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Effect of foliar application of phosphorus on yield, quality and economics of *Bt* cotton

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Abstract
A field experiment was conducted during *Kharif*, 2023 in Northern dry zone of Karnataka to study the "Effect of foliar application of phosphorus on yield, quality and economics of *Bt* cotton" at Main Agricultural Research Station, UAS, Raichur. The Experiment was laid out in randomized complete block design with 11 treatments replicated thrice. The results revealed that, application of 75 percent recommended dose of phosphorus + foliar application of PSAP @ 0.5% each at 50, 75 and 100 DAS have shown significantly higher seed cotton yield and uptake whereas higher net returns and BC ratio were recorded with application of 75 percent recommended dose of phosphorus + foliar application of MKP @ 0.5% each at 50, 75 and 100 DAS. Whereas, control without phosphorous application has recorded lower yield, gross returns, net returns and BC ratio.

Keywords: Cotton, foliar nutrition, potassium salt of active phosphorus, Monopotassium phosphate

Introduction
Cotton is one of the most versatile and widely used materials. It is one of the most popular material used in textiles in the clothing manufacturing industry, as well as a common material in paper products. At present most of the world's cultivated cotton is occupied by *Bt* cotton. Though, India has the largest cotton area, the productivity is just 446 kg ha^{-1} and lags significantly behind when compared with leading cotton-producing countries like Australia (2388 kg ha^{-1}), USA (2027 kg ha^{-1}), China (2015 kg ha^{-1}), Brazil (1840 kg ha^{-1}), Turkey (1583 kg ha^{-1}) and Mexico (1549 kg ha^{-1}) (Anon., 2022) [1]. In Karnataka, the cotton is grown over an area of 8.16 lakh hectares with production of 24.47 lakh tonnes and average productivity of 510 kg ha^{-1} (Anon., 2023) [2].

Phosphorus (P) plays a pivotal role in cotton by enhancing the reproductive growth and yield formation. Cotton cultivars vary greatly in response to P availability, especially under P deficient conditions. So, it is hypothesized that the increasing P level promotes the reproductive growth in cotton cultivars varying with P sensitivity.

Phosphorus helps regulate protein synthesis in plants which leads to healthy development, cell division and ultimate growth for the plant. Phosphorus helps in the formation of new plant tissues and when additional quantities are added to the soil, root growth is exponential, making the plant more resistant to changing weather conditions. Lack of phosphorus in crops can result in yield disaster, if not treated immediately. Stay ahead of the problem as always by applying the correct amount of Monopotassium Phosphate fertilizer as needed. Low phosphorus levels in the soil can be corrected with the help of Monopotassium Phosphate, a heavy metal free, water soluble solution that plants will respond positively to MKP. By knowing the availability of phosphorus in soil uptake by crops, its fixation in soil, the result approach of applying phosphorous is through foliar nutrition to reduce the fertilizer loss and to increase its efficiency.

Potassium Salt of Active Phosphorus (PSAP) is exceedingly water soluble molecule, combination and synergetic formulation of phosphorus with potash. PSAP composed of 90 percent active ingredient. PSAP alleviates abiotic and biotic stresses, boosts immunity, induces tolerance, reduces disease and pest incidences, supplementary to P & K fertilizer, gets absorb in foliage of many crops, is approved in organic farming input.

PSAP impact on yield and quality is tested. In year 2002-03 work on activation of phosphorus started. PSAP was discovered after 6 years of untiring, in depth rigorous research. PSAP was tried and tested on farmer's field in different crops. PSAP was found to be very effective in most of these crops. It is proved that split sprays of PSAP increases yield by 20 to 50 percent, improves produce quality and reduces pesticide use by 50 to 100 percent.

2. Material and Methods

The field experiment was conducted during *Kharif*, 2023 at Main Agricultural Research Station, UAS, Raichur on *vertisols* with pH of 8.31 and EC of 0.37 d Sm^{-1}. The soil was medium in organic carbon content (0.65%), low in available N (242.8 kg ha^{-1}) and high in available P_2O_5 (29.9 kg ha^{-1}), K_2O content (262.3 kg ha^{-1}). The experimental site was situated in North-Eastern Dry Zone (Zone 2) of Karnataka on latitude 16º 12' North, longitude of 77º 20' East and at an altitude of 407 m above the mean sea level. The higher monthly rainfall of 128.4 mm and 198.4 mm was received during the months of May and July, respectively and total rainfall of 608.0 mm rainfall was received during the year 2023. During the crop growing period (July to December), total of 345.2 mm rainfall was received. The average maximum temperature during the crop growth period was 34.0 °C in the months of July, August and September. Average monthly minimum temperature of 18 °C was noticed in the month of December. The highest relative humidity of 88.0 percent was recorded in the month of September followed by July and August (87 and 81%, respectively). The cotton hybrid used is (US7067) SWCH 4749 BG-II.

