Indian Journal of Agronomy **63** (1): 91–94 (March 2018)

Research Paper

Effect of soil and foliar applied potassium fertilizers on yield, quality and economics of Bt cotton (*Gossypium hirsutum*) in Vertisol

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Received : May 2017; Revised accepted : November 2017

ABSTRACT

A cotton (*Gossypium hiresutum* L.) hybrid 'MRC 7351' was grown during 2012–13 and 2013–14 at main Agricultural Research Station, University of Agricultural Sciences, Dharwad in Vertisols under rainfed condition with protective irrigation to check the effect of potassium on growth, yield and fibre quality of Bt cotton. The crop was sown in a randomized complete-block design and was replicated thrice. Pooled data of 2 years indicated that number of sympodial branches (24.7), number of total bolls/plant (46.9), mean boll weight (7.0 g) and seed-cotton yield/plant (150.4 g) in treatment receiving 100 : 50 : 75 [reccommended dose of nitrogen and phosphorus (RDNP) + 150% recommended dose of potassium (RDK)] + 2% KNO_3 foliar spray at 70, 90 and 110 days after sowing (DAS) resulted in significantly higher seed-cotton yield (2,689 kg/ha) over other treatments. Significantly higher fibre length (33.5 mm), uniformity ratio (48.8%), ginning outturn (38.5%), seed oil content (16%) and lowest micronaire value [4.4 µg/inch (2.54 cm)] were also recorded in the same treatment.

Key words : Balanced fertilizers, Cotton, Fibre quality, Foliar spray, Net returns, Potassium

India is important grower of cotton on a global scale (Deshpande *et al.*, 2014). It is a very good source of natural fibre and to some extent supplementary source of edible oil cotton is very important crop in the economy of the farmers. Cotton plants require a specific amount of certain nutrients in specific format applied at an appropriate time for their growth and development (Oosterhuis, 2001; Sajid *et al.*, 2008). Balanced fertilization has been proved kingpin in agriculture production under different farming situations. Balanced use of plant nutrients corrects nutrient deficiency, improves soil fertility, increases nutrient and water-use efficiency, enhances crop yields and farmer's income, maintains crop and environmental quality.

Potassium is the major plant nutrient that determines crop production and quality and plays an important role in translocation of carbohydrates, photosynthesis, water relations, resistance against insects and diseases and ion balance (Brar and Tiwari, 2004). Additionally, K also plays a significant role in photophosphorylation, turgour maintenance, photoassimilate transport from source tissues via phloem to sink tissues, stress tolerance and enzyme activation in plants (Usherwood, 2000), enhances boll weight and size, lint yield (Akhtar *et al*., 2003) and fibre development and fibre quality (Pettigrew *et al*., 1996).

Since cotton plant has an indeterminate growth habit and therefore requires high K throughout growing season, potassium uptake has profound impact on cotton plant growth, development, lint yield and fibre quality (Cassman *et al.*, 1990). The major demand for K by the plant comes at boll set because bolls are the major sink for potassium. Cotton plant requires large amount of potassium ranging from 3 to 5 kg/ha/day. Potassium taken up by plant represents total quantity that is related to the level of available soil and potassium fertilizer (Kerby and Adams, 1985) and yield demand of the crop. To produce one bale of cotton fibre (218 kg), cotton plant requires 20 kg of potassium of which approximately 2–5 kg are being removed by seeds (Rimon 1989; Hodges, 1992). Even in soils rated high in available K, in-season K shortage can develop due to the heavy demand during rapid boll set and fill. When heavy boll load is set, the demand for K often exceeds the ability of the soils and leaves to supply potassium. Foliar K applications under certain conditions, however, can supplement soil-applied K to increase yield and improve fibre quality of fast fruiting cotton varieties. Foliar K applications offer an opportunity to correct the deficiency more quickly (within 20 hr) and efficiently, especially late in the season when soil application of K may not be effec-

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tive (Abaye, 2009). It is in this context, a systematic field study was planned and executed with an objective to determine the effect of soil and foliar fertilizer K application on yield, quality and economics of Bt cotton in Vertisols.

