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Phosphorus Management in Salt Affected Soil - A Review

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Abstract: *Phosphorus is the second most limiting nutrient in crop production after nitrogen. It is a constituent of cell nuclei, essential for cell division and development of meristematic tissue (Russell, 2001) and has a well-known impact on photosynthesis as well as synthesis of nucleic acids, proteins, lipids and other essential compounds. About 80 to 90% soils of Pakistan are P deficient (Memon and Puno, 1992). Deficiency limits growth of plants, especially when plants are deprived of P at early stages of growth. Deficiency reduces amino acid and protein synthesis. Correlated with this decrease in protein synthesis, there is often an accumulation of sugars in the leaf tissues, which favors phenol synthesis. The latter inhibits cell division and cell expansion as well as the development of plant tissues and organs. Phosphorous availability is influenced by various factors like soil pH, clay lattice and organic matter contents. In alkaline soils, calcareousness leads to the low recovery of P. Fixation of P in silicate clay is also responsible for deficiency. Soil salinity hinders the availability of essential nutrients to plants, amongst which the phosphate uptake by the plant in the saline soil has broadened the extent of the hazard. Hence, this work carried out to document the phosphorus management in salt affected soil and its effect of growth, yield and quality of different crops. It also creates an idea about to mitigate the deficiency of P in salt affected soil.*

Keywords: Phosphorous ,Saline Soil, Growth, Yield and Quality

I. INTRODUCTION

Phosphorus is the second most limiting nutrient in crop production after nitrogen. It is a constituent of cell nuclei, essential for cell division and development of meristematic tissue (Russell, 2001) and has a well-known impact on photosynthesis as well as synthesis of nucleic acids, proteins, lipids and other essential compounds (Taiz and Zeiger, 1991). About 80 to 90% soils of Pakistan are P deficient (Memon and Puno, 1992;. Deficiency limits growth of plants, especially when plants are deprived of P at early stages of growth (Hearn, 1981). Deficiency reduces amino acid and protein synthesis. Correlated with this decrease in protein synthesis, there is often an accumulation of sugars in the leaf tissues, which favors phenol synthesis. The latter inhibits cell division and cell expansion as well as the development of plant tissues and organs.

Plants acquire P from soil. However, most of the soil phosphorus, approximately 95–99%, is present in the form of insoluble phosphates. As a result, the amount available to plants is usually a small proportion of the total P. To increase the availability of phosphorus to plants, farmers apply large quantities of phosphoric fertilizer. But, after application, a large proportion of available phosphorus quickly turned into the insoluble form. Hence, a very small percentage of applied phosphorus is used by plants.

The major problems related to the phosphate in soil are very low solubility of phosphate mineral and its strong binding or adsorption on to the particle surfaces causing low phosphate concentration in the soil. As soon as soil is fertilized with phosphatic fertilizer only a small portion of it became available for plant uptake while rest of it gets adsorbed or form precipitate. As a result, phosphate deficiency in crops is very common.

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Phosphorous availability is influenced by various factors like soil pH, clay lattice and organic matter contents. In alkaline soils, calcareousness leads to the low recovery of P. Fixation of P in silicate clay is also responsible for deficiency. Soil salinity hinders the availability of essential nutrients to plants, amongst which the phosphate uptake by the plant in the saline soil has broadened the extent of the hazard. The interaction between salinity and phosphorus uptake of plants is a complex or more confusing phenomenon.

Phosphorus buildup and its role in sustainable soil fertility have been identified so long by agriculturists throughout the world, but we are still lagging behind in understanding the phosphorous behavior and its dynamics in soil-plant system. Although scientists have investigated the phosphorous transformation dynamics, release and fixation pattern in soil. However, actual amount of labile phosphorous to be made available in a growing season is still in question.

