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Response of *Bt* cotton to different levels of Nitrogen, Phosphorus and Potash under Rainfed conditions

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Abstract : A field experiment was conducted at Junagadh Agricultural University, Dry Farming Research Station, Kukada (Gujarat) during *kharif* seasons of 2013-2014 to 2020-2021 to ascertain the nutrient management in *Bt* cotton under rainfed conditions. The experiment comprising of three levels of nitrogen *viz.,* 60, 80 and100 N/ha, two level of phosphorus *viz.,* 0 and 30 P_2O_5/ha and two level of potash *viz.*, 0 and 60 kg K_2O/ha and was laid out in Factorial Randomized Block Design and replicated thrice. On the basis of pooled results, maximum values of all the attributes like plant height, (FRBD) monopodia, sympodia and bolls/plant of cotton crop were recorded with treatment combination of 100 kg N/ha, 30 kg P_2O_5/ha and 60 kg K_2O/ha. The application of nitrogen 100 kg N/ha, phosphorus 30 kg P_2O_5/ha and potassium 60 kg K_2O/h significantly increased the seed cotton yield, stalk yield and net return. The pH, EC and organic carbon content of soil were remain unaffected due to different treatments combination. Significantly higher values of available status of nitrogen and phosphorus in soil were recorded with treatment combination of 100 kg N/ha, 30 kg P_2O_5/ha and 60 kg K_2O/ha and significantly the highest available potash was found with application of 60 kg K_2O/ha, but, application of nitrogen and phosphorus were not affected significantly on availability of potash.

Keywords: *Bt* cotton, nitrogen, phosphorus, potash

Cotton (*Gossypium hirsutum* L.), the "White Gold", is one of the most important commercial and industrial crop. Cotton 'The king of apparel fibers' is an important cash crop and it supplies a major share of raw material for the textile industry and playing a key role in the economic and social affairs of the world. It is grown chiefly for its fiber which is used in the manufacture of cloths, making of threads and extraction of oil from cotton seed (Vora *et al.,* 2019). In India, cotton is grow in 13.01 million hectare with production 35.38 million bales and 462 kg/ha productivity and in Gujarat, cotton is grown in 2.27 million hectare area with production of 7.27 million bales and 544 kg/ha productivity (DES, 2021).

The cultivation of cotton is increasing day by day in north Saurashtra agro-climatic zone due to change in rainfall pattern, sustained price at higher level, demand for export and introduction of pest resistant variety. Nitrogen, phosphorus and potassium are primary elements to increase of agricultural crop production. Among these, nitrogen is one of the decisive as well as expensive inputs, which has quickest and most pronounced effect on plant growth. As a constituent of protoplasm, it is intimately involved in the process of photosynthesis and ultimately, in the dry matter production. Phosphorus (P) is vital to plant growth and is found in every living plant cell. It is involved in several key plant functions, including energy transfer, photosynthesis, transformation of sugars and starches, nutrient movement within the plant and transfer of genetic characteristics from one generation to the next. Potassium is associated with the movement of water, nutrients and carbohydrates in plant tissue. It's involved with enzyme activation within the plant, which affects protein, starch and adenosine triphosphate (ATP) production. The production of ATP can regulate the rate of

photosynthesis. At present acute problems of reddening of cotton are observed due to lack of proper nutrient management practice (Das *et al.*, 2004). Keeping in view, the experiment was planned to study the nutrient management in *Bt* cotton under rain fed condition, at Dry Farming Research Station, Junagadh Agricultural University, Kukada, Gujarat.

MATERIALS AND METHODS

A field experiment entitled "nutrient management in *Bt.* cotton under rainfed condition'' was carried out at Dry Farming Research Station, Junagadh Agricultural University, Kukada (Gujarat) during *kharif* seasons of 2013-2014 to 2020-2021.

The experiment comprising twelve treatments combination with three levels of nitrogen *viz.*, 60, 80 and 100 kg N/ha, two levels of phosphorus 0 and 30 kg P_2O_5/ha and two levels of potash 0 and 60 kg K_2O/ha were evaluated in factorial randomized block design with three replications.

The soil of the experimental field was medium blackand alkaline in reaction (pH of 8.0 and EC of 2.10dS/m). The soil was medium in organic carbon (0.65 %), low in available nitrogen (195 kg/ha), low in available phosphorus (20.56 kg/ha) and medium in available potassium (250 kg/ha).