Experiment was laid out in randomized complete block design. There were 11 treatments (T_1: RDF, T_2: 75% RDP as soil application + foliar application of MKP @ 5 g l^{-1} each at 50 DAS and 75 DAS, T_3: 75% RDP as soil application + foliar application of MKP @ 5 g l^{-1} each at 50 DAS, 75 DAS and 100 DAS, T_4: 75% RDP as soil application + Foliar application of PSAP @ 5 g l^{-1} each at 50 DAS and 75 DAS, T_5: 75% RDP as soil application + foliar application of PSAP @ 5 g l^{-1} each at 50 DAS, 75 DAS and 100 DAS, T_6: 50% RDP as soil application + foliar application of MKP @ 5 g l^{-1} each at 50 DAS and 75 DAS, T_7: 50% RDP as soil application + foliar application of MKP @ 5 g l^{-1} each at 50 DAS, 75 DAS and 100 DAS, T_8: 50%RDP as soil application + foliar application of PSAP @ 5 g l^{-1} each at 50 DAS, 75 DAS, T_9: 50% RDP as soil application + foliar application of PSAP @ 5 g l^{-1} each at 50 DAS, 75 DAS and 100 DAS, T_{10}: 1% 19:19:19 + 1% $MgSO_4$ at 55-60 DAS (Flowering),75-80 DAS (Boll initiation) and 95-100 DAS (Boll development) (RPP –Recommended Package of Practices), T_{11}: Without P_2O_5 (control).

3. Results and Discussion

The data on yield, quality parameters and economics of *Bt* cotton at harvest as influenced by foliar spray of phosphorus are presented in Table 1, 2, 3 and depicted in Figure 1. At harvest, the seed cotton yield (kg ha^{-1}), Net returns, Gross returns and BC ratio has shown significant differences whereas the quality paramters like mean fibre length, bundle strength and fibre fineness did not show significant difference among different treatments.

3.1 Seed cotton yield and yield attributes

Among the different treatments significantly higher boll weight (6.33 g), numbers of good open bolls per plant (27), seed cotton yield (177.4 g $plant^{-1}$) and seed cotton yield (3284 kg ha^{-1}) was obtained with T_5 *i.e.* 75 percent recommended dose of phosphorus + foliar application of PSAP @ 0.5% at 50, 75 and 100 DAS followed by T_3 (3232 kg ha^{-1}) *i.e.* 75 percent recommended dose of phosphorus + foliar application of PSAP @ 0.5% at 50, 75 and 100 DAS followed by 75 percent recommended dose of phosphorus + foliar application of PSAP @ 5 g l^{-1} each at 50 and 75 DAS (T_4) (3129 kg ha^{-1}) and 75 percent recommended dose of phosphorus + foliar application of MKP @ 5 g l^{-1} each at 50 and 75 DAS (T_2) (2980 kg ha^{-1}) which are found *on par* with each other. The treatment T_{11} (1869 kg ha^{-1}) *i.e.* control (without RDP) recorded significantly lower seed cotton yield.

This was mainly attributed to supplementation of phosphorus through foliar spray at different growth stages. The results are in conformity with Jat *et al.* (2014) [3] who revealed that seed cotton yield was significantly higher with 100 percent RDF over 75 percent RDF. However, it was on par with 125 percent RDF and Shasthri *et al.* (2000) [7] also observed that seed cotton yield and seed yield were improved when cotton sprayed with 2 percent DAP at 75 and 90 DAS. The phosphorus foliar spray resulted in numerically larger boll weight, which may have been caused by increased nutrient availability during flowering since it improved the source-sink relationship inside the plant. The results were confirmed with Paramasivam (1991) [4] who demonstrated that the quantity of bolls per plant rose with the application of P through DAP spray together with the basal doses of N, P, and K. Significant increase in the total bolls per plant and seed cotton yield is observed with foliar application of phosphorous fertilizers. It is also recognized that supplementary foliar fertilization during crop growth improves the mineral status of the plant and improve the yield parameters of plant.