Strategies to enhance P availability in salt affected soils

In intensive agricultural system decline in soil available nutrient pool is showing fatigue in essential micro and macro nutrients. Deteriorated salt affected soils require special handling for a successful farming. Therefore, necessary measures are needed to understand phosphorous dynamics in soil plant system in order to maximize PUE, proper management practices to lessen the chemical fertilization, optimization of biological potential of microbial community in P mobilization, assimilation of soil phosphorous by plants and its recycling from organic manure. In this regard, 4R strategy i.e. right source, right rate, right time and right method is of great importance. Since prices of the commercial phosphate fertilizers have been increasing in the world and use of fertilizers has become a necessary evil for the sustainable crop production that corrects nutrient deficiencies. Here are some strategies that can be adopted to overcome phosphorous deficiency in salt affected soil.

Ahmed *et al.* (2013) investigated the effect of different levels of phosphorus on the yield and P uptake by maize (*Zea mays*) on calcareous soil(19% lime on W/W basis) of Peshawar soil series under field experiment condition. The results showed that maize plant height, number of cobs plot^{-1},grain and biomass yields increased with increasing levels of phosphorous, the increase the yield and yield parameter where observed up to 135 kg ha^{-1} after that decreasing trend was observed.

The higher plant height (219.6 cm) grain,yield (8.18 t ha^{-1}) and was observed by the application of 135 P kg ha^{-1}. This was followed by the application of 180 kg ha $^{-1}$ and 90 kg P ha $^{-1}$. The higher cobs plants and biomass was observed in application of 180 kg P ha^{-1}. This was followed by 135 kg ha^{-1} and 90 kg ha^{-1} of P. Regarding VCR of this study all the P levels where economical as VCR in any case was greater the critical VCR value of 2.0. However, application of lower dose of P is 45 kg P_2O_5 ha^{-1} was more economical than the higher doses. Similarly, application of 135 P_2O_5 ha^{-1} with VCR value of 3.41:1 was more economical than 90 or 180 kg P_2O_5 ha^{-1}. The decreased yield over 135 kg ha^{-1} may be due to detrimental either due to complexes formation of higher P levels with other nutrients in antagonistic effect with zinc or limitation of N and K nutrients in soil.

Table 1. Maize plant height, no of cobs, grain and biomass yield as affected by different levels of P in silt clay loam calcareous soil `

P(kg P_2o_5 ha^{-1})	Plant height(cm)	Cobs plot^{-1}	Grain yield(t ha^{-1})	Biomass(t ha^{-1})	VCR
0	180.60	81.0	5.43	9.85	-
45	195.3	83.6	6.40	11.92	4.07
90	213.9	93.3	6.87	13.50	3.19
135	219.6	100.3	8.18	13 .51	3.41
180	217.9	103.6	7.99	14.00	2.49
LSD (p=0.05)	6.12	10.13	1.10	1.53	

(Ahmad *et al.*, 2013)

Sundara *et al* (2002) studied the Influence of application of phosphorus solubilizing bacteria (PSB), *Bacillus megatherium* var. phosphaticum, at 10 kg ha^{-1} of lignite based culture with and without varying amounts of P fertilizer was studied on soil available P changes and sugarcane growth and yield .The PSB application increased the PSB population in the rhizosphere and the plant available P status in the soil .it also enhanced tillering, and stalk weight, and led to a cane yield increase of 12.6% over no application ,When used in conjunction with P fertilizers, PSB reduced the required P dosage by 25%. In addition, it was found that 50% of the costly super phosphate could be replaced by rock phosphate (RP), a cheap source of P, When applied in conjunction with PSB.

The effects of PSB and P fertilizer treatments on stalk population , stalk weight ,cane yield ,CCS% and sugar yield are presented in the PSB application increased all the parameters significantly over control .The recommended P application through SSP increased the stalk weight and cane yield over control and only PSB application .Addition of PSB to the recommended P rate d id not further influence the yield and its components .when the P rate was reduced to 75 or 50% without the addition of PSB ,significant reduction in the stalk weight, and cane yield occurred .But when the P rate was reduced to 75% with the addition of PSB ,no such reductions were noticed. However, further reduction of the rate to 50% with the addition of PSB reduced the yield. Substitution of SSP with RP by 50% at different P rates caused significant reduction in cane yield as compared to the corresponding P rates supplied entirely through SSP. But no such reduction were noticed when RP Was used along with PSB. Thus treatments in which P was supplied at recommended rate through SSP, SSP+PSB,75% P through SSP+PSB,100% P (through SSP+RP) +PSB or 75% P (through SSP+ RP) + Were at per in cane yield components and cane yield.