The nutrients of N, P and K were applied by using sources of Urea, DAP and MOP, respectively. The cotton variety " G. cot. Hy.-8 BGII" planted in month of June with 90 × 30 cm spacing, plot size 4.8 x 2.7 m and seed rate of 2.5 kg/ha. The crop was raised with all the standard package of practices and protection measures also timely carried out as required. The observation of each parameter was taken at harvest of crop. The experimental results recorded for growth parameters, yield attributes and yield parameters were statistically analyzed for level of significance. Economics was calculated based on mean of seven years data and cost of inputs like urea Rs. 5.92/kg, DAP Rs. 24/kg and MOP Rs. 19/kg and produced rate like seed cotton and stalk rate was Rs. 55/kg and Rs. 0.5/kg, respectively.

RESULTS AND DISCUSSION

Effect on growth and yield attributes:

(A) Effect of nitrogen

The data depicted in Table 1. revealed that the effect of different levels nitrogen on plant height, monopodia, sympodia and bolls/plant of cotton were found significant and ginning per cent was remain non significant. Significantly higher plant height (91.09 cm), monopodia (2.76), sympodia (14.26) and bolls (25.45) were recorded with application of 100 kg N/ha (N_{100}), which was *at par* with application of 80 kg N/ha (N_{80}).

(B) Effect of phosphorus

The data (Table 1.) pertaining to the effect of different levels of phosphorus on plant height, monopodia, sympodia and bolls/plant of cotton were found significant and ginning per cent was found non significant. Significantly higher plant height (91.10 cm), monopodia (2.69), sympodia (13.74) and bolls (24.69) were recorded with application of 30 kg P_2O_5/ha (P_{30}), which was *at par* with control (P_0) in case of monopodia and sympodia.

(C) Effect of potash

The results (Table 1.) showed that plant height, monopodia, bolls and ginning per cent of cotton were not affected significantly due to application of different levels of potash. In case of sympodia, significantly the highest sympodia (13.44) of cotton was recorded with application of 60 kg K_2O/ha.

(D) Interaction effect

Interaction effect of PxK on plant height (Table 1.1) and NxPx K on ginning per cent (Table

Table 1. Effect of nutrient management on growth, yield attributes, yield and quality parameters of *Bt* cotton (Over 7 year pooled)

Treatments	Seed cotton yield (kg/ha)	Stalk yield (kg/ha)	Plant height (cm)	Monopodia/ plant	Sympodia/ plant	Bolls/ plant	Ginning (%)
(A) Levels of Nitrogen (kg N/ha)							
N60	1884	3001	88.22	2.37	12.20	22.30	34.88
N80	1996	3127	90.26	2.55	13.31	23.80	35.48
N100	2081	3192	91.09	2.76	14.26	25.45	35.27
S.Em.±	25	53	0.54	0.08	0.57	0.80	0.32
C.D. (p: 0.05)	70	148	1.51	0.25	1.77	2.48	NS
(B) Levels of Phosphorus (kg P_2O_5/ha)							
P0	1923	3036	88.62	2.43	12.78	23.01	33.45
P30	2051	3177	91.10	2.69	13.74	24.69	33.46
S.Em.±	20	43	0.44	0.08	0.29	0.37	0.16
C.D. (p: 0.05)	57	121	1.24	0.27	0.99	1.29	NS
(C) Levels of Potash (kg K_2O/ha)							
K0	1936	3020	89.62	2.54	13.08	23.08	33.39
K60	2039	3193	90.09	2.58	13.44	24.62	33.52
S.Em.±	33	43	0.44	0.03	0.12	0.62	0.16
C.D. (p: 0.05)	115	121	NS	NS	0.32	NS	NS
C.V. (%)	11.50	15.63	5.53	15.26	9.80	9.51	4.98
(D) Interactions							
Interaction NxP							
S.Em.±	35	75	0.77	0.06	0.36	0.35	0.27
C.D. (p: 0.05)	NS	NS	NS	NS	NS	NS	NS
Interaction NxK							
S.Em.±	56	75	0.77	0.06	0.33	0.64	0.27
C.D. (p: 0.05)	NS	NS	NS	NS	NS	NS	NS
Interaction PxK							
S.Em.±	29	61	0.63	0.05	0.16	0.29	0.22
C.D. (p: 0.05)	NS	NS	1.75	NS	NS	NS	NS
Interaction NxPxK							
S.Em.±	50	106	1.08	0.09	0.28	0.49	0.38
C.D. (p: 0.05)	NS	NS	NS	NS	NS	NS	1.07

1.2) were found significant. In case of interaction effect of PxK on plant height, significantly the highest plant height (92.21 cm) was recorded under treatment combination of30 kg P_2O_5 and 60 kg K_2O/ha ($P_{30}K_{60}$). For interaction effect of NxPxK on ginning per cent, significantly higher ginning per cent (36.33) was recorded under treatment combination of 80 kg N, 30 kg P_2O_5 and0 kg K_2O/ha ($N_{80}P_{30}K_0$), but it was remained *at par* with treatment combination of $N_{80}P_0K_{60}$, $N_{80}P_{30}K_{60}$, $N_{100}P_0K_{60}$ and $N_{100}P_{30}K_{60}$.