3.2 Quality attributes

The different phosphorus doses and foliar application of phosphorus had no significant influence on staple length, bundle strength and fibre fineness. However, 75 percent recommended dose of phosphorus + foliar application of PSAP @ 0.5% each at 50, 75 and 100 DAS (T_5) has recorded higher staple length (29.27 mm), bundle strength (28.49 g tex^{-1}), Fibre fineness (3.87) among different treatments.

3.3 Economics

Among the different treatments gross returns were significantly higher with 75 percent recommended dose of phosphorus + foliar application of PSAP @ 0.5% each at 50, 75 and 100 DAS (T_5) application (Rs.2,42,987 ha^{-1}) and it was followed by application of 75 percent recommended dose of phosphorus + foliar application of MKP @ 0.5% each at 50, 75 and 100 DAS (T_3) (Rs.2,39,174 ha^{-1}), 75 percent recommended dose of phosphorus + foliar application of PSAP @ 5 g l^{-1} each at 50 and 75 DAS (T_4) (Rs.2,31,539 ha^{-1}) and 75 percent recommended dose of phosphorus + foliar application of MKP @ 5 g l^{-1} each at 50 and 75 DAS (T_2) (Rs. 2,20,483 ha^{-1}) which are found *on par* with each other. Net returns were significantly higher with 75 percent recommended dose of phosphorus + foliar application of MKP @ 0.5% each at 50, 75 and 100 DAS (T_3) application (Rs. 1,63,632 ha^{-1}) and it was followed by application of 75 percent recommended dose of phosphorus + foliar application of PSAP @ 0.5% each at 50, 75 and 100 DAS (T_5) (Rs. 1,58,595 ha^{-1}), 75 percent recommended dose of phosphorus + foliar application of PSAP @ 5 g l^{-1} each at 50 and 75 DAS (T_4) (Rs. 1,50,997 ha^{-1}) and 75 percent recommended dose of phosphorus + foliar application of MKP @ 5 g l^{-1} each at 50 and 75 DAS (T_2) (Rs. 1,45,851 ha^{-1}) which are found *on par* with each other. BC ratio

were significantly higher with 75 percent recommended dose of phosphorus + foliar application of MKP @ 0.5% each at 50, 75 and 100 DAS (T_3) application (3.17) and it was followed by application of 75 percent recommended dose of phosphorus + foliar application of MKP @ 0.5% each at 50 and 75 DAS (T_2) (2.95), T_5 (2.88) and T_4 (2.87) which are found *on par* with each other. Even though the gross returns are high for T_5, net returns are low compared to T_3 as cost of cultivation is comparatively high for T_5 than T_3. Raju *et al.* (2008) [6] reported that foliar application of DAP recorded higher B:C over soil application alone.

Table 1: Effect of application of phosphorus through foliar nutrition on number of good open bolls plant^{-1}, Boll weight (g) seed cotton yield (g plant^{-1}) and seed cotton yield (kg ha^{-1}) of *Bt* cotton

Treatments	Number of good opened bolls plant^{-1}	Boll weight (g)	Seed cotton yield (g plant^{-1})	Seed cotton yield (kg ha^{-1})
T_1 : RDF	20.4	5.83	144.4	2674
T_2: 75% RDP as soil application + Foliar application of MKP @ 5 g l^{-1} each at 50 DAS and 75 DAS	23.7	6.12	160.8	2980
T_3: 75% RDP as soil application + Foliar application of MKP @ 5 g l^{-1} each at 50 DAS, 75 DAS and 100 DAS	26.0	6.29	174.6	3232
T_4: 75% RDP as soil application + Foliar application of PSAP @ 5 g l^{-1} each at 50 DAS and 75 DAS	24.7	6.18	167.0	3129
T_5: 75% RDP as soil application + Foliar application of PSAP @ 5 g l^{-1} each at 50 DAS, 75 DAS and 100 DAS	27.0	6.33	177.4	3284
T_6: 50% RDP as soil application + Foliar application of MKP @ 5 g l^{-1} each at 50 DAS and 75 DAS	18.7	5.69	138.1	2561
T_7: 50% RDP as soil application + Foliar application of MKP @ 5 g l^{-1} each at 50 DAS, 75 DAS and 100 DAS	21.2	5.88	144.5	2685
T_8: 50%RDP as soil application + Foliar application of PSAP @ 5 g l^{-1} each at 50 DAS and 75 DAS	19.7	5.75	137.7	2571
T_9: 50% RDP as soil application + Foliar application of PSAP @ 5 g l^{-1} each at 50 DAS, 75 DAS and 100 DAS	22.3	5.93	151.6	2804
T_{10}: 1% 19:19:19 + 1% $MgSO_4$ at 55-60 DAS (Flowering),75-80 DAS (Boll initiation) and 95-100 DAS (Boll development) (RPP – Recommended Package of Practices)	22.8	6.03	154.9	2860
T_{11}: Without P_2O_5 (Control)	17.3	5.37	99.8	1869
S. Em.±	0.3	0.10	13.8	207
C.D. at 5%	1.0	0.29	40.5	608