The CCS % Was better in treatments Where P Was applied entirely through SSP or P fertilizer +PSB at 100 or 75% of the dosage. The RP +PSB applied plots in general registered a higher level of CCS %. Sugar yield increased significantly by the application of the entire P through SSP or By 100 or 75 % through P fertilizer + PSB .The sugar yield trend was similar to that of the cane yield

Table 2. The effect of PSB and P fertilizer treatment on stalk weight ,cane yield ,CCS % and sugar yield

Treatment	Stalk weight (kg)	Cane yield (t ha^{-1})	CCS %	Sugar yield	Available P (mg/kg)
T_1 – Control	1.38	101.4	12.46	12.63	4.3
T_2 - PSB	1.47	112.1	12.63	14.16	4.2
T_3 -100 % P as SSP	1.51	125.5	13.02	16.34	5.0
T_4 -75 % P as SSP	1.48	113.3	12.54	14.21	4.8
T_5 -50 % P as SSP	1.46	103.6	12.51	12.96	4.6
T_6 –T_3 +PSB	1.46	126.2	12.76	16.10	5.0
T_7 –T_4 + PSB	1.47	126.3	12.87	16.25	4.9
T_8 –T_5 +PSB	1.44	114.6	12.56	14.39	4.8
T_9 -100% P (50% as SSP +50 % as RP	1.46	106.4	12.56	13.36	4.8
T_{10} -75% P (50% as SSP +50 % as RP)	1.49	101.2	12.47	12.62	4.6
T_{11} -50% P (50% as SSP +50 % as RP)	1.42	101.3	12.46	12.62	4.6
T_{12} – T_9 +PSB	1.46	127.1	13.20	16.77	6.0
T_{13} – T_{10} + PSB	1.46	125.3	13.30	16.66	5.8
T_{14} –T_{11} + PSB	1.44	115.4	12.81	14.78	5.3
LSD (P=0.05)	0.05	7.8	0.28	1.01	0.3

(Sundara *et al.*,2002)

Sayed *et al* (2014) Two field experiments were conducted at farmer's field , Ebshwa ,El –Fayoum Governorate , Egypt during two seasons (2012 -2013 and 2013 -2014). Foliar application of humic acid at the rate 0.1% combined with super bio –phosphate at a rate 100 kg p_20_5 fed $^{-1}$ had statistically significant effect on fresh and dry weight of root and shoot ,root length and diameter as well as nutrient content and uptake. The fresh and dry root and shoot of radish plant at harvest a remarkable increased as affected by humic acid application with different source of phosphorus fertilization particularly with application of super bio –phosphate at a rate of 100 kg p_20_5 fed $^{-1}$ and foliar application Humic acid (HA) at a rate 0.1% as compared with control of on applied P. Significantly increased of root length and root diameter by 31.3%and 48.1% respectively as compared with super bio- phosphate also applied at the rate 100kg p_20_5 fed $^{-1}$ .Formation of complex between humic acid and mineral ions, catalysis of humic acid by the enzymes in plants

,influence of humic acid on respiration and photosynthesis, stimulation of nucleic acid metabolism hormonal activity of humic acid are amongst effective assumption that has been expressed to describe the effect of humic acid on plant growth parameters

Table 3. Yield parameters of radish as affected by Humic acid and phosphorus source (Data mean of two seasons).

