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Effect of sodic water, biofertilizer and phosphorus on physical properties of soil, yield attributes and yield of mungbean

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Abstract

A pot experiment was conducted to asses the effect of phosphorus management and biofertilizer in mungbean irrigated with sodic water during 2013. Three levels each of sodic water (control, 3.0 and 6.0 mmol/L), biofertilizer (control, PSB and PSB + VAM) and phosphorus (control, 15 and 30 mg/kg of soil), were tested in factorial randomized block design with three replications. The results indicated that application of irrigation water having RSC 1.0 mmol/L, biofertilizer *viz.* PSB + VAM and phosphorus 30 mg/kg of soil recorded the maximum and significantly higher total and available phosphorus, dehydrogenase enzyme activity, alkaline phosphate activity, total and effective nodules, nodule index, number of pods per plant, grain yield, straw yield and biological yield of mungbean over rest of the treatments. A application of irrigation water having RSC 6.0 mmol/L recorded significantly higher pH, EC and ESP as compared to other treatments. However, pH, EC and ESP did not show any significantly difference under different levels of phosphorus and biofertilizers.

Key words: Mungbean, phosphorus, PSB, RSC and yield

The information on the combined effect of phosphate solubilizing bacteria (PSB) and vesicular arbuscular mycorrhiza (VAM) strains and P levels in which conditions is scanty, therefore, the response of mungbean to "phosphorus and biofertilizer irrigated with sodic water was studies. The quality of irrigation water plays a vital role in crop production. Generally, irrigation water from all sources contains dissolved salts in very low concentration. The use of sodic water for irrigation adversely affects the productivity of soil by influencing the availability of nutrients for the plants and various soil properties (Chauhan *et al.* 1988). This problem aggravates when the carbonate and bicarbonate of sodic water occur in association with sodium, creating the problem of residual sodium carbonate (RSC). Mungbean is an important pulse crop but its productivity, particularly in area having sodic irrigation water is quite low because the crop is very sensitive to sodicity. Inoculation of phosphorus solublizing or mobilizing micro-organisms with legume crops through substitute around 20% P requirement P solublization. The rate of P mineralization depends on microbial activity of free phosphates, which is controlled by the solution P concentration. Solublization of inorganic phosphorus in soil is mostly mediated by microbial activity (*Pseudo-monas straita, Bacillus polymixa, Aspergillus awamori*) due to secretion of organic acids and release of CO_2, which prevents fixation of phosphate ion with chelating effect by production of inorganic acids and proton extrusion or ammonium assimilation (Pattanayak *et al.* 2009). In addition to acid production, these P-solublizing micro-organisms produce phosphates enzyme, which causes solublization of native P in soil. Hence, productivity of mungbean can be increased by proper phosphorus nutrition through the introduction of efficient P-solublizers.

Table 1. Composition of irrigation water

RSC mmol/L	EC (dS/m)	SAR	Ionic composition (mmol/L)						
			Na^+	Ca^{2+}	Mg^{2+}	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}
1.0 Base water	1.31	8.2	10.0	1.5	1.5	0.5	3.5	7.5	1.5
3.0	3.27	16.7	26.4	2.5	2.5	1.0	7.0	12.4	12.3
6.0	3.27	16.7	26.4	2.5	2.5	1.0	8.5	11.0	10.7

Response of different crops to P application on sodic soils have been reported by several workers (Tomar *et al.* 1996 and Yadav *et al.* 2009) and it has been suggested that plants grown on saline and sodic soils may have higher P requirements than normal soils because the work against the osmotic force on absorption, translocation and accumulation of inorganic ions may be accomplished at the expense of phosphate energy, phosphorilated intermediates could act as a carrier or trapping agents of anions and cations and inorganic phosphates are components of buffer system of plants (Pattanayak *et al.* 2009).

