Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(6): 430-433
Received: 13-09-2019
Accepted: 15-10-2019

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Effect of nutrient management on yield of Bt cotton under rainfed condition in North Saurashtra agro climatic zone

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Abstract
The field experiment carried out to study the effect of nutrient management on seed cotton yield of Bt. Cotton and economics under rainfed condition at Dry Farming Research Station, Junagadh Agricultural University, Jamkhambhalia, Gujarat during *Kharif* 2011-12 to 2015-16. The experiment was laid out in randomized block design with 9 different treatments comprising of T_1 - 80 kg N/ha, T_2 - 80 kg N/ha + 20 kg P_2O_5/ha + 40 kg K_2O/ha + 20 kg S/ha, T_3 - 80 kg N/ha + 20 kg P_2O_5/ha + 40 kg K_2O/ha + 40 kg S/ha, T_4 - 80 kg N/ha + 20 kg P_2O_5/ha + 80 kg K_2O/ha + 20 kg S/ha, T_5- 80 kg N/ha + 20 kg P_2O_5/ha + 80 kg K_2O/ha + 40 kg S/ha, T_6 - 80 kg N/ha + 40 kg P_2O_5/ha + 40 kg K_2O/ha + 20 kg S/ha, T_7 - 80 kg N/ha + 40 kg P_2O_5/ha + 40 kg K_2O/ha + 40 kg S/ha, T_8 - 80 kg N/ha + 40 kg P_2O_5/ha + 80 kg K_2O/ha + 20 kg S/ha, T_9 - 80 kg N/ha + 40 kg P_2O_5/ha + 80 kg K_2O/ha + 40 kg S/ha, replicated thrice. On the basis of pooled results, maximum values of all the attributes like plant height, number of branches per plant and number of bolls per plant of cotton crop were recorded with treatment T_9 (80-40-80-40 NPKS kg/ha).The significantly higher seed cotton yield (1798 kg/ha) and stalk yield (3536 kg/ha) of cotton were recorded under treatment T9 (80 kg N/ha + 40 kg P_2O_5/ha + 80 kg K_2O/ha + 40 kg S/ha) in pooled results. Whereas, lower seed cotton yield (1452 kg/ha) and stalk yield (2569 kg/ha) of cotton were recorded under T_1 (80 kg N/ha). The highest total income (Rs. 80905/ha) was also obtained with application of 80-40-80-40 NPKS kg/ha (T_9). The pH, EC and organic carbon content of soil were remain unaffected due to different treatments. Significantly higher values of available status of phosphorus, potassium and sulphur in soil were recorded with treatment T_9 (80-40-80-40 NPKS kg/ha).

Keywords: Bt cotton, nitrogen, phosphorus, potassium, sulphur, seed cotton yield, stalk yield

Introduction
Cotton (*Gossypium hirsuum*), 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 (Anonymous, 2010; Hosamani *et al*., 2013) [2, 5]. 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 (Deshmukh *et al*., 2013) [3]. The cotton (*Gossypium hirsutum* L.), an important fiber crop, is grown throughout India under both rainfed and irrigated conditions on an area of 9.5 million ha (Mayee *et al*., 2008; Yang *et al*., 2014) [7, 13]. India ranks first in area and production is far below the world average of over 600 kg ha (Gadhiya *et al*., 2009) [4]. 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 element 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. At present acute problems of reddening of cotton are observed due to lack of proper nutrient management practice (Das *et al*., 2004) [2]. Keeping in view, the experiment was planned to study the effect of nutrient management in Bt cotton under rain fed condition, at Dry Farming Research Station, Junagadh Agricultural University, Jamkhambhalia, Gujarat.

Materials and Methods
A field experiment was conducted during *Kharif* 2011-12 to 2015-16 at Dry Farming Research Station, Junagadh Agricultural University, Jamkhambhalia under North Saurashtra Agro-climatic Zone. The soil of the experimental field was medium black having good drainage

