Enhancing the Productivity of Cotton by Nutrients and Plant Growth Regulators

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Abstract: Field investigations were carried out at Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar (India) to identify sustainable, eco-friendly and economically viable agronomic techniques for irrigated cotton. The conjoint application of 1-napthalene acetic acid (NAA) @ 40 ppm with 60 kg sulphur (S) + 5 kg zinc (Zn) + 0.5 kg boron (B) ha^{-1} had a remarkable influence on the growth, yield attributes, yield and economics of irrigated cotton. However, it was on par with application of NAA @ 40 ppm and 45 kg S + 5 kg Zn + 0.5 kg B ha^{-1}. With regard to the economics of treatments imposed in this investigation, the trend was different from the earlier parameters discussed. This was due to the high cost involved in excessive application of sulphur. Application of NAA @ 40 ppm and 45 kg S + 5 kg Zn + 0.5 kg B ha^{-1} exhibited a salutary effect on economic analysis in terms of net return and return rupee^{-1} invested in irrigated cotton.

Keywords: Cotton, NAA, Mepiquat chloride, Sulphur, Zinc and Boron.

Introduction

Cotton is one of the important fibre crops playing a key role in the economic and social affairs of the world, providing basic input to the textile industry. It is the oldest among the commercial crops of the world and is regarded as "white gold". Cotton is grown mainly for its fibre, which is used in the manufacture of cloth for mankind. India is the second largest producer of cotton in the world having the largest acreage, which is ¼th of the world's cotton area. In India, cotton occupies five per cent of the total cultivable area and contributes about 85 per cent raw material to textile industry. It is cultivated in an area of 89.60 lakh hectares with a production of 232 lakh bales (170 kg/bale) and an average productivity of 526 kg of lint ha^{-1} against the world average productivity of 764 kg lint ha^{-1}. Poor agronomic management practices like imbalance and inadequate use of secondary, micronutrients, hormonal imbalance, pests and diseases infestation are some of the important reasons for low productivity.

Sulphur deficiencies have been reported over 70 countries worldwide, of which 130 districts in India, were suffering from some degree of sulphur deficiency. Tamil Nadu is one of the agriculturally important states with very little data on soil sulphur status. It has been reported that 80 per cent of samples obtained from 15-benchmark clay soil from Cuddalore district were found to be sulphur deficient (Balasubramanian *et al.*, 1990). Makhdum and Malik (2004) concluded that S application significantly increased seed cotton yield, boll number and boll weight. Dunn *et al.* (2008) reported that cotton lint yields significantly responded to sulphur application. Seed cotton yield was significantly reduced by S deficiency (Chauhan and Bhunia 2010). Vaiyapuri *et al.* (2010) reported that application of sulphur @ 40 kg ha^{-1} increased the seed cotton yield by 21.7 per cent over no S application. Sulphur deficiency significantly reduced the number of bolls plant^{-1} (Fang and Chen, 2011). Boron is one of the most important micronutrient that cotton requires throughout crop growth, particularly during flowering, fruiting and boll development. Moreover, cotton is very sensitive to B deficiency because of its high B requirement (Shorrocks, 1992). Gormus (2005) observed that B application increased the number of bolls plant^{-1} and size of the bolls. The micronutrients act as catalyst in the uptake and use of certain other macronutrients (Phillips, 2004).

Zinc is one of the first micronutrients recognized as important for plants. It is the micronutrient that most commonly limiting crop yields in Indian soils. Zinc is transported to plant root surface through diffusion. It aids in the synthesis of plant growth substances and enzyme systems and is essential for promoting certain metabolic reactions. It is also necessary for production of chlorophyll and carbohydrates. Application of zinc to cotton crop promotes boll retention and thereby increases the seed cotton yield (Prasad and Prasad, 1998). Zinc is essential for normal plant growth and development as carbohydrates, protein metabolism and sexual fertilization (Vasconcelos *et al.*, 2011). Zinc application increases zinc uptake and yield of cotton and wheat (Ejaz Rafique *et al.*, 2012). Plant growth regulators like promoters, inhibitors or retardants play key role in internal control mechanism of plant growth by interacting with key metabolic processes such as nucleic acid and protein synthesis. Hence, it fetches new momentum in intensive agriculture. In the recent years, growth regulators considered as new generation agrochemicals after fertilizers and pesticides. Plant growth regulators are capable of increasing yield upto 200 per cent under laboratory conditions, 10 - 15 per cent in the field conditions (Kiran Kumar, 2001).