Note: MKP: Monopotassium phosphate
PSAP: Potassium Salt of Active Phosphorus
RDP: Recommended Dose of Phosphorus

Table 2: Effect of application of phosphorus through foliar nutrition on staple length (mm), fibre strength (g tex^{-1}) and micronaire value of *Bt* cotton

Treatments	Staple length (mm)	Fibre strength (g tex^{-1})	Micronaire value (fibre fineness)
T_1 : RDF	28.36	27.16	3.63
T_2:75% RDP as soil application+ Foliar application of MKP @ 5 g l^{-1} each at 50 DAS and 75 DAS	28.47	27.30	3.75
T_3: 75% RDP as soil application + Foliar application of MKP @ 5 g l^{-1} each at 50 DAS, 75 DAS and 100 DAS	29.10	28.42	3.78
T_4: 75% RDP as soil application + Foliar application of PSAP @ 5 g l^{-1} each at 50 DAS and 75 DAS	29.00	28.30	3.72
T_5: 75% RDP as soil application + Foliar application of PSAP @ 5 g l^{-1} each at 50 DAS, 75 DAS and 100 DAS	29.27	28.49	3.87
T_6: 50% RDP as soil application + Foliar application of MKP @ 5 g l^{-1} each at 50 DAS and 75 DAS	28.43	27.25	3.59
T_7: 50% RDP as soil application + Foliar application of MKP @ 5 g l^{-1} each at 50 DAS, 75 DAS and 100 DAS	28.50	27.70	3.66
T_8: 50%RDP as soil application + Foliar application of PSAP @ 5 g l^{-1} each at 50 DAS and 75 DAS	28.46	27.90	3.62
T_9: 50% RDP as soil application + Foliar application of PSAP @ 5 g l^{-1} each at 50 DAS, 75 DAS and 100 DAS	28.49	27.97	3.74
T_{10}: 1% 19:19:19 + 1% $MgSO_4$ at 55-60 DAS (Flowering),75-80 DAS (Boll initiation) and 95-100 DAS (Boll development) (RPP -Recommended Package of Practices)	28.57	28.05	3.81
T_{11}: Without P_2O_5 (Control)	28.14	27.06	3.56
S. Em.±	1.06	1.04	0.11
C.D. at 5%	NS	NS	NS

Note: MKP: Monopotassium phosphate
PSAP: Potassium Salt of Active Phosphorus
RDP: Recommended Dose of Phosphorus

Table 3: Effect of application of phosphorus through foliar nutrition on cost of cultivation, gross returns, net returns and benefit cost ratio of *Bt* cotton

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	BC ratio
T_1 : RDF	74165	197847	123683	2.67
T_2:75% RDP as soil application+ Foliar application of MKP @ 5 g l^{-1} each at 50 DAS and 75 DAS	74642	220483	145841	2.95
T_3:75% RDP as soil application + Foliar application of MKP @ 5 g l^{-1} each at 50 DAS, 75 DAS and 100 DAS	75542	239174	163632	3.17
T_4:75% RDP as soil application + Foliar application of PSAP @ 5 g l^{-1} each at 50 DAS and 75 DAS	80542	231539	150997	2.87
T_5:75% RDP as soil application + Foliar application of PSAP @ 5 g l^{-1} each at 50 DAS, 75 DAS and 100 DAS	84392	242987	158595	2.88
T_6:50% RDP as soil application + Foliar application of MKP @ 5 g l^{-1} each at 50 DAS and 75 DAS	73319	189489	116170	2.58
T_7:50% RDP as soil application + Foliar application of MKP @ 5 g l^{-1} each at 50 DAS, 75 DAS and 100 DAS	74219	198692	124473	2.68
T_8:50%RDP as soil application + Foliar application of PSAP @ 5 g l^{-1} each at 50 DAS and 75 DAS	79219	190219	111000	2.40
T_9:50% RDP as soil application + Foliar application of PSAP @ 5 g l^{-1} each at 50 DAS, 75 DAS and 100 DAS	83069	207527	124458	2.50
T_{10}:1% 19:19:19 + 1% $MgSO_4$ at 55-60 DAS (Flowering),75-80 DAS (Boll initiation) and 95-100 DAS (Boll development)(RPP-Recommended Package of Practices)	77465	211634	134170	2.73
T_{11}: Without P_2O_5 (Control)	68873	138276	69403	2.01
S. Em.±	-	15332	15332	0.20
C.D. at 5%	-	44971	44971	0.57