and high moisture retentive capacity. Some important characteristics of the soil were pH 8.30, EC 0.35 dSm^{-1}, Organic carbon 0.41 per cent, available N, P_2O_5, K_2O and S were 230.3, 28.6, and 336 kg ha^{-1} and 17.8 ppm, respectively and micronutrient Fe, Mn and Zn were 10.19, 12.84 and o.66 ppm, respectively. The experiment comprised total 9 treatments i.e. T_1 - 80 kg N/ha, T_2 - 80 kg N/ha + 20 kg P_2O_5/ha + 40 kg K_2O/ha + 20 kg S/ha, T_3 - 80 kg N/ha + 20 kg P_2O_5/ha + 40 kg K_2O/ha + 40 kg S/ha, T_4 - 80 kg N/ha + 20 kg P_2O_5/ha + 80 kg K_2O/ha + 20 kg S/ha, T_5- 80 kg N/ha + 20 kg P_2O_5/ha + 80 kg K_2O/ha + 40 kg S/ha, T_6 - 80 kg N/ha + 40 kg P_2O_5/ha + 40 kg K_2O/ha + 20 kg S/ha, T_7 - 80 kg N/ha + 40 kg P_2O_5/ha + 40 kg K_2O/ha + 40 kg S/ha, T_8 - 80 kg N/ha + 40 kg P_2O_5/ha + 80 kg K_2O/ha + 20 kg S/ha, T_9 - 80 kg N/ha + 40 kg P_2O_5/ha + 80 kg K_2O/ha + 40 kg S/ha in randomized block design, replicated thrice. Bt cotton variety BG-II G.Cot. Hy. 8 was sown, the 80 kg nitrogen/ha was applied in three splits i.e. 25% as basal, 50% as top dressing at 35-40 days and 25% as top dressing at 60-65 days and all the agronomic practices were adopted as per need of the crop. The growth and yield parameters, seed cotton and stalk yield of cotton were recorded. After harvest of crop soil samples were collected and analyzed for EC, pH, OC, available NPK status in soil using standard methods (Jackson, 1973) [6].

Results and Discussion

Yield attributes

The result presented in table 1 regarding yield attributes i.e. plant height, number of branches per plant and number of bolls per plant of cotton crop were significantly affected due to different nutritional treatments during all the years of experimentation and in pooled results also. On the basis of pooled results, maximum values of all the yield attributing characters were recorded with treatment T_9 (80-40-80-40 NPKS kg/ha). This might be due to application of NPKS fertilizers at higher dose which required for the plant. Similar results were also observed by Gadhiya *et al*., (2009) [4], Sakarvadia *et al*., (2009) [10] and Vora *et al*., (2015) [12].

Yield

The result presented in table 2 revealed that seed cotton yield of Bt. cotton was significantly affected due to different nutritional treatments during all the years of experimentation and in pooled results also. On the basis of pooled results, maximum seed cotton yield (1798 kg/ha) was recorded with T_9 (80-40-80-40 NPKS kg/ha) which was significantly higher than treatment T_1 (80 kg N/ha) & T_6 (80-40-40-20 NPKS kg/ha) and statistically at par with rest of all the treatments. The minimum seed cotton yield (1452 kg/ha) was recorded under recommended dose of fertilizer i.e. 80 kg N/ha (T_1). Thus, the result clearly indicated that combine application of NPKS at higher dose resulted in increase yield. The results are in concurrence with those reported by Gadhiya *et al*., (2009) [4], Megha *et al*., (2009) and Sakarvadia *et al*., (2009) [10].

The result presented in table 3 revealed that stalks yield of cotton was significantly affected due to different nutritional treatments during 2011-12, 2012-13, 2014-15 and 2015-16 and in pooled results. On the basis of pooled results, significantly higher stalks yield (3536 kg/ha) of cotton was recorded with T_9 (80-40-80-40 NPKS kg/ha) over treatments T_1, to T_4 and T_6 and statistically at par with treatments T_5 (80-20-80-40 NPKS kg/ha) and T_7 (80 kg N/ha + 40 kg P_2O_5/ha + 40 kg K_2O/ha + 40 kg S/ha). The increase in cotton stalk yield with N, P, K and S fertilization was ascribed to their impact on plant height and also on branching as supported by Gadhiya *et al*., (2009) [4] and Sakarvadia *et al*., (2009) [10].