Treatments	Fresh weight (g plant $^{-1}$)		Dry weight (g plant $^{-}$)		Root length (cm plant $^{-}$1	Toot diameter (cm plant^{-} 1)
	Root	Shoot	Root	Shoot		
P0 (control)	21.9	22.8	2.11	5.04	8.40	1.19
Ca super p (1)	23.5	32.9	3.64	6.12	9.43	1.39
Ca super p (2)	24.6	37.3	4.11	6.83	10.63	1.66
Super Bio P (1)	24.2	33.9	3.72	6.28	10.10	1.53
Super Bio P (2)	25.6	39.5	4.47	7.09	10.73	1.73
PO + HA 0.05%	22.8	27.2	2.90	5.35	8.80	1.26
Ca super (1) + HA 0.05%	26.1	40.0	4.87	7.39	11.30	1.94
Ca super (2) + HA 0.05%	27.4	43.2	5.83	8.13	11.83	2.33
Super Bio p (1) + HA 0.05%	26.7	42.9	5.24	7.84	11.50	2.12
Super Bio p (2) + HA 0.05%	28.2	44.7	5.85	9.11	12.13	2.42
PO + HA 0.1 %	23.2	30.6	3.07	5.95	9.10	1.34
Ca super (1) + HA 0.1%	27.8	43.9	6.12	8.63	12.10	2.34
Ca super (2) + HA 0.1%	28.6	49.9	7.65	9.34	13.33	2.62
Super Bio p (1) + HA 0.1%	29.8	58.0	8.34	9.91	14.70	2.95
Super Bio p (2) + HA 0.1%	29.2	54.3	8.13	9.82	14.40	2.85
LSD 0.05%	0.71	1.79	0.38	0.34	0.39	0.16

(Sayed *et al*.,2014)

Ahmad *et al* (2009 conducted a field experiment to evaluate the effect of P on the growth, yield and fiber quality of cotton on a sandy loam calcareous soil at farmer's field in cotton growing area of district khanewal , Punjab. five of P (O,17,26,34, AND 43 kg P ha^{-1} there was significant increases in the growth and yields parameters with each additional rate of P, The response of number of bolls per plant, boll weight and seed cotton yield .respectively at P application rate of 34 kg ha^{-1}. Cotton quality components(lint % age, fiber length, and fiber strength) improved from 2% where 43 kg ha^{-1} was added.

All the yield components were improved significantly with P application. number of symbodial branches increased from 31.50 where P was applied at the rate of 34 kg ha^{-1} further improvement was not observed with higher P rate .plant height is a genetic trait but balanced nutrition showed positive effect .there was a gradual improvement in main stem height with different levels of P application.

Table 4. Effect of P rate on yield components and seed cotton yield

P (kg ha^{-1})	Symbodial branches	Main stem height (cm)	Dry matter yield (mg ha^{-1})	Bolls plant $^{-1}$(No ´s)	Bolls weight (g)	Seed cotton yield (kg ha^{-1})
Control	31.50	134	3.04	17	3.15	2705
17	33.35	137	5.32	21	3.30	2992
26	35.95	140	5.76	27	3.59	4245
34	37.75	141	5.92	32	3.66	4766
43	37.05	140	5.89	32	3.66	4680

LSD at P = 0.05	1.566	4.540	0.3315	2.188	0.1248	157.5

(Ahmad *et al.*, 2009)

Poonia and B.L. Dhaka (2012) A field experiment was conducted to study the effect phosphate solubilizing bacteria (PSB) on growth and yield of tomato. Treatments applied were : T1-100% of recommended P (Control) T2-75 % of recommended P with seedling dip in PSB 1:10 solution (1kg PSB:10 lit water), T3 -100% of recommended P with seedling dip in PSB 1:10 solution (1 kg PSB:10 lit water), T4- 75% of recommended P with soil application of PSB @ 5 kg ha^{-1} and T-5 100 % of recommended P with soil application of PSB @ 5 kg ha^{-1}

.PSB culture was applied through soil and seedling root dip before transplanting with two levels of phosphorus fertilizers, and 100% of recommended P, and compared. Results revealed that application of 100% P with seedlings dip in PSB 1:10 solution recorded significantly higher plant height (86.30 cm) ,leaf area index(3.52), number of fruits/plant(16.32),fruit weight (77.75 g),fruit yield/plant (1125 g) and yield (392.26 q/ha) compared to other treatment combination ,except 100 % P with 5 kg/ha soil application of PSB. The same treatment also recorded the highest (3.41) cost benefit ratio.