Note: MKP: Monopotassium phosphate
PSAP: Potassium Salt of Active Phosphorus
RDP: Recommended Dose of Phosphorus

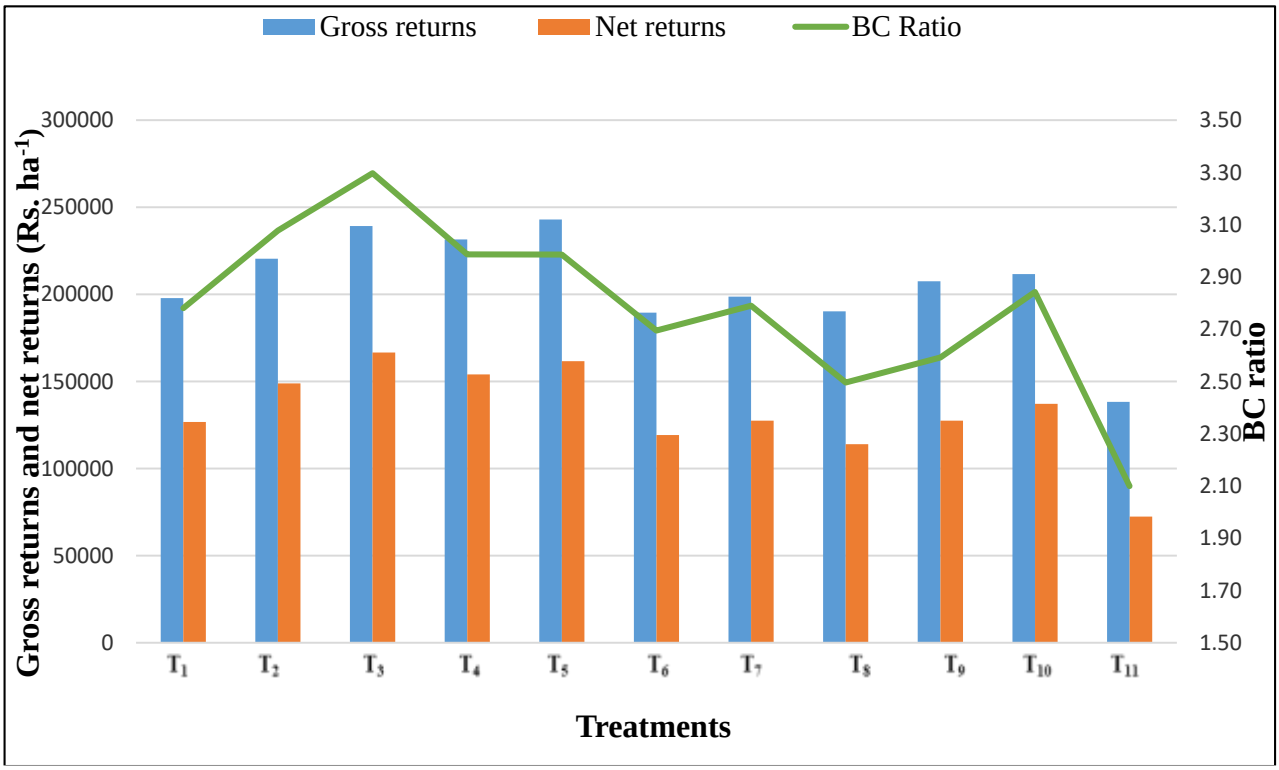

Fig 1: Gross returns, net returns and BC ratio of *Bt* cotton as influenced by application of phosphorus through foliar nutrition.

4. Conclusion

Based on the results of present study, it is concluded that there was a significant response of 75 percent RDP as soil application + foliar application of PSAP @ 5 g l^{-1} each at 50 DAS and 75 DAS at three stages recorded higher yield attributes and quality attributes. Whereas, higher economics was recorded by 75 percent RDP as soil application + foliar application of MKP @ 5 g l^{-1} each at 50 DAS, 75 DAS and 100 DAS by the plants when compared to other treatments.

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