Post-harvest soil fertility

The data given in table 4 revealed that pH, EC and organic carbon content of soil were remain unaffected due to different treatments. However, higher value of organic carbon content (0.471%) was recorded due to higher levels of fertilizer i.e. T_9. Available status of phosphorus, potassium and sulphur in soil was significantly affected due to different treatments and maximum values were observed with T_9 (80-40-80-40 NPKS kg/ha). The minimum values for availability of all the nutrients were found under recommended dose of fertilizer i.e. 80 kg N/ha (T_1). The result is similar to Ravi kiran and Halepyati (2013) [9], Sujatha and Vijayalakshmi (2013) [11] and Vora *et al*., (2015) [12].

In case of micronutrients, the status of Fe, Zn and Mn in the soil was significantly affected due to different treatments. Maximum status of Fe (14.34 ppm) and Zn (0.77 ppm) in the soil were recorded under T_5 (80-20-80-40 NPKS kg/ha) and that of Mn with T_9 (Table 5).

Economics

The data pertaining to economics of various nutrient management treatments (table 6) revealed that highest total income (Rs. 80905/ha) was obtained when cotton crop was fertilized with 80-40-80-40 NPKS kg/ha (T_9). However, higher net realization (Rs. 52091/ha) and cost benefit ratio (1.94) was obtained with treatment T_2 (80-20-40-20 NPKS kg/ha).

Conclusion

The application of NPKS @ 80-40-80-40 kg/ha resulted in significantly higher seed cotton and stalk yield.

Table 1: Effect of nutrient management on yield attributes of Bt cotton

Treatment		Plant height, cm	Number of branches/plant	Number of bolls/plant
T_1	80 kg N/ha	86.6	13.13	26.75
T_2	80-20-40-20 NPKS kg/ha	88.9	13.56	31.60
T_3	80-20-40-40 NPKS kg/ha	91.0	14.66	29.44
T_4	80-20-80-20 NPKS kg/ha	88.2	14.52	30.69
T_5	80-20-80-40 NPKS kg/ha	92.3	15.32	32.32
T_6	80-40-40-20 NPKS kg/ha	91.8	15.18	27.97
T_7	80-40-40-40 NPKS kg/ha	92.3	15.98	32.44
T_8	80-40-80-20 NPKS kg/ha	90.1	15.07	29.39
T_9	80-40-80-40 NPKS kg/ha	97.5	16.59	33.21
S.Em.±		2.7	0.70	2.1
C.D. at 5%		7.9	2.04	6.1
C.V. %		4.1	18.41	17.7

Y			
S.Em.±	1.8	0.47	1.4
C.D. at 5%	5.3	1.36	4.1
YXT			
S.Em.±	2.2	1.58	3.1
C.D. at 5%	6.1	4.47	8.8

Table 2: Effect of nutrient management on seed cotton yield of Bt cotton

Treatment		Seed Cotton yield, kg/ha			
		2011-12	2013-14	2014-15	Pooled
T_1	80 kgN/ha	898	1742	1715	1452
T_2	80-20-40-20 NPKS kg/ha	1129	2030	2091	1754
T_3	80-20-40-40 NPKS kg/ha	1207	2003	2051	1751
T_4	80-20-80-20 NPKS kg/ha	1138	1948	2030	1705
T_5	80-20-80-40 NPKS kg/ha	1148	2085	2058	1763
T_6	80-40-40-20 NPKS kg/ha	1175	1852	2016	1676
T_7	80-40-40-40 NPKS kg/ha	1161	2099	2044	1759
T_8	80-40-80-20 NPKS kg/ha	1124	1989	1975	1696
T_9	80-40-80-40 NPKS kg/ha	1224	2058	2112	1798
S.Em.±		54	72	74	40
C.D.at 5%		162	217	221	113
CV%		10.17	9.41	11.28	6.99
		Year	YxT		
S.Em.±		23	69		
C.D. at 5%		65	NS		

Table 3: Effect of nutrient management on stalks yield of Bt cotton

Treatment		Stalks yield, kg/ha				
		2011-12	2013-14	2014-15	2015-16	Pooled
T_1	80 kg N/ha	2126	3278	3073	1797	2569
T_2	80-20-40-20 NPKS kg/ha	2195	3923	3717	2277	3028
T_3	80-20-40-40 NPKS kg/ha	2291	3937	4184	2154	3141
T_4	80-20-80-20 NPKS kg/ha	2318	3937	3045	2565	2966
T_5	80-20-80-40 NPKS kg/ha	2401	4321	3813	2689	3306
T_6	80-40-40-20 NPKS kg/ha	2292	4047	3525	2840	3176
T_7	80-40-40-40 NPKS kg/ha	2401	4321	3923	2963	3402
T_8	80-40-80-20 NPKS kg/ha	2428	3896	3402	2551	3069
T_9	80-40-80-40 NPKS kg/ha	2840	4252	4239	2812	3536
S.Em.±		122	245	190	119	115
C.D.at 5%		366	NS	569	357	337
CV%		10.87	14.63	12.01	11.06	11.65
		Year	YxT			
S.Em.±		77	177			
C.D. at 5%		225	500			