Materials and Methods

A pot experiment was conducted at Agronomy Farm, College of Agriculture, Jobner during 2013 in Randomized complete block design (RCBD) with three replications. The soil was loamy sand in texture, alkaline in reaction (pH 8.10), low in organic carbon (1.85 g/kg), and available nitrogen (128 kg/ha), medium in available phosphorus (20 kg P_2O_5/ha) and potassium (146 kg K_2O/ha) content. Bulk density, particle density, Na, Ca, Mg, CEC, exchangeable Na and ESP (1.50 Mg m^{-3}, 2.60 Mg m^{-3}, 9.60 me/L, 1.2 me/L, 1.2 me/L, 6.8 cmol (P+) kg/soil, 0.65 cmol/kg and 9.55, respectively) of experimental soil. The experiment was consisted of three levels of sodic water (control, 3.0 and 6.0 mmol/L), three levels of biofertilizer (control, PSB and PSB + VAM) and three levels of phosphorus (control, 15 and 30 mg/kg of soil), thereby, making 27 treatment combinations. The different RSC water were prepared artificially by dissolving required amount of $NaHCO_3$, NaCl, Na_2SO_4, $CaCl_2$ and $MgCl_2$ in base water (control). The tap water (base water) was used for first irrigation in all the pots and later on crop was irrigated 6 times with water of varying RSC during experimentation as per treatment. The composition of prepared water is given in Table 1.

Soil was filled in cylindrical ceramic pots (20 cm diameter and 28 cm height). Each pot contained 10 kg of soil. At the time of filling the pots, the broken pieces of stone were placed on the bottom hole to allow free drainage. The mungbean cv. 'RMG-62' was sown on 18th March, 2013 with a seed rate of 18 kg/ha and a row spacing of 45 cm. The crop was harvested on 29th May, 2013. Fully mature and developed pods from randomly selected five plants from each plot were plucked and number of seeds was counted. The average number of pods and seeds per plants was worked out. After threshing and winnowing the weight of seeds for each net plot area was recorded in kg per plot and then converted to kg/ha.

Results and Discussion

Soil studies

Effect of irrigation water: The results indicated that application of irrigation water with RSC 6.0 mmol/L significantly increased the soil pH, EC and ESP in mungbean as compared to other treatments. Application of RSC water @ 6.0 mmol/L recorded the maximum pH, EC and ESP over other treatments (Table 2). Increase in pH, EC and ESP of the soil due to use of irrigation water with higher RSC for irrigation is attributed to increased sodicity and decreased Ca in irrigation water because of precipitation of Ca and Mg as carbonates provide more opportunity for Na to be adsorbed on the exchange complex (Minhas and Bajwa 2004 and Naga *et al.*, 2013). Application of low RSC irrigation water (1.0 mmol/L) showed significantly higher total phosphorus, available phosphorus, dehydrogenase enzyme activity and alkaline phosphate activity over rest of treatments.

Table 2. Effect of different RSC water, biofertilizer and phosphorus on pH, EC, ESP, total and available phosphorus, dehydrogenase enzyme activity and alkaline phosphatase activity.

Treatments	pH	EC (dS/m)	ESP (%)	Total P (%)	Available P (kg/ha)	Dehydrogenase enzyme activity (p kat/kg soil)	Alkaline phosphatase activity (μ ml PNP produced/g/h)
RSC water (1.0 mmol/L)							
S_0: 1.0	8.00	2.89	17.21	0.032	9.59	6.00	10.22
S_3: 3.0	8.22	2.67	18.83	0.028	9.36	5.81	9.50
S_6: 6.0	8.41	2.45	20.45	0.025	9.03	5.62	8.72
SEm$\pm$	0.03	0.01	0.08	0.001	0.04	0.06	0.04
CD (P=0.05)	0.07	0.03	0.24	0.003	0.12	0.18	0.12
Biofertilizer							
No inoculation	8.23	2.69	18.85	0.024	8.78	5.60	8.44
PSB	8.22	2.67	18.83	0.028	9.36	5.81	9.50
PSB + VAM	8.19	2.65	18.81	0.034	9.90	6.01	10.50
SEm$\pm$	0.03	0.01	0.08	0.001	0.04	0.06	0.04
CD (P=0.05)	NS	NS	NS	0.003	0.12	0.18	0.12
P level (mg P/kg soil)							
P_0 : Control	8.25	2.65	18.99	0.025	8.96	5.60	8.77
P_{15} : 15	8.21	2.67	18.85	0.029	9.37	5.80	9.40
P_{30} : 30	8.17	2.69	18.65	0.031	9.65	6.03	10.27
SEm$\pm$	0.03	0.01	0.08	0.001	0.04	0.06	0.04
CD (P=0.05)	NS	NS	NS	0.003	0.12	0.18	0.12