MATERIALS AND METHODS

A field experiment was conducted to investigate the effect of soil and foliar application of potassium on yield, quality and economics of Bt cotton at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad (15°29'647" N, 74°59'254" 695 m above sea-level) during 2012–13 and 2013–14. The soil was clay having neutral *p*H (7.3), non-saline, low in available N (230.5 kg/ha), medium in available P_2O_5 (31.60 kg/ha) and available K_2O (334.0 kg/ha). The spacing adopted was 90 cm × 60 cm as recommended for hybrid cotton. The experiment was executed in randomized complete-block design with 3 replications and 9 treatments, viz. T_1, 100 : 50 : 0 (RDNP); T_2, 100 : 50 : 50 (RDF); T_3, 100 : 50 : 62.5 (RDNP + 125% RDK); T_4, 100 : 50 : 75 (RDNP + 150% RDK); T_5, 100 : 50 : 0 (RDNP) + 2% KNO_3 foliar spray at 70, 90 and 110 days after sowing (DAS); T_6, 100 : 50 : 50 (RDF) + 2% KNO_3 foliar spray at 70, 90 and 110 DAS; T_7, 100 : 50 : 62.5 (RDNP + 125% RDK) + 2% KNO_3 foliar spray at 70, 90 and 110 DAS; T_8, 100 : 50 : 75 (RDNP + 150% RDK) + 2% KNO_3 foliar spray at 70, 90 and 110 DAS; T_9, 100 : 50 : 50 (RDF) + water spray at 70, 90 and 110 DAS.

Gap filling was done 7 days after sowing to avoid patchy crop stand. To maintain desired plant density, thinning was done at about 20 days after sowing (DAS). Entire recommended dose of P and K and half of N were applied after germination by ring method. The remaining N was applied at 60 DAS as per the package of practice. Foliar spray of KNO_3 @ 2% was applied at 70, 90 and 110 DAS as per treatment details. Adequate plant-protection measures were taken as per the recommended package for Bt cotton as and when required at various growth stages commonly to all the treatments. During growth of the crop and at maturity, different yield parameters like sympodial branches, number of bolls and boll weight were recorded.

RESULTS AND DISCUSSION

Yield attributes and yield

In the present study, owing to the integration of all the favourable yield components such as number of total bolls/plant (46.9), boll weight (7.0 g) and seed-cotton yield/plant (150.4 g) in treatment receiving 100 : 50 : 75 (RDNP + 150% RDK) + 2% KNO_3 foliar spray at 70, 90 and 110 DAS resulted in significantly higher seed cotton yield (2,689 kg/ha) over other treatments (Table 1). It also recorded 26.7% yield increase over RDF. However, the treatment 100 : 50 : 62.5 (RDNP + 125% RDK) + 2% KNO_3 foliar spray at 70, 90 and 110 DAS was on par with 100 : 50 : 75 (RDNP + 150% RDK) + 2% KNO_3 foliar spray at 70, 90 and 110 DAS. Similar findings were recorded by Channakeshava *et al.* (2013), who reported that increase in bolls/plant was attributed to the supply of sufficient quantity of potassium at critical period, particularly during boll-development stage which resulted in retention of more number of bolls/plant than control which received no KNO_3 spray. The higher boll weight was also attributed to additional nutrition due to foliar spray of KNO_3 which increased the dry-matter accumulation and in turn boll size, weight and kapas yield (Kumar *et al.*, 2011). Thus, synchronizing the nutrient supply at different stages through foliar application resulted in growth and consequently higher yields.

Application of only RDNP (100 : 50 : 0 kg N : P_2O_5 : K_2O/ha) resulted in lower number of bolls per plant, mean boll weight and seed cotton yield (27.3, 5.3 g, 124.7 g/plant and 1,867 kg/ha, respectively) compared with the treatments. The reason for decrease in boll weight and yield in potassium-deficient treatment is that potassium deficiency resulted in early abscission of leaves and carbohydrates accumulation in main stem leaves, so the top bolls of cotton plant developed incompletely, consequently the boll weight and seed yield were lower in potassium-deficient plants. The results of the present study are in line with Gormus (2002), who observed reduced boll weight and seed-cotton yield in K-deficient plants.

Fibre quality

Although fibre quality is genetically controlled, application of nutrients has been observed to modulate the quality. In this study, results of fibre quality parameters in Tables 1 showed that the soil-and foliar-applied potassium had significant effect on quality parameters of Bt cotton. Significantly higher fibre length (33.5 mm), uniformity ratio (48.8%), ginning outturn (38.5%), seed oil content (16%) and lowest micronaire value (4.4 µg/inch) were recorded in the treatment receiving 100 : 50 : 75 (RDNP + 150% RDK) + 2% KNO_3 foliar spray at 70, 90 and 110 DAS compared with rest of the treatments (Table 1). The higher fibre length (28.6 mm), uniformity ratio (42.2%), micronaire value (4.9 mµ g/inch), tenacity (21.8 g/tex), ginning outturn (32.1%) and seed oil content (14.9%) were registered in treatment with no potassium (RDNP only). Shanmugham and Bhat (1991) and Dewdar and Rady (2013) reported positive effects of K on lint quality characteristics and according to them potassium has its role in fibre development and hence the foliar application of potassium at later stages of cotton crop might have helped in improving the fibre qualities of cotton. This