Table 4: Effect of different treatments on post harvest soil fertility (At harvest 2015-16)

Treatment		pH	EC (dS/m)	Org. C. (%)	Avail. P_2O_5 (kg/ha)	Avail. K_2O (kg/ha)	Avail. S ppm
	Initial	8.30	0.35	0.411	28.6	366	17.8
T_1	80 kg N/ha	8.29	0.39	0.416	27.79	360	16.7
T_2	80-20-40-20 NPKS kg/ha	8.23	0.35	0.428	35.66	381	21.2
T_3	80-20-40-40 NPKS kg/ha	8.20	0.33	0.432	36.83	388	23.6
T_4	80-20-80-20 NPKS kg/ha	8.24	0.34	0.434	38.70	429	25.0
T_5	80-20-80-40 NPKS kg/ha	8.22	0.33	0.441	41.16	431	27.2
T_6	80-40-40-20 NPKS kg/ha	8.25	0.35	0.447	44.96	411	25.8
T_7	80-40-40-40 NPKS kg/ha	8.20	0.36	0.452	47.79	420	28.9
T_8	80-40-80-20 NPKS kg/ha	8.26	0.38	0.468	49.76	452	26.4
T_9	80-40-80-40 NPKS kg/ha	8.24	0.36	0.471	52.17	459	30.1
S.Em.±		0.06	0.02	0.02	2.14	11.04	1.6
C.D.at 5%		NS	NS	NS	6.43	33.11	4.7
CV%		1.32	8.60	6.69	8.92	4.61	10.87

Table 5: Effect of different treatments on post harvest soil fertility

Treatment		DTPA Extractable Micronutrient, ppm		
		Fe	Zn	Mn
	Initial	10.19	0.66	12.84
T_1	80 kg N/ha	9.73	0.61	12.47
T_2	80-20-40-20 NPKS kg/ha	12.59	0.68	13.24
T_3	80-20-40-40 NPKS kg/ha	13.38	0.72	13.58
T_4	80-20-80-20 NPKS kg/ha	13.93	0.75	14.15
T_5	80-20-80-40 NPKS kg/ha	14.34	0.77	14.64
T_6	80-40-40-20 NPKS kg/ha	11.86	0.54	15.44
T_7	80-40-40-40 NPKS kg/ha	12.24	0.55	16.63
T_8	80-40-80-20 NPKS kg/ha	12.87	0.58	17.62
T_9	80-40-80-40 NPKS kg/ha	13.69	0.62	17.95
S.Em.±		0.68	0.03	1.17
C.D.at 5%		2.05	0.10	3.50
CV%		9.29	9.04	13.39

Table 6: Effect of nutrient management on monetary returns

Treatment	Pooled seed cotton yield (kg/ha)	Gross monetary return (Rs/ha)	Cost of cultivation (Rs/ha)	Net monetary return (Rs/ha)	B:C Ratio
T_1-80 Kg N/ha	1452	65329	23266	42063	1.81
T_2-80-20-40-20 NPKS kg/ha	1754	78909	26818	52091	1.94
T_3-80-20-40-40 NPKS kg/ha	1751	78773	26967	51806	1.92
T_4-80-20-80-20 NPKS kg/ha	1705	76736	27818	48918	1.76
T_5-80-20-80-40 NPKS kg/ha	1763	79354	28247	51107	1.81
T_6-80-40-40-20 NPKS kg/ha	1676	75437	27742	47695	1.72
T_7-80-40-40-40 NPKS kg/ha	1759	79141	28200	50941	1.81
T_8-80-40-80-20 NPKS kg/ha	1696	76325	28767	47558	1.65
T_9-80-40-80-40 NPKS kg/ha	1798	80905	29340	51565	1.76

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