Divalent cations enhanced P adsorption relative to monovalent cations, hence soil saturated with Na+ retained less amount of P than those saturated with Ca^{2+} ions (Tisdle *et al.*, 1995). Activities of dehydrogenase and alkaline phosphatase as well as microbial biomass build-up were significantly decreased with increasing level of RSC of irrigation water. The results were in close agreement with the findings of Antil *et al.* (2002) and Tripathi *et al.* (2006).

Effect of biofertilizer : The seed inoculation with biofertilizer significantly influnced the total phosphorus, available phosphorus, dehydrogenase enzyme activity and alkaline phosphate activity in mungbean. The seed inoculation with PSB + VAM significantly increased total phosphorus, available phosphorus, dehydrogenase enzyme activity and alkaline phosphate activity over rest of treatments (Table 2). Kumar, 1998 has also reported that seed inoculation with PSB significantly increased the total and available P in soil after harvest and helped in releasing native P as well as in protecting fixation of added phosphorus. The phosphatase activity in soil at harvest of mungbean over no inoculation of biofertilizer significantly enhanced the alkaline. Increased microbial and root activity in the rhizosphere generally accounts for higher activity including phoshpatase as reported by Singh *et al.* (2012) and Nath *et al.*, (2012).

Effect of phosphorus : The application of phosphorus @ 30 kg/ha significantly increased total phosphorus, available phosphorus, dehydrogenase and alkaline phosphate activity over rest of treatments (Table 2). Maximum soil microbial biomass, total and available phosphorus in soil was recorded under treatment receiving dual inoculation of PSB+VAM and minimum in soil under no inoculation. The application of PSB + VAM significantly enhanced the alkaline phosphatase activity in soil at harvest of mungbean over no inoculation of biofertilizer. Increased microbial and root activity in the rhizosphere generally accounts for higher activity including phoshpatase (Singh *et al.*, 2012 and

Nath *et al.*, 2012). However, pH, EC and ESP did not show significantl differences under different levels of phosphorus.

Yield attributes and yield

Effect of irrigation water : The results indicated that application of irrigation water with RSC 1.0 mmol/L showed significantly higher total and effective, nodule index, number of pods per plant, grain, straw and biological yield in mungbean as compared to other treatments (Table 3). This may be explained on the basis that increasing level of RSC water increased the ESP and pH of soil resulting into decreased availability of P, K, Ca and Mg but increased the uptake of Na which is toxic element. The higher amount of Na might have adversely affected the physiological, metabolic and enzymatic activities and utilization of photosynthates in plant. There are several evidences that cationic (Ca, Mg, Na and K) imbalance could lead to disturbances in photosynthesis and activity of stroma enzymes. The inability of the crop to grow under high RSC water was due to the toxicity of Na itself and Ca and between Na and K frequently becomes as limiting factor for plant growth (Dwivedi and Burrows, 1979). Restricted supply of Ca was reciprocated by a high Na content and was shown to affect the growth of the roots and shoots. Such a reduction in growth under Ca deficiency caused by Na accumulation was attributed to K leakage (Ben-Hauyyim *et al.*, 1987).

