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Nitrogen and Phosphorus Requirement to Soybean in High Phosphorus Soils

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A B S T R A C T

A net house experiment was conducted during *kharif,* 2018 at Agricultural Research Institute, Rajendranagar, Hyderabad, Telangana state to know the requirement of N and P to soybean crop in high phosphorus soils. The soils employed for the experiment were sandy clay loam in texture, low in available nitrogen, high in phosphorus and high in potassium status. The experiment was conducted employing 4 levels of N (60, 80, 100 and 120 kg N ha^{-1}) 2 levels of phosphorus (42 and 60 kg P_2O_5 ha^{-1}) and with three high P soils having 69, 82 and 107 kg native available P_2O_5 ha^{-1}. Application of nitrogen @ 80 kg ha^{-1} resulted in higher seed (14.60 g pot^{-1}) and haulm yield (21.03 g pot^{-1}) when compared with 60 kg N ha^{-1} but it was found to be on par with the application of 100 and 120 kg N ha^{1}.The significant increment in the seed yield of soybean was observed in all the three hig h P soils with increase in nitrogen levels from 60 to 80 kg N ha^{-1}. Application of phosphorus @ 100% RDP or 70% RDP resulted in on par seed and haulm yield in all three high P soils. Thus reducing the level of phosphorus application from 60 to 42 kg P_2O_5 ha^{-1} had no significant effect on the yield of soybean. The yield achieved by application of 80 kg N ha^{-1} and 100% RDP was found to be on par with the application of 100, 120 kg N ha^{-1} along with 70 or 100% RDP.

Introduction

Soybean is a major oilseed crop in the world. The crop's share in global oilseed output is estimated at over 50 percent. Soybean *(Glycine max* (L.) Merrill) is a dual purpose legume crop recognized as an efficient producer of protein as well as oil. These are not only the major components in the diet of vegetarians mass but a boon to the developing countries as well. Therefore, soybean is an important crop promising great scope for elimination of dietary deficiency of protein and fat in the country. It contains about 40-42 percent protein and 20-22% oil (Barik and Chandel, 2001). It is one of the major rainy season cash crop and its cultivation is fast spreading in India. Soybean contributes to 30-37% of India's oil seed production with 109.7 lakh ha of area, 114.9 lakh metric tonnes production and 1047 kg ha^{-1} of average yield (www.sopa.org. 2017). In India, soybean is grown in 6.22 million hectares with total production of 8-9 million tonnes. In

Telangana, it occupies about 2.43 lakh ha with 2.52 lakh tonnes of production and 1036 kg ha^{-1} of average productivity (DES, 2017). The major uses of soybean are as a source of edible oil and protein rich food, as well as cattle feed. The nutrient requirement and interaction of different nutrients under high phosphorus conditions were not worked out so far in soybean track. To improve the productivity levels of soybean it is imperative to assess the nitrogen and phosphorus requirement under high P fertility soils to obtain the potential yield by the farmers.

Materials and Methods

A pot culture experiment with soybean crop (Var: Basara) was conducted during *kharif*, 2018 at Agricultural Research Institute, Hyderabad, Telangana state. Soils having high status of available phosphorus are used in this investigation. For this purpose, soils of representative surface soils (0-l5 cm) were collected in and around Ranga Reddy district and used in the present investigation. These soils were initially tested for available P, using Olsen's extractant as per standard procedures to find out the status of available phosphorus in soils to conduct pot culture experiment. Based on status of available P, bulk samples of high P soils were collected from those sites and were employed in the present investigation. Physical, Physico-chemical and chemical properties of soils employed for pot culture study were estimated by following standard procedures and presented in table1.

Three phosphorus accumulated soils, S-1(69kg$P_2O_5$$ha^{-1}$), S-2(82 kg$P_2O_5$$ha^{-1}$) and S-3(107 kg$P_2O_5$$ha^{-1}$) with two P levels as P1 (Soil test based phosphorus -70 %RDP) and P2 (RDP-100% RDP) along with 4 levels of nitrogen (60, 80, 100 and 120 N ha^{-1}) were selected for pot culture study with 3 replications. The collected soils after processing were filled in pots of 5 kg capacity and pot culture experiment was conducted with soybean as test crop (Var: Basara). Recommended doses of fertilizers (60:60:40 kg NPK ha^{-1}) were applied during crop growth period and all package of practices were followed during crop growth period. The crop was raised till maturity and yield was recorded at harvest.