Materials and methods

The field experiments were conducted at Experimental farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Chidambaram, Tamil Nadu, India. The experiments were laid out in factorial randomized block design and replicated thrice. The treatments consisted of plant growth regulators G_0 -Control (Water spray), G_1 – NAA @ 40 ppm (45th and 60th DAS) and G_2 – Mepiquat chloride @ 100 ppm (70th and 90th DAS) were assigned with sulphur, zinc and boron (N_0 – Control, N_1 – 30 kg S ha^{-1} as gypsum + 5 kg Zn ha^{-1} as zinc sulphate + 0.5 kg B ha^{-1} as borax, N_2 – 45 kg S ha^{-1} as gypsum + 5 kg Zn ha^{-1} as zinc sulphate + 0.5 kg B ha^{-1} as borax and N_3 – 60 kg S ha^{-1} as gypsum + 5 kg Zn ha^{-1} as zinc sulphate + 0.5 kg B ha^{-1} as borax). The recommended dose of fertilizer 80:40:40 kg nitrogen, phosphorus, potassium (NPK) ha^{-1} was applied uniformly to all the plots through urea, di-ammonium phosphate (DAP) and muriate of potash (MOP), respectively. The soil of the experimental fields were clay loam in texture, low in available N, medium in available P, high in available K and deficient in S, Zn and B.

Results and discussion

Growth characters (Table 1)

Among the different treatments tried, G_1N_3 (NAA @ 40 ppm with 60 kg S + 5 kg Zn + 0.5 kg B ha^{-1}) increased the DMP and CGR. This could be due to application of NAA (40 ppm) increased the plant height, hence it significantly recorded higher dry matter as compared to other treatments. Yield in this treatment was also increased because of the retention of more bolls and diversion of higher proportion of photosynthates to reproductive parts. Similar observation on dry matter partitioning and yield was made by Nagabhushana *et al.* (1993). Further optimum and sustained availability of nutrients during the entire growth phase of cotton because of the supply of nutrients through soil. The improvement in growth attributes as a result of B application may be due to the enhanced photosynthetic and metabolic activity which led to an increase in various plant metabolic pathways responsible for cell division and elongation (Hatwar *et al.*, 2003) because the chlorophyll content increased considerably in Zn and B treated group of plants.

Table 1. Effect of nutrients and plant growth regulators on growth characters of cotton

Treatments	DMP (Kg ha^{-1})		CGR	
	First crop	Second crop	First crop	Second crop
G_0 N_0	4012	4026	4.95	4.91
G_0 N_1	4212	4200	6.88	6.84
G_0 N_2	4882	4802	7.52	7.47
G_0 N_3	4915	4856	7.54	7.50
G_1 N_0	4201	4175	5.64	5.60
G_1 N_1	4765	4689	7.50	7.45
G_1 N_2	5235	5146	8.34	8.30
G_1 N_3	5316	5286	8.38	8.24
G_2 N_0	4131	4100	5.28	5.24
G_2 N_1	4376	4289	6.50	6.46
G_2 N_2	5002	4923	8.11	8.03
G_2 N_3	5089	4996	8.13	8.04
S.Ed	68.37	65.57	0.10	0.09
CD (P=0.05)	136.75	131.15	0.20	0.18

Yield attributes and yield (Table 2)

Among the different treatments tried, G_1N_3 (NAA @ 40 ppm with 60 kg S + 5 kg Zn + 0.5 kg B ha^{-1}) increased the number of sympodial branches plant^{-1}, number of squares plant^{-1} and number of bolls plant^{-1}. This beneficial effect might be due to interaction effect of sulphur and micronutrient and their role in the synthesis of IAA, metabolism of auxins and chlorophyll in the plant. These observations corroborate with the findings of Basavarajappa *et al.*, (1997). Application of micronutrients significantly increased number of opened bolls per plant over the untreated control. Zinc is required in the synthesis of tryptophan, a precursor of IAA synthesis (Oosterhuis *et al.*, 1991), which is the major hormone that inhibits abscission of squares and bolls (Rathinavel *et al.*, 2004). Foliar application of NAA (40 ppm) produced more number of sympodial branches as compared to other treatments. This might be attributed to increased plant height, which is amenable for more number of nodes and internodes from where sympodial branches emerge. Similarly, increased number of sympodial branches was noticed in cotton and reported by Patel (1993) and Pothiraj *et al.* (1995). The increase in boll number was due to reduction in the abscission of intact buds and bolls per plant. The application of NAA completely counteracted the abscission promotive effect of ABA and thus reduced the shedding over the control.