Effect of biofertilizer : The seed inoculation of biofertilizer significantly influenced nodulation, yield attributes and yield of mungbean. The seed inoculation with PSB + VAM significantly increased total and effective, nodule index, number of pods per plant, grain yield, straw yield and biological yield as compare to other treatments (Table 3). Seed inoculation with PSB significantly increased the total and available P in soil after harvest of the crop. The significantly enhanced the alkaline phosphatase activity in soil at harvest of mungbean over no inoculation of biofertilizer. Increased microbial and root activity in the rhizosphere generally account for higher activity including phoshpatase Singh *et al.* (2012) and Nath *et al.*, (2012). However, pH, EC and ESP remained materially unchanged under different treatments of biofertilizer. Increase in grain and straw yield due to inoculation of PSB + VAM

Table 3. Effect of different RSC water, biofertilizer and phosphorus on yield attributes and yield of mungbean.

Treatments	Total nodules	Effective nodules	Nodule index	Number of pods/plant	Grain yield (g/pot)	Straw yield (g/pot)	Biological yield (g/pot)
RSC water							
S_0: 1.0	25.00	20.70	2.58	7.69	4.45	6.20	10.65
S_3: 3.0	20.10	16.00	2.49	5.59	3.71	5.70	9.41
S_6: 6.0	15.00	12.50	2.43	4.45	3.06	5.08	8.14
SEm±	0.12	0.09	0.01	0.09	0.05	0.06	0.09
CD (P=0.05)	0.34	0.26	0.02	0.25	0.13	0.18	0.25
Biofertilizer							
No inoculation	15.10	12.50	2.30	4.62	3.07	5.06	8.13
PSB	20.10	16.00	2.49	5.59	3.71	5.70	9.41
PSB + VAM	24.00	19.20	2.70	7.20	4.45	6.21	10.66
SEm±	0.12	0.09	0.01	0.09	0.05	0.06	0.09
CD (P=0.05)	0.34	0.26	0.02	0.25	0.13	0.18	0.25
P level (mg P/kg soil)							
P_0 : Control	15.00	13.60	2.37	4.21	3.05	5.06	8.11
P_{15} : 15	20.10	15.00	2.49	6.40	3.71	5.72	9.43
P_{30} : 30	25.00	20.60	2.64	7.12	4.46	6.20	10.66
SEm±	0.12	0.09	0.01	0.09	0.05	0.06	0.09
CD (P=0.05)	0.34	0.26	0.02	0.25	0.13	0.18	0.25

might be attributed to its phosphate solubilizing effect. PSB solubilize insoluble fixed P in soil by production of organic acids in solubilizing minerals and phosphorylated minerals is attributed to the lowering of pH which helps in release of phosphorus from the stable complexes with cations such as Ca^{2+}, Mg^{2+}. Such reaction also prevent the fixation of phosphate ions. Organic acids solubilize more P than inorganic acids at same pH due to the chelating effect of former (Somani, 2002). Production of CO_2 by soil microorganisms and plant roots leads to formation of carbonic acid which also encourages solubilization of insoluble P. The solubilization of insoluble phosphatase without production of acid may be due to release of protons accompanying respiration or ammonium assimilation and insoluble phosphate, thus directly solubilized at the microbial cell surface (Somani, 2002).

Effect of phosphorus : The application of phosphorus @ 30 kg/ha significantly increased total and effective nodules, nodule index, number of pods per plant, grain, straw and biological yield over rest of treatments (Table 3). Phosphorus has been recognized as an essential constituent of all living organisms and play an important role in the conservation and transfer of energy in the metabolic reaction of living cell including biological energy transformation. It is the main constituent of co-enzymes, ATP and ADP which act as "energy currency" within plants. Thus phosphorus influences photosynthesis, biosynthesis of proteins and phospholipids, nuclic acid synthesis membrane transport and cytoplasmic streaming. The results obtained in this investigation were in close conformity with those of Tiwari and Kumar (2009) and Akbari *et al.* (2010).

Conclusion

On the basis of one year field experimentation, it seems quite logical to conclude that grain and straw yield increased with increase in level of phosphorus and seed inoculation with PSB and VAM. However, higher RSC of irrigation water adversely affect the nodulation and yield of mungbean.

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