



Effect of soil salinity and bio-organics on yield, nutrient content and uptake by cowpea (*Vigna unguiculata* L.)

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Abstract

A pot experiment was conducted during *kharif* 2019 at S.K.N. College of Agriculture, Jobner (Rajasthan), to study the effect of soil salinity and bio-organics on yield, nutrient content and uptake by cowpea. The experiment comprising of 16 treatment combinations replicated thrice, was laid out in completely randomized design with four levels of soil salinity (1.22, 2, 4 and 6 dS/m) and four sources of bio-organics (control, *Rhizobium*, vermicompost and *Rhizobium*+ vermicompost) as variables. Results showed that effect of soil salinity levels on yield, nutrient content (P, K,) and uptake by grain and straw were found lower at 6 dSm⁻¹, while N, content increased significantly in seed and straw at soil salinity level of 6 dSm⁻¹ and uptake of N was found significantly lower. The *Rhizobium* treated seeds along with soil manured with vermicompost @ 5 t/ha significantly increased yield, nutrient content (N, P, K,) and uptake by grain and straw over control. Among the treatment combinations at 1.22 dSm⁻¹ level of soil salinity with use of bio-organics (*Rhizobium* + vermicompost @ 5 t/ha) proved to be superior in all these parameters over other treatments.

Keywords: Bio-organics, Cowpea, Nutrient content, Soil salinity, Uptake of nutrients

Introduction

India is the major producer, consumer and exporter of pulses and also its occupied a key position in the Indian diet/food and meet out more than 30 per cent of the daily protein requirement (Jadeja *et al.*, 2019^[8]; Kapoor *et al.*, 2023)^[11]. Pulse crops growing in India are chickpea (*Cicer arietinum* L.), pigeonpea (*Cajanus cajan* L.), mungbean (*Vigna radiata* L.), urdbean (*Vigna mungo* L.), cowpea (*Vigna unguiculata* L.) *etc.* In India cowpea is very important *kharif* crop among pulses which is grown for multipurpose i.e. vegetable, grain, forage and green manuring. Cowpea is rich in nutrients like calcium, phosphorus, iron and also rich in proteins that's why it is also known as vegetable meat. India has the largest demand and market for the pulses. It was reported that the pulse crops grown only on 25.26-million-hectare area and produces only 16.47 million tonnes with an average productivity of 652 kg/ha during 2015-16. Among states, Madhya Pradesh has contributed 22.81% in area and 31.07% in total production and retained on the top of the pulse growing as well as total pulse production in India. After Madhya Pradesh, share of three states in the total area and production are Rajasthan (15.33 and 11.86%), Maharashtra (13.29 and 8.56%) and Karnataka (11.01 and 8.43%), respectively. More than 75% area and production has been obtained from Madhya Pradesh, Rajasthan, Maharashtra, Karnataka, Andhra Pradesh and Uttar Pradesh (Sukla and Mishra, 2020).

Salinity is one of the most brutal environmental factors limiting the productivity of crop plants because most of the

crop plants are sensitive to salinity caused by high concentrations of salts in the soil, and the area of land affected by it is increasing day by day. For all important crops, average yields are only a fraction – somewhere between 20% and 50% of record yields (Shrivastava and Kumar, 2015)^[29]. Salinity stress is the main cause in declining the productivity of pulses. Pulses are very sensitive to salinity than cereals and oilseed crops. In arid and semi arid regions, high temperature causes evaporation of underground water. During evaporation, salts like Ca, Mg come along with water up to the surface. Finally, the water evaporates and salt accumulates on the surface of soil resulting in poor soil fertility. Salinity causes decrease in microbial population in soil environment hence ecological function and soil fertility badly affected (Choudhary *et al.*, 2011)^[5]. Salt affected soils area covered worldwide is nearly 932.2 M ha (Kumar and Sharma, 2020)^[12], Around 6.727 million ha area in India, which is around 2.1% of geographical area of the country, is salt-affected, of which 2.956 million ha is saline and the rest 3.771 million ha is sodic. Around 2.347 million ha of the salt-affected soils occur in the Indo-Gangetic plains of the country, of which 0.56 million ha are saline and 1.787 million ha are sodic (Arora and Sharma, 2017)^[3]. Nearly 75% of salt-affected soils in the country exist in the states of Gujarat (2.23million ha), Uttar Pradesh (1.37 million ha), Maharashtra (0.61 million ha), West Bengal (0.44 million ha), and Rajasthan (0.38 million ha) (Mandal *et al.*, 2018)^[19].