This might be due to application of NPK fertilizers at higher dose which required for the plant. Similar results were also observed by Sakarvadia *et al.*, (2009), Vora *et al.*, (2015) and Vora *et al.*, (2019).

Table 1.1: Interaction effect of P and K on plant height of *Bt* Cotton

Treatments	Pooled	
	K_0	K60
P_0	89.26	87.98
P_{30}	89.98	92.21
S.Em.±	0.63	
C.D. (p: 0.05)	1.75	

1. YIELD

(A) Effect of nitrogen

The data depicted in Table 1. revealed

Table 1.2: Interaction effect of N, P and K on ginning per cent of *Bt* cotton

Treatments	Pooled			
	P0K0	P0K60	P30K0	P30K60
N60	34.51	35.06	34.80	35.17
N80	34.66	35.67	36.33	35.28
N100	35.40	35.39	34.44	35.83
S.Em.±		0.38		
C.D. (p: 0.05)		1.07		

Table 2. Effect of nutrient management on post harvest soil fertility of *Bt* cotton

Treatment	pH (1:2.5)	EC (dS/m) (1:2.5)	OC (%)	Avail. (kg/ha)	NAvail. P_2O_5 (kg/ha)	Avail. K_2O (kg/ha)
Initial	8.0	2.10	0.65	195	20.56	250
(A) Levels of Nitrogen (kg N/ha)						
N60	7.91	2.26	0.50	213	24.32	327
N80	8.05	2.35	0.53	239	25.78	323
N100	8.07	2.38	0.55	262	26.63	326
S.Em.±	0.06	0.20	0.02	2.72	0.52	14.25
C.D. (p: 0.05)	NS	NS	NS	7.98	1.52	NS
(B) Levels of Phosphorus (kg P_2O_5/ha)						
P0	7.96	2.32	0.53	232	19.86	324
P30	8.07	2.34	0.53	244	31.29	327
S.Em.±	0.05	0.17	0.02	2.22	0.42	11.64
C.D. (p: 0.05)	NS	NS	NS	6.51	1.24	NS
(C) Levels of Potash (kg K_2O/ha)						
K0	8.02	2.28	0.53	234	24.51	269
K60	8.01	2.38	0.52	242	26.65	382
S.Em.±	0.05	0.17	0.02	2.22	0.42	11.64
C.D. (p: 0.05)	NS	NS	NS	6.51	1.24	34.14
CV%	2.75	3.31	14.41	3.96	7.00	15.18
(D) Interactions						
Interaction NxP						
S.Em.±	0.09	0.29	0.03	3.85	0.73	20.16
C.D. (p: 0.05)	NS	NS	NS	NS	NS	NS
Interaction NxK						
S.Em.±	0.09	0.29	0.03	3.85	0.73	20.16
C.D. (p: 0.05)	NS	NS	NS	NS	NS	NS
Interaction PxK						
S.Em.±	0.07	0.24	0.03	3.14	0.60	16.46
C.D. (p: 0.05)	NS	NS	NS	NS	NS	NS
Interaction NxPxK						
S.Em.±	0.13	0.41	0.04	5.44	1.03	28.51
C.D. (p: 0.05)	NS	NS	NS	NS	NS	NS

that the effect of different levels nitrogen on seed cotton yield and stalk yield were found significant in pooled result. Application of 100 kg N/ha (N_{100}) recorded significantly the highest seed cotton yield (2081 kg/ha) in pooled result, While significantly higher stalk yield (3192 kg/ha) was recorded with application of 100 kg N/ha, but remained *at par* with application of 80 kg N/ha (N_{80}).

(B) Effect of phosphorus

The data (Table 1.) pertaining to the effect of different levels of phosphorus on seed cotton yield and stalk yield were found significant. Significantly the highest seed cotton yield (2051 kg/ha) and stalk yield (3177 kg/ha) of cotton were registered under application of 30 kg P_2O_5/ha (P_{30}).