Results and Discussion

Effect of different doses of N and P levels on seed and haulm yield of soybean was presented in table 2 and 3.Application of different levels of nitrogen fertilizer to soybean crop in high P soils significantly influenced the soybean seed yield. It was found that increasing the N application from 60 to 80 kg ha^{-1} enhanced the soybean seed yield by 12.7% significantly from 12.96 to 14.60 g pot^{-1}. Subsequent enhancement of N application from 80 to 120 kg ha^{-1} to soybean crop did not affect the yield of soybean seed significantly in these high P soils. The overall yield of soybean seed at different levels of N application was in range of 12.96 to 15.18 g pot^{-1} with mean of 14.41 g pot^{-1}.Application of P fertilizer to soybean crop in high P soils at the rate of 100% RDP (60 kg P_2O_5 ha^{-1}) or 70% RDP (42 kg P_2O_5 ha^{-1}) did not influence the seed yield of soybean and they were found to be statistically on par (14.56 and 14.26 g pot^{-1}).The interaction effect of N X P on soybean seed yield was found to be significant. Maximum seed yield of 15.34 g pot^{-1} was recorded due to combination of N120 + P 100% RDP treatment. Similar on par yields are also observed when N 100 was in combination with either 100% RDP or 70% RDP. Different high P soils significantly affected the soybean seed yield. Highest seed yield of 15.56 g pot^{-1} was observed in soil with native available P_2O_5 of 107 kg P_2O_5 ha^{-1} (S3) fallowed by soil with 82 (14.47 g pot^{-1}) and 69 kg P_2O_5 ha^{-1} (13.29 g pot^{-1}). These differences in seed yield were found to be statistically significant. The interaction effect of high P soils and doses of N application was found to be significant on seed yield of soybean. In general, the combination of high N doses like 100 and 120 kg P_2O_5 ha^{-1} in very high P soil (107 kg P_2O_5 ha^{-1}) resulted in highest soybean seed yield when compared to other combination in study. The interaction effect of high P soils and P doses applied to crop on soybean seed yield was found to be statistically significant. The interaction effect of N, P and different high P soils on soybean seed yield was found to be statistically significant. It was observed that the seed yield in general was higher in very high P soil at high doses of N irrespective of 100% or 70% RDP.

Haulm yield of soybean is significantly influenced by application of different levels of nitrogen fertilizer to soybean crop in high P soils. The overall yield of soybean haulm at different levels of N application was in range of 18.42 to 22.37 g pot^{-1} with mean of 20.93 g pot^{-1}. It was found that increasing the N application from 60 to 80 kg ha^{-1} enhanced the haulm yield significantly from 18.42 to 21.03 g pot^{-1}. Subsequent enhancement of N application from 80 to 120 kg ha^{-1} to soybean crop did not effect the haulm yield of soybean significantly in these high P soils. Application of P fertilizer to soybean crop in high P soils at the rate of 100% RDP (60 kg P_2O_5 ha^{-1}) or 70% RDP (42 kg P_2O_5 ha^{-1}) did not influence the haulm yield of soybean and they were found to be statistically on par (21.31 and 20.55 g pot^{-1}).There was a significant result in the interaction effect of N X P on soybean haulm yield. Maximum haulm yield of 22.81 g pot^{-1} was recorded due to combination of N120 + P 100% RDP treatment. Similar on par yields are also observed when N100 was in combination with either 100% RDP or 70% RDP. Different high P soils had a significant effect on haulm yield of soybean. Highest haulm yield of 22.35 g pot^{-1} was observed in soil with native available P_2O_5 of 107 kg P_2O_5 ha^{-1} (S3) fallowed by soil with 82 (20.85 g pot^{-1}) and 69 kg P_2O_5 ha^{-1} (19.58 g pot^{-1}). The interaction effect of high P soils and doses of N application was found to be significant on haulm yield of soybean. In general, the combination of high N doses like 100 and 120 kg P_2O_5 ha^{-1} in very high P soil (107 kg P_2O_5 ha^{-1}) resulted in highest soybean haulm yield when compared to other combination in study. The interaction effect of high P soils and P doses applied to crop on soybean haulm yield was found to be statistically significant. The interaction effect of N, P and different high P soils on haulm yield of soybean was found to be statistically significant. It was observed that the haulm yield in general was higher in very high P soil at high doses of N irrespective of 100% RDP or 70% RDP.