Vermicompost is humus like material formed from the aerobic biodegradation process in which organic waste is

converted into a product through the use of earthworms, which can be used as nutrient source for crops along with increasing soil health. Vermicompost is a rich source of nutrients which reduces the external use of fertilizers to a great extent. The average concentration of nutrients in vermicompost is nitrogen- 1.5 to 3%, phosphorus-1.05 to 2.20%, potassium-1.01 to 1.75%, Ca- 0.9 to 1.0%, Mg-0.4 to 0.5% and S- 0.15 to 0.29%. Vermicompost contains micro sites rich in carbon and nitrogen and available phosphorus. The available potassium in vermicompost rich soils is two to three times higher in comparison to surrounding soils without vermicompost (Tulema *et al*, 2007) [35].

In pulses, inoculation of seeds with *Rhizobium* results in enhancement in crop yield, N uptake and growth parameters. *Rhizobium* inoculation increases soil fertility through improvement in physico-chemical and biological properties. Legumes are specific to *Rhizobium* species. Proper inoculation of legume seeds with specific *Rhizobium* species is very important for healthy and productive stands of legumes. After planting of legumes with inoculation, nodulation starts in 30 to 40 days. Selecting the right *Rhizobium* species results in effective nodulation and nitrogen fixation (Agegnehu *et al*, 2015) [2]. Integrated use of vermicompost and *Rhizobium* results in higher productivity as well as stable crop yields for sustainable crop production (Mohammad *et al.*, 2017).

Materials and methods

A pot experiment was conducted during *kharif* 2019 at S.K.N. College of Agriculture, Jobner (Rajasthan). The experiment was laid out in completely randomized design (CRD) with three replications. The experimental soil was analyzed for the physico-chemical properties. The soil texture consist of coarse sand (%) 35.61, fine sand (%) 45.51, silt (%) 10.23, clay (%) 7.95 then soil was loamy sand in texture, bulk density 1.51 Mg m⁻³, partical density 2.59 Mg m⁻³, alkaline in reaction (pH 8.4), low in available nitrogen(127.67 kg / ha) and organic carbon (1.84 g /kg), medium in available phosphorus (20.00 kg /ha), available potassium (144.99 kg /ha) content. ECe, Na⁺, Ca²⁺, Mg²⁺ and SAR were 1.22 dS/m, 10.0 me /L, 1.2 me /L, 1.0 me/L

and 9.61, respectively. The experiment was conducted with four levels of soil salinity (1.22, 2, 4 and 6 dS/m) and four sources of bio-organics (control, *Rhizobium*, vermicompost and *Rhizobium*+ vermicompost) as variables. To attain the ECe level of 2, 4 and 6 dSm⁻¹, the desired Cl⁻, SO₄²⁻ and HCO₃⁻ of Na⁺, Ca²⁺ and Mg²⁺ were added as solution and thoroughly mixed in the soil before seeding (Table 1) in the ratio of 60:25:15 for Na⁺:Ca²⁺:Mg²⁺ and 2:1:1 for Cl⁻, SO₄²⁻ and HCO₃⁻. The amount of cations and anions of base soil were included in the salts dissolved for salinity development.

The cylindrical ceramic pots (20 cm diameter and 28 cm height) were filled with 10 kg of soil per pot taking care of proper drainage. The cowpea variety RC-19 was sown on 16 July, 2019 with 10 seeds per pot. After germination numbers of plants per pot were maintained. The crop was harvested on 19 September, 2019. Three plants of each pot were harvested at maturity and tied up and kept on threshing floor for sun drying. After complete sun drying the produce of each pot was weighed for recording biological yield. After threshing, winnowing and cleaning the produce of each pot was weighed separately and weighed as grain yield in g per pot.