Alkaline cultivable soil contains less available phosphorus .due to higher concentration of calcium , whenever phosphatic fertilizers are applied in such soil. a large quantity gets immobilized and becomes to unavailable to the crop .phosphorus is one of the most important mineral nutrients for plant growth and development. however ,most of the soil phosphorus ,approximately 95-99%,is present in the form of insoluble phosphates as a result, the amount available to plants is usually a small proportion of the total P. to increases the availability of phosphorus to plants, phoaphates solubilizing bacteria play an important role in supplementing phosphorus to plants, allowing sustainable use of phosphate. soil and seed inoculation with phosphates solubilizing bacteria (PSB) improves solubilization fixed soil phosphorus and of applied phosphates, resulting in higher crop yields.

Table 5. Effect of phosphorus solubilizing bacteria on the growth and yield attributes of tomato.

Treatments	**Plant height (cm)**	**Leaf area index**	**No .of fruits / plant**	**Fruit weight (g)**	**Fruit yield (q / ha)**
T1 -100% of recommended P	75.88	2.96	14.93	67.18	344.16
T2-75% of recommended P With seedling dip in PSB 1: 10 solution (1 kg PSB : 10 lit water	81.05	3.20	15.49	73.38	364.61
T3-100% of recommended P With seedling dip in PSB 1: 10 solution (1 kg PSB : 10 lit water	86.30	3.53	16.32	77.75	392.26
T4-75% of recommended P With soil application of PSB @ 5 kg ha $^{-1}$	80.70	3.21	15.44	72.90	362.47
T5-100% of recommended P With soil application of PSB @ 5 kg ha $^{-1}$	85.58	3.51	16.24	76.98	389.93
CD (P= 0.05)	1.21	0.076	0.37	1.21	4.41
SEm±	0.96	0.060	0.29	1.01	3.50

(Poonia and Dhaka.,2012)

Mihoub and Naima (2014) A field experiment was conducted to determine the judicious use of phosphorus (P) at agricultural farm to the performance of wheat yield under different fertilizers types and doses in calcareous light textured soil . there was four treatments 30,60,90 and 120 kg $p_2 o_5$ ha^{-1}with five replication .the results showed that the wheat responded positively at this phosphorus fertilization ,maximum wheat yield of 7.4 t ha^{-1} was obtained by fosfactyl with 90 kg $p_2 o_5$ indicating importance of phosphorus at its highest dose in achieving maximum wheat productivity. the 1000 – grains weight, grain and straw yields significantly increased with P levels. phosphorus concentration in grain and straw and P uptake by wheat also significantly increased in all the treatments.

In most cases the rate of 120 kg p_2 o_5 ha^{-1} which showed the highest values. the maximum 1000 grains weight was recorded by Fosfactyl at the 120 kg p_2 o_5 ha^{-1} the results showed that maximum wheat yield of 7.49 t ha^{-1} were obtained in the treatments Fosfactyl fertilizer indicating importance of phosphorus at its highest dose in achieving maximum wheat productivity that increasing levels of P can contribute to ameliorate obtained grain yield of wheat

Table 6. Effect of different rates of phosphorus application on 1000 grain weight (g) and grain and straw yield (t ha^{-1}) of wheat

Treatments p_2o_5 (kg ha^{-1})	1000 grains weight (g)	Grain yield (t /ha)	Straw yield (t/ha)
Fosfactyl			
30	57.83	7.17	4.57
60	59.54	6.86	4.38
90	59.17	6.82	5.07
120	61.96	7.49	5.24
SSP			
30	59.96	4.95	3.50
60	57.73	7.41	4.84
90	55.48	7.10	5.01
120	60.62	6.87	4.76

(Mihoub and Deraoui 2014)

II. CONCLUSION

The different phosphorus fertilizer, PSB and organic manures application individually or combined application might increased yield and quality of crops. But individual application or combined application is decide by benefit cost ratio of the crop production.

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