Application of different doses of nitrogen to this high P soils resulted response to soybean seed yield (Table. 2). Application of N@ 80 kg N ha^{-1} increased the soybean seed yield significantly by 12.7% over 60 kg N ha^{-1}. Further increase in dose of N from 80 to 120 kg N ha^{-1} to soybean crop did not influence the yield of soybean seed significantly in these high P soils. At higher levels of nitrogen doses crop not responded to external application of nitrogen might be as a leguminous crop soybean meets their nitrogen requirement through biological nitrogen fixation. Previous research results conducted on low N and low to medium P soils resulted in seed yield response to N application in the range of 10-30 % (Siddiqui *et al.,* 2007, Abdalmoshin, 2016) when N was applied in the range of 0 to100 kg N ha^{-1}.

Application of phosphorus fertilizer based on conventional soil test based P recommendation (30% reduction of RDP) to high P soils recorded on par yields with 100% RDP (Table.2). It is noticed that the enhancement in seed yield of soybean was only 2 % due to application of 100% recommended dose of phosphorus (60 kg P_2O_5 ha^{-1}) over 70%RDP (42 kg P_2O_5 ha^{-1}) to this high P soils. These observations clearly indicate that it is possible to reduce current RDP by 30% in high P soils without scarifying the yield. Application of RDP to many crops having low to medium available phosphorus was found to result in enhanced yields to the tune of 15 to 20% depending upon initial available P status (Varavipour *et al.*, 1999; Akhtar *et al.*, 2003; Ikeogu and Nwofia, 2013; Dhage *et al.*, 2014).

At the same time the seed yields obtained with reduced P application (70% RDP) below 100% RDP is also found to result in on par yield like that of 100% RDP in the high P soils. Babu *et al.*, (2005) reported possible saving of as much as 50% of P from recommended dose for rice crop in high P soils. Reduced P application by 25-50% from the current RDP in high P soils is reported to be a possible P saving measure without scarifying the yields in crops for *e.g.*, in rice, sunflower, rice-rice, rice-sunflower (Babu *et al.*, 2005; Ramya *et al.*, 2015, Srinivas *et al.*, 2017). Thus the present results clearly establish once again that the P application can be saved in high P soils including the P loving crop like soybean.

Different high P soils having different native available phosphorus status also significantly affected the seed yield of soybean (Table. 2).

Table.1 Salient characteristics of soils employed in experiment

Soil properties	S-1	S-2	S-3
1.Physical Properties			
Mechanical composition			
a) Sand (%)	55	50	50
b) Silt (%)	25	25	24
c) Clay (%)	20	25	26
d) Textural class	Sandy clay loam	Sandy clay loam	Sandy clay loam
2. Physico- Chemical Properties			
a) pH	7.82	7.74	7.68
b) EC (dS m^{-1})	0.84	0.96	0.74
3. Chemical Properties			
a) Soil organic carbon (%)	0.54	0.58	0.51
b) Free Calcium Carbonate (%)	1.22	1.86	1.94
c) Available nitrogen (kg ha^{-1})	182	188	188
d) Available phosphorus (kg P_2O_5 ha^{-1})	69	82	107
e) Available potassium (kg K_2O ha^{-1})	575	506	486
f) Available sulphur (mg kg^{-1})	18.2	17.6	17.3
g) Available copper (mg kg^{-1})	0.79	0.72	0.76
h) Available manganese (mg kg^{-1})	3.88	3.91	4.15
i) Available iron (mg kg^{-1})	5.86	5.92	6.28
j) Available zinc (mg kg^{-1})	0.78	0.75	0.72

Table.2 Effect of different levels of N and P on seed yield (g pot-1) of soybean crop in high phosphorus soils