Analysis of nutrient content in plant parts

For N determination, plant and grain samples were collected separately, oven dried and grounded in a grinder. Similarly grain samples were collected, ground and both the samples separately digested by conc. H₂SO₄ using colorimetric method of Snell and Snell. For P and K determination, 1 gram of grinded sample was transferred into a 100ml conical flask and digested with 20 ml acid mixture and flask was heated slowly. After the initial reaction was completed and brown fumes ceased to evolve, heat was increased and heating was continued till the oxidation was completed *i.e* material becomes transparent and white fumes evolve and remained within flask. After cooling, content was filtered into volumetric flask by washing the conical flask with water and volume was made 100 ml. P content in plant parts were measured in spectrophotometer at 420 nm, k content in plant parts were measured in flame photometer.

Table 1: Amount of different salts and their ionic composition added in base for creating different salinities.

EC (dSm ⁻¹)	Na ⁺	Ca ²⁺	Mg ²⁺	Cl ⁻	SO ₄ ²⁻	HCO ₃ ⁻	Final EC (dSm ⁻¹)
1.22 (base soil)	10.0	1.2	1.0	2.2	6.0	6.0	1.22
2	7.2	4.4	2.5	5.0	2.5	2.5	2.63
4	14.0	8.8	5.6	10.0	5.0	5.0	4.16
6	21.8	13.3	8.4	15.0	7.5	7.5	6.00

Nutrient uptake: N, P and K uptake were computed with the help of formula:

$$N, P, K \text{ uptake (mg/pot)} = \frac{\text{Nutrient content in seed/straw (\%)} \times \text{Seed/straw yield (g/pot)}}{100} \times 1000$$

Statistical analysis: The experiment was laid in completely randomized design. The statistical analysis of the data on the grain yield and straw yield, content of N, P, K in grain and straw were done by statistical method for analysis of variance. To compare the treatments difference, the critical difference (CD) at 5 % level of significance was calculated by Panse and Sukhatme (1967) [21] whereas ‘F’ test was found significant.

Results and discussion

Effect of soil salinity: The grain and straw yield of cowpea decreased significantly (p= 0.05) with increasing levels of soil salinity (Table 2). The decrease in grain yield with the application of S₂, S₄ and S₆ was 16.48, 28.70 and 37.96 per cent over S₁, respectively and the S₂, S₄ and S₆ level decreased the straw yield to the extent of 14.66, 27.26 and 34.47 per cent over S₁. In general, the significant decrease in grain and straw yield under influence of different salinity levels was due to the increase in EC of soil which inturn responsible for the reduction in grain and straw yield by causing a restricted availability of nutrients and water to the plant. Several workers have also observed the significant yield reduction Dhaka *et al.* (2013) [7], Aechra *et al.* (2017) [1], and Jat (2011) [10] with the increasing level of soil

salinity. Reduction in crop yield as a result of salt stress has also been reported by Sohrabi *et al* (2008)^[32] and Vekaria *et al* (2018)^[37].

The N content in grain and straw increased significantly with increasing levels of soil salinity, while uptake of N by grain and straw decreased significantly with increasing levels of soil salinity (Table 3). The N content under S₆ was higher in grain by 30.20 percent over S₁. Similarly, due to S₆ the N content in straw higher by 33.94 per cent as compared to S₁. This increase may be explained on the basis of hypothesis of Strogonov and Oknina (1961)^[33] who stated that in crop plants grown under higher salinity, the contraction of protoplast destroys the intercellular connections in many plant parts. This brings about a diminution in the exchange of water and nutrients between the cells. Accumulation of N content in grain of chickpea was also reported by Manchanda *et al.* (1991) and in wheat by Sharma *et al.* (2007)^[28] with increasing soil salinity levels.

