments on NPK content in seed and stover

Treatment	N content (%) in seed	P content (%) in seed	K content (%) in seed	N content (%) in stover	P content (%) in stover	K content (%) in stover
T_1	2.41	0.30	1.20	1.29	0.19	1.59
T_2	4.16	0.49	1.46	2.99	0.39	1.99
T_3	3.45	0.39	1.29	2.31	0.29	1.68
T_4	4.01	0.48	1.42	2.88	0.38	1.92
T_5	3.41	0.34	1.30	1.81	0.27	1.69
T_6	3.86	0.43	1.40	2.63	0.34	1.86
T_7	3.24	0.37	1.26	1.84	0.26	1.66
T_8	3.79	0.46	1.37	2.70	0.34	1.74
T_9	3.13	0.33	1.25	1.70	0.23	1.66
T_{10}	3.78	0.42	1.36	2.53	0.32	1.77
T_{11}	4.27	0.48	1.50	2.93	0.38	1.96
T_{12}	3.68	0.41	1.33	2.49	0.31	1.72
S.Em.±	0.14	0.01	0.04	0.09	0.01	0.04
C.D. at 5%	0.42	0.04	0.11	0.26	0.03	0.12
C.V.%	6.88	5.85	4.86	6.62	5.95	4.10

Table 2: Effect of different treatments on NPK uptake, available NPK and organic carbon in soil after harvest of crop

Treatment	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)	Soil available nutrients (kg/ha)			Organic carbon (%)
				N	P	K	
T_1	42.05	5.71	37.81	231.01	21.89	215.21	0.54
T_2	117.57	14.74	62.63	258.78	23.94	231.37	0.59
T_3	79.17	9.54	45.59	265.38	25.48	246.57	0.61
T_4	104.50	13.14	56.05	289.29	33.34	262.70	0.70
T_5	67.16	8.55	44.93	269.32	28.04	256.26	0.63
T_6	93.06	11.46	52.43	300.11	37.14	286.34	0.78
T_7	64.32	8.24	42.95	252.83	27.87	252.95	0.58
T_8	92.88	11.55	49.03	280.31	34.71	278.77	0.69
T_9	59.79	7.25	42.13	248.13	24.28	240.25	0.58
T_{10}	88.88	10.60	49.21	272.40	30.44	260.99	0.67
T_{11}	111.49	13.67	59.77	337.12	40.52	304.25	0.81
T_{12}	85.88	10.34	47.43	312.41	38.49	292.12	0.79
S. Em.±	4.17	0.54	1.87	15.75	1.57	13.55	0.03
C.D. at 5%	12.22	1.58	5.48	46.20	4.60	39.73	0.10
C.V.%	8.60	8.99	6.58	9.87	8.91	9.00	8.72

Conclusion

On the basis of the results obtained from the one year field experimentation, it seems quite logical to conclude that higher available NPK, organic carbon in the soil and nutrients content and uptake by cowpea (var. GC-6) under organic farming can be secured by application of *Panchagavya* as foliar spray @ 3% at 30 and 45 DAS along with FYM 2 t/ha or FYM @ 4 t/ha + Biofertilizers (*Rhizobium* @ 30 ml/kg seed + PSB @ 3 L/ha + KSB @ 3 L/ha on clayey soil of South Saurashtra Agro-climatic Zone.

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