3 Factor Table										
N Levels	**S1 (69 kg P_2O_5 ha^{-1})**			**S2 (82 kg P_2O_5 ha^{-1})**			**S3 (107 kg P_2O_5 ha^{-1})**			**Grand Mean**
	P1 (70%RDP)	**P2 (100%RDP)**	**Mean**	**P1 (70%RDP)**	**P2 (100%RDP)**	**Mean**	**P1 (70%RDP)**	**P2 (100%RDP)**	**Mean**	
N1(60 kg N ha^{-1})	11.99	12.26	12.12	12.88	13.21	13.04	13.57	13.86	13.71	12.96
N2 (80 kg N ha^{-1})	13.14	13.43	13.28	14.51	14.78	14.65	15.72	16.00	15.86	14.60
N3 (100 kg N ha^{-1})	13.33	13.71	13.52	14.78	15.09	14.93	16.12	16.39	16.25	14.90
N4 (120 kg N ha^{-1})	13.75	14.03	13.89	15.11	15.42	15.27	16.22	16.58	16.40	15.18
Mean	13.05	13.35	13.20	14.32	14.62	14.47	15.40	15.71	15.56	14.41

2 Factor Tables												
Treatment	**P1**	**P2**	**Mean**	**Treatment**	**S1**	**S2**	**S3**	**Mean**	**Treatment**	**P1**	**P2**	**Mean**
N1	12.81	13.11	12.96	**N1**	12.12	13.04	13.71	12.96	**S1**	13.05	13.35	13.20
N2	14.46	14.74	14.60	**N2**	13.28	14.65	15.86	14.60	**S2**	14.32	14.62	14.47
N3	14.74	15.06	14.90	**N3**	13.52	14.93	16.25	14.90	**S3**	15.40	15.71	15.56
N4	15.03	15.34	15.18	**N4**	13.89	15.27	16.40	15.18	**Mean**	14.25	14.56	14.41
Mean	14.26	14.56	14.41	**Mean**	13.20	14.47	15.56	14.41		**S**	**P**	**S X P**
	N	**P**	**N X P**			**N**	**S**	**N X S**	**SEd±**	0.23	-	0.32
SEd(±)	0.26	-	0.37	**SEd(±)**		0.26	0.23	0.45	**CD (P=0.05)**	0.47	NS	0.67
CD (P=0.05)	0.66	NS	0.77	**CD (P=0.05)**		0.66	0.47	0.94	**N X S X P:SEd±:**0.64		**CD (p=0.05):**1.33	

Table.3 Effect of different levels of N and P on haulm yield (g pot-1) of soybean crop in high phosphorus soils

3 Factor Table										
N Levels	**S1 (69 kg P_2O_5 ha^{-1})**			**S2 (82 kg P_2O_5 ha^{-1})**			**S3 (107 kg P_2O_5 ha^{-1})**			**Grand Mean**
	P1 (70%RDP)	**P2 (100%RDP)**	**Mean**	**P1 (70%RDP)**	**P2 (100%RDP)**	**Mean**	**P1 (70%RDP)**	**P2 (100%RDP)**	**Mean**	
N1(60 kg N ha^{-1})	16.80	17.50	17.15	18.06	18.65	18.35	19.40	20.11	19.75	18.42
N2 (80 kg N ha^{-1})	19.26	20.15	19.70	20.60	21.32	20.96	22.15	22.70	22.42	21.03
N3 (100 kg N ha^{-1})	20.23	20.90	20.56	21.47	22.25	21.86	22.85	23.72	23.29	21.90
N4 (120 kg N ha^{-1})	20.59	21.24	20.92	21.89	22.59	22.24	23.29	24.59	23.94	22.37
Mean	19.22	19.94	19.58	20.50	21.20	20.85	21.92	22.78	22.35	20.93

2 Factor Tables												
Treatment	**P1**	**P2**	**Mean**	**Treatment**	**S1**	**S2**	**S3**	**Mean**	**Treatment**	**P1**	**P2**	**Mean**
N1	18.08	18.75	18.42	**N1**	17.15	18.35	19.75	18.42	**S1**	19.22	19.94	19.58
N2	20.67	21.39	21.03	**N2**	19.70	20.96	22.42	21.03	**S2**	20.50	21.20	20.85
N3	21.51	22.29	21.90	**N3**	20.56	21.86	23.29	21.90	**S3**	21.92	22.78	22.35
N4	21.92	22.81	22.37	**N4**	20.92	22.24	23.94	22.37	**Mean**	20.54	21.30	20.93
Mean	20.55	21.31	20.93	**Mean**	19.58	20.85	22.35	20.93		**S**	**P**	**S X P**
	N	**P**	**N X P**			**N**	**S**	**N X S**	**SEd±**	0.54	-	0.76
SEd(±)	0.62	-	0.88	**SEd(±)**		0.62	0.54	1.08	**CD (P=0.05)**	1.11	NS	1.57
CD (P=0.05)	1.55	NS	1.82	**CD (P=0.05)**		1.55	1.11	2.23	**N X SX P: SEd±:**1.52		**CD (p=0.05):**3.15	