The P and K content in grain and straw significantly decreased with increasing levels of soil salinity (Tables 3). Decrease in P content may be due to synergism between SO₄²⁻ and PO₄³⁻ and antagonism between Cl⁻ and PO₄³⁻ ions. Antagonism has also been reported between Cl and P in tomato (Awad *et al.* 1990)^[4], Chickpea (Manchanda and Sharma, 1989^[17], Manchanda *et al.* (1991) and cowpea

(Dhaka *et al.* 2013)^[7]. The decrease in K is due to an increased concentration of Na in the soil solution. The increased concentration of sodium in soil solution causes more absorption of sodium by plants and decreases the uptake of K as Na competes with K on absorbing sites. These results find support from the work of Manchanda *et al.* (1991)^[18], Patel *et al.* (2010)^[22] and Dhaka *et al.* (2013)^[7] who reported a reduction in K content with increasing soil salinity levels.

Table 2: Effect of soil salinity and bio-organics on grain and straw yield

Treatments	Grain yield (g/pot)	Straw yield (g/pot)
Soil salinity levels		
S ₁ (1.2 dS/m)	5.40	8.73
S ₂ (2 dS/m)	4.51	7.45
S ₄ (4 dS/m)	3.85	6.35
S ₆ (6 dS/m)	3.35	5.72
SEm±	0.04	0.10
CD (P=0.05)	0.12	0.29
Bio-organics		
B ₀ (Control)	3.44	6.02
B ₁ (<i>Rhizobium</i>)	4.06	6.85
B ₂ (Vermicompost @ 5 t/ha)	4.55	7.47
B ₃ (<i>Rhizobium</i> + vermicompost @ 5 t/ha)	5.07	7.91
SEm±	0.04	0.10
CD (P=0.05)	0.12	0.29

Table 3: Effect of soil salinity and bio-organics on nutrient content in grain and straw and their uptake

Treatments	N content (%)		N uptake (mg/pot)		P content (%)		P uptake (mg/pot)		K content (%)		K uptake (mg/pot)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Soil salinity levels												
S ₁ (1.2 dS/m)	2.880	1.090	157.25	97.06	0.385	0.160	21.03	14.14	0.705	1.749	38.17	153.84
S ₂ (2 dS/m)	3.300	1.300	150.71	98.57	0.358	0.142	16.35	10.70	0.685	1.687	31.02	126.52
S ₄ (4 dS/m)	3.630	1.410	141.40	91.12	0.335	0.129	13.05	8.28	0.666	1.587	25.72	101.45
S ₆ (6 dS/m)	3.750	1.460	127.33	84.49	0.321	0.119	10.90	6.86	0.655	1.459	22.04	83.84
SEm±	0.043	0.019	3.70	3.78	0.004	0.002	0.58	0.42	0.003	0.016	0.48	2.08
CD (P=0.05)	0.123	0.055	10.64	10.87	0.012	0.006	1.68	1.20	0.009	0.045	1.37	6.00
Bio-organics												
B ₀ (Control)	2.943	1.029	99.42	61.00	0.302	0.115	10.51	7.02	0.650	1.469	22.48	89.30
B ₁ (<i>Rhizobium</i>)	3.303	1.212	131.59	81.70	0.345	0.134	14.19	9.30	0.676	1.584	27.56	109.46
B ₂ (Vermicompost @ 5 t/ha)	3.582	1.337	159.93	98.00	0.364	0.147	16.76	11.19	0.688	1.681	31.41	126.93
B ₃ (<i>Rhizobium</i> +vermicompost @5t/ha)	3.732	1.682	185.75	130.56	0.388	0.155	19.88	12.48	0.697	1.748	35.50	139.95
SEm±	0.043	0.019	3.70	3.78	0.004	0.002	0.58	0.42	0.003	0.016	0.48	2.08
CD (P=0.05)	0.123	0.055	10.64	10.87	0.012	0.006	1.68	1.20	0.009	0.045	1.37	6.00

Effect of source of bio-organics

The grain and straw yield of cowpea increased significantly with bio-organics. *Rhizobium* + vermicompost showed an increase of 11.43, 24.88 and 47.38 per cent in grain yield over vermicompost, *Rhizobium* and control, respectively. The seeds inoculated with *rhizobium* and soil treated with vermicompost (*Rhizobium*+ vermicompost) combinedly noted significantly higher straw yield over vermicompost, *Rhizobium* and control, representing an increase of 5.89, 15.47 and 31.39 per cent over vermicompost, *Rhizobium* and control, respectively. The higher increase in these yield and yield attributes have been reported to be associated with the release of macro and micronutrients during the course of microbial decomposition of organic matter (Singh and Ram 1992)^[31]. Vermicompost is a rich source of available nutrients and contains certain growth promoting substance like auxins and enzymes responsible for increase in yield attributes and yield (Devidayal and Agrawal, 1999^[6] and