Among the different treatments tried, G_1N_3 (NAA @ 40 ppm with 60 kg S + 5 kg Zn + 0.5 kg B ha^{-1}) increased the seed cotton yield. Supply of sulphur in addition to recommended NPK might be the lifting factor behind the increased seed cotton yield. Application of sulphur resulted in increased growth characters. Besides, there was significant increase in the number of number of sympodial branches, number of squares, number of bolls plant^{-1} and boll weight. Obviously, the growth and yield attributes collectively contributed to the increased seed cotton yield of the crop. These results are in accordance with the observation of Gobi *et al.,* (2006). Application of micronutrients significantly increased yield attributing characters such as number of sympodial branches, squares and bolls plant^{-1}. Similar results were recorded by Chhabra *et al.,* (2004) in cotton. Application of NAA @ 40 ppm increased the photosynthetic efficiency through stabilization of chlorophyll, higher production of photosynthesis, which resulted in increased translocation of organic material from source to sink. Thus partitioning of photosynthates move towards the development of reproductive parts than to the vegetative growth and would have resulted in higher seed cotton yield. These results are in close agreement with the findings obtained in cotton by Khandage *et al.*, (1992) and Rajagowthaman (2007).

Table 2. Effect of nutrients and plant growth regulators on yield attributes and yield of cotton

Treatments	No. of sympodial branches plant^{-1}		No. of squares plant^{-1}		No. of bolls plant^{-1}		Seed cotton yield (q ha^{-1})	
	First crop	Second crop	First crop	Second crop	First crop	Second crop	First crop	Second crop
G_0 N_0	10.85	10.26	30.85	30.59	12.21	12.01	13.21	13.11
G_0 N_1	16.48	16.37	38.75	38.24	17.45	17.20	20.38	19.80
G_0 N_2	17.85	17.69	41.35	40.25	18.65	18.18	21.68	21.56
G_0 N_3	17.92	17.85	41.39	40.36	18.69	18.35	21.72	21.64
G_1 N_0	16.70	16.45	39.89	39.84	17.21	17.10	17.82	17.75
G_1 N_1	17.26	17.14	41.60	40.75	18.85	18.36	21.12	21.04
G_1 N_2	20.15	20.11	43.88	42.75	20.35	19.98	23.90	23.55
G_1 N_3	20.21	20.19	43.95	42.81	20.38	20.07	23.96	23.60

G_2 N_0	15.04	14.76	36.24	35.89	15.21	15.15	17.03	16.94
G_2 N_1	16.89	16.71	40.75	40.01	18.25	17.95	20.95	20.90
G_2 N_2	18.95	19.01	42.37	41.36	19.45	19.15	22.52	22.46
G_2 N_3	19.06	19.04	42.41	41.58	19.50	19.26	22.61	22.50
S.Ed	0.51	0.50	0.70	0.67	0.42	0.40	0.55	0.51
CD (P=0.05)	1.03	1.01	1.42	1.35	0.85	0.80	1.16	1.03

Economics (Table 3)

With regard to the economics of treatments imposed in this investigation, the trend was different from the earlier parameters discussed. This was due to the higher cost involved in excessive application of sulphur. Among the treatments imposed, application of NAA @ 40 ppm + 45 kg S + 5 kg Zn + 0.5 kg B recorded the higher net return of Rs. 37546 and Rs. 36706 ha^{-1} and return $rupee^{-1}$ invested of Rs. 2.90 and Rs. 2.85 in first and second crop, respectively.

Table 3. Effect of nutrients and plant growth regulators on economics of cotton

Treatments	Net income (Rs. ha^{-1})		Return $rupee^{-1}$ invested	
	First crop	Second crop	First crop	Second crop
G_0 N_0	14975	14735	1.90	1.88
G_0 N_1	29958	28566	2.51	2.50
G_0 N_2	32778	32490	2.70	2.68
G_0 N_3	32574	32478	2.66	2.66
G_1 N_0	25479	25311	2.47	2.46
G_1 N_1	31174	30982	2.59	2.58
G_1 N_2	37546	36706	2.90	2.85
G_1 N_3	37390	36526	2.86	2.81
G_2 N_0	23093	22877	2.30	2.28
G_2 N_1	30276	30156	2.51	2.51
G_2 N_2	33744	33600	2.66	2.65
G_2 N_3	33660	33396	2.63	2.62

Conclusion

The application of nutrients and plant growth regulators was highly impressive which had a remarkable effect on the growth, yield components and seed cotton yield of irrigated cotton. Cognizing the several parameters in unison on first and second crop, the combined application of plant growth regulators and nutrients registered the maximum values for most of the parameters like growth, yield attributes, seed cotton yield and economics of irrigated cotton. Therefore, application of NAA @ 40 ppm + 45 kg S + 5 kg Zn + 0.5 kg B is found to be agronomically sound and economically viable technique to the cotton farmers for realizing better yields and returns.

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