Highest seed yield (15.56 g pot^{-1}) of soybean was observed in soil with native available P_2O_5 of 107 kg P_2O_5 ha^{-1} which is significantly higher by 7.53% (14.47g pot^{-1}) and 17.87% (13.20 g pot^{-1}) over seed yield recorded in soil with native available P_2O_5 of 82 and 69 kg P_2O_5 ha^{-1}, respectively. As the native P fertility of soil was high there is possibility of more availability of P in soil solution which demands more nitrogen also for balanced nutrition might be the reason for higher yields in very high P soil.

Haulm yield of soybean also significantly influenced by application of different doses of N in high P soils (Table. 3). Application of N@ 80 kg N ha^{-1} increased the soybean haulm yield significantly by 14.16% over 60 kg N ha^{-1}. Further increase in dose of N from 80 to 120 kg N ha^{-1} to soybean crop did not influence the haulm yield of soybean crop significantly in these high P soils. Increase in haulm yield in response to N application was also reported by Begum *et al.,* (2015) and Yadravi and Angadi (2015). Application of different doses of phosphorus fertilizer to high P soils does not influenced significantly the haulm yield of soybean crop. It is noticed that the application of 70 % RDP recorded on par haulm yield (20.55 g pot^{-1}) with that of 100% RDP (21.31g pot^{-1}) in this high P soils. The increment in haulm yield due to 100% RDP was 3.69 % with that of 70% RDP. These observations clearly indicate that it is possible to reduce current RDP by 30% in high P soils. Improvement in haulm yields depending upon initial available phosphorus status was reported by Kakad *et al.,* (2008) and Dhage *et al.,* (2014). The combination of N 100 kg N ha^{-1} in conjunction with 70 or 100% RDP to soybean crop results in highest haulm yield in high P soils. Increase in haulm yields with increase in doses of N and P was also reported by Patel and Chandravanshi (1996), Begum *et al.,* (2015) and Raghuveer *et al.,* (2017).

High P soils having different native available phosphorus status also significantly affected the haulm yield of soybean (Table.3). Highest haulm yield (22.35 g pot^{-1}) of soybean was observed in soil with native available P_2O_5 of 107 kg P_2O_5 ha^{-1} which is significantly higher by 6.71% (20.85g pot^{-1}) and 12.39% (19.58 g pot^{-1}) over soils with native available P_2O_5 of 82 and 69 kg P_2O_5 ha^{-1}, respectively. In general the combination of high N doses like 100 or 120 kg N ha^{-1} in very high P soil (107kgP_2O_5ha^{-1}) recorded highest haulm yields when compared to other combinations.

The experiment revealed that significant increasing in the seed yield of soybean from 12.96 to 14.60 g pot^{-1} (12.7%) was found with increase in application of N from 60 to 80 kg N ha^{-1}. Application of P fertilizer to soybean crop in high P soils at the rate of 100% RDP (60 kg P_2O_5 ha^{-1}) or 70% RDP (42 kg P_2O_5 ha^{-1}) were found to be statistically on par (14.56 and 14.26 g pot^{-1}) with each other. The soil with native available P_2O_5 of 107 kg P_2O_5 ha^{-1} (S3) resulted in highest seed yield of 15.56 g pot^{-1} followed by soil with 82 (14.47 g pot^{-1}) and 69 kg P_2O_5 ha^{-1} (13.29 g pot^{-1}).Similar trend was observed increase of haulm yield of soybean. Thus, application of 80 kg N ha^{-1} with 70% RDP recorded highest yield and is the better combination to obtain maximum yields of soybean in high P soils.

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