Kumawat and Yadav, 2011)^[14]. Increased availability of nitrogen because of *Rhizobium* might open the door for increased utilization of others nutrient also and have resulted in more increase in yield attributes and ultimately the yield in comparison to *Rhizobium* inoculations. Similar findings were also reported by Saraf *et al.* (1997)^[26] in chickpea, and Yadav (2001) in cowpea and Kumar *et al.* (2018)^[13] in fenugreek.

The effect of application of bio-organics on N, P and K content in grain and straw was found significant. *Rhizobium* + vermicompost recorded significantly higher N content in grain and straw over vermicompost, *Rhizobium* and control and represented an increase of 4.18, 14.15 and 26.80 per cent in grain, and 25.80,38.77 and 63.45 per cent in straw, respectively. Similarly, phosphorus content an increase of 6.59, 12.46 and 28.47 per cent in grain and 5.44, 15.67 and 34.78 per cent in straw, and K content also noted an increase of 1.30, 3.10 and 7.23 per cent in grain and 3.98, 10.35 and

18.99 per cent in straw, respectively over vermicompost, *Rhizobium* and control. The effect of application of bio-organics on N, P and K uptake in grain and straw was found significant. It could be attributed to better root growth due to increased availability of nutrients by *Rhizobium* besides secretion of growth promoting substances (Totawat *et al.*, 2000) [34]. The nutrient content and uptake by crops were enhanced when the seeds were inoculated prior to sowing which can be described to the increased specific activities of isocitric and malic dehydrogenase, the source of electrons for fixation (Kurtz and Larue, 1975) [16] which creating a better nutritional environment. Interactive effect of two or more organisms and increased uptake of phosphorus due to solubilization effect. Similar results have also reported by Rao (1998) [23] and Saini *et al.* (2004) [25]. These findings are in confirmation with findings of Kundu and Gaur (1980) [15] and Jain *et al.* (2018) [9] in pearl millet the significant increase in nutrient content in plant ascribed to the ascribed to the beneficial role of vermicompost in mineralization of native as well as nutrients in soil through added fertilizers in addition of its own nutrient content which increased the available nutrient pool of the soil. The favourable conditions for microbial as well as chemical activities due to addition of vermicompost increased the mineralization of nutrients and ultimately the available nutrient pool of the soil led to higher uptake of nutrients by plant (Satyajeet *et al.*, 2006) [27]. These results are in agreement with those of Vasanthi and Kumaraswamy (1999) [36] and Nehra and Grewal (2001) [20] who have reported significant increase in available nutrient pool of soil with the use of vermicompost @ 5 t ha⁻¹. When the vermicompost is added to soil, long chain added to soil, long chain nitrogenous compounds slowly break down and make steady nutrient supply throughout crop growth period, leading to higher nutrient availability to plant (Rao, 2003) [24]. Interaction between soil salinity and bioorganics on grain and straw yield was found significant.

Conclusion

In arid and semiarid region of Rajasthan soil salinity has limitation in production of cowpea. On the basis of experiment results, that increasing concentration of salt in soil reduced the crop yield, nutrient content and uptake by plants. Whereas, use of bioorganics improved the crop yield as well as mineral nutrition of the crop. The maximum grain yield was recorded under S₁B₃. The grain yield recorded under treatment combinations S₁B₁ and S₂B₃, S₂B₂ and S₄B₃ as well as S₄B₂ and S₆B₃ remained statistically at par among them. The magnitude of decrease in seed and straw yield with increasing level of soil salinity was less under the seeds treated with *Rhizobium* and application of vermicompost combinedly indicating that salinity tolerance in cowpea can be increased to some extent by treating seeds with *Rhizobium* and vermicompost @ 5t/ha. This type of study could be used for enhancing the cowpea production in high salinity agricultural fields by use of bioorganics.

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