(C) Effect of potash

The results (Table 1.) showed that seed cotton yield and stalk yield of cotton were affected significantly due to application of different levels of potash. In case of seed cotton yield, significantly higher seed cotton yield (2039 kg/ha) of cotton was recorded with application of 60 kg K_2O/ha, but remained *at par* with application of 0 kg K_2O/ha (K_0). While, significantly the highest stalk yield (3193 kg/ha) was recorded with application of 60 kg $K2_O$/ha Interaction effect of NxP, NxK, PxK and NxPxK was found non significant in respect of seed cotton yield and stalk yield of cotton.

Nitrogen, Phosphorus and Potassium is a major plant nutrients because of the large amount in which it is absorbed by plants and its significant place for the production of high yield. These nutrients play an essential role in plant growth and metabolism. This might be due to application of NPK fertilizers at higher dose which required for the plant. Similar results were also observed by Rajan *et al.,* (2005), Sakarvadia *et al.*, (2009), Vora *et al.*, (2015), (2019).

2. POST HARVEST SOIL FERTILITY

(A) Effect of nitrogen

The data depicted in Table 2. revealed that the effect of nitrogen levels on post-harvest soil fertility like pH, EC, organic carbon and available potash were found non-significant and available nitrogen and available phosphorus were significantly affected due to different levels of nitrogen. Significantly the highest available nitrogen (262 kg/ha) was recorded under application of 100 kg N/ha (N_{100}). Whereas available phosphorus (26.63 kg/ha) was recorded significantly higher under application of 100 kg N/ha (N_{100}), but it was remained *at par* with application of 80 kg N/ha (N_{80}).

(B) Effect of phosphorus

The effect of different phosphorus levels on post-harvest soil fertility of cotton like pH, EC, organic carbon and available potash were found non-significant and available nitrogen and phosphorus were significantly affected due to different levels of phosphorus (Table 2.). Significantly the highest available nitrogen (244 kg/ha) and phosphorus (31.29 kg/ha) were recorded under application of 30 kg P_2O_5/ha (P_{30}).

(c) Effect of potash

The effect of different levels of potash on

Table 3. Economics of *Bt* cotton as influenced by different nutrient management practices

Treatments	Yield (kg/ha)		Gross realization (Rs./ha)	Total cost of cultivation (Rs./ha)	Net realization (Rs./ha)
	Seed cotton	Stalk			
Levels of nitrogen (kg N/ha)					
N_{60}	1884	3001	105121	50204	54917
N_{80}	1996	3127	111344	51042	60302
N_{100}	2081	3192	116051	51723	64328
Levels of phosphorus (kg P_2O_5/ha)					
P_0	1923	3036	107283	49895	57388
P_{30}	2051	3177	114394	52084	62310
Levels of potash (kg K_2O/ha)					
K_0	1936	3020	107990	49692	58298
K_{60}	2039	3193	113742	52290	61452

post harvest soil fertility of cotton like pH, EC and organic carbon were found non significant and available nitrogen, phosphorus and potash were significantly affected due to different levels of potash (Table 2). Significantly the highest available nitrogen (242 kg/ha), phosphorus (26.65 kg/ha) and potash (382 kg/ha) were recorded under application of 60 kg K_2O/ha (K_{60}). The interaction effect of NxP, NxK, PxK and NxPxK on post harvest soil fertility of cotton was found non significant.

Similar results were also observed by Rajan *et al.,* (2005), Sakarvadia *et al.*, (2009), Sujatha and Vijayalakshmi (2013), Vora *et al.*, (2015) and Vora *et al.*, (2019).

(D) Economics

The economics of different treatments was worked out on the basis of pooled results and presented in Table 3. The data indicated that the maximum net realization of Rs. 64328/ha was recorded under application of 100 kg N/ha (N_{100}).While in application of phosphorus and potash, maximum net realization of Rs. 62310 and 61452/ha were recorded with application of 30 kg P_2O_5 (P_{30}) and 60 kg K_2O/ha (K_{60}), respectively.

CONCLUSION

The farmers of north Saurashtra agro climatic zone (AES-VI) growing *Bt* cotton are recommended to apply 100-30-60 N-P_2O_5-K_2O kg/ha for obtaining higher yield and net return as well as sustaining soil fertility under rainfed conditions. The phosphorus and potash should be applied as basal, while nitrogen should be applied in three splits *i.e.* 25 per cent as basal at the time of sowing, 50 and 25 per cent as top dressing at 35-40 and 60-65 days after sowing, respectively by drilling in 10 cm soil depth.

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