Table 1. Yield attributes, yield and fibre-quality parameters of Bt cotton as influenced by soil application of NPK fertilizers and foliar application of KNO_3 (pooled data of 2012–14) in Vertisol

Treatment	Total number of bolls/plant	Mean of 10 bolls weight (g)	Seed-cotton yield (g/plant)	Seed-cotton yield (kg/ha)	2.5% span length (mm)	Uniformity ratio	Micronaire value (g/inch)	Tenacity 3.2 mm (g/tex)	Ginning out turn (%)	Seed oil content (%)
T_1, 100 : 50 : 0 (RDNP)	27.3	5.3	124.7	1,867	28.6	42.2	4.9	21.8	32.1	14.9
T_2, 100 : 50 : 50 (RDF)	34.3	6.3	132.1	2,122	30.2	43.5	4.8	22.8	33.8	15.2
T_3, 100 : 50 : 62.5 (RDNP + 125% RDK)	38.4	6.5	137.6	2,291	31.8	44.0	4.7	24.2	36.0	15.5
T_4, 100 : 50 : 75 (RDNP+ 150% RDK)	42.9	6.8	141.9	2,407	32.0	46.0	4.6	24.7	37.0	15.6
T_5, 100 : 50 : 0 (RDNP) + 2% KNO_3 spray at 70, 90 and 110 DAS	28.6	5.5	126.7	1,940	29.0	42.8	4.8	21.9	32.4	14.9
T_6, 100 : 50 : 50 (RDF) + 2% KNO_3 spray at 70, 90 and 110 DAS	38.2	6.6	136.5	2,189	31.7	45.3	4.6	24.0	35.3	15.4
T_7, 100 : 50 : 62.5 (RDNP + 125% RDK) + 2% KNO_3 spray at 70, 90 and 110 DAS	44.3	6.9	146.4	2,579	33.0	47.8	4.5	25.4	38.1	15.8
T_8, 100 : 50 : 75 (RDNP+ 150% RDK) + 2% KNO_3 spray at 70, 90 and 110 DAS	46.9	7.0	150.4	2,689	33.5	48.8	4.4	26.0	38.5	16.0
T_9, 100 : 50 : 50 (RDF) + water spray at 70, 90 and 110 DAS	34.6	6.4	132.7	2,151	30.9	43.7	4.7	22.9	33.9	15.3
SEm±	0.97	0.03	1.4	30.73	0.3	1.02	0.03	1.0	0.3	0.3
CD (P=0.05)	2.89	0.08	4.3	92.12	1.0	3.06	0.10	NS	0.9	NS

FYM, 5 t/ha; RDF, 100 : 50 : 50 kg; N : P_2O_5 : K_2O/ha

might be owing to the enough supply of potassium during active fibre growth period, which may cause an increase in the turgour pressure of the fibre, resulting in higher cell elongation and long fibres at maturity. Improvement of fibre length, uniformity ratio, fibre strength and fineness were associated with foliar application of K at flowering. The possible reason of increased ginning out turn percentage might be due to the cellulose synthesis and dry-matter accumulation (Li *et al.*, 1999). The possible reason of increased seed oil content might be attributed to the role of K in biochemical pathways in plants. Potassium increases the photosynthetic rates of crop leaves, CO_2 assimilation facilitates carbon movement and it has favourable effects on metabolism of nucleic acids and proteins. The results are in conformity with the findings of Bednarz and Oosterhuis (1999).

Economics

In the present study, the application of 100 : 50 : 75 (RDNP + 150% RDK) + 2% KNO_3 foliar spray at 70, 90 and 110 DAS recorded significantly higher gross returns (₹137,282/ha), net returns (₹99,670/ha) and benefit: cost ratio (3.7) (Table 2). However, the treatment receiving 100 : 50 : 62.5 (RDNP + 125% RDK) + 2% KNO_3 foliar spray at 70, 90 and 110 DAS was at par with 100 : 50 : 75 (RDNP + 150% RDK) + 2% KNO_3 foliar spray at 70, 90 and 110 DAS. Aladakatti *et al.* (2011) and Ashraf *et al.* (2015) also observed similar results with basal soil application of potassium plus foliar application of potassium at flowering and boll-formation stages. They reported that, the higher net returns observed in the above treatments was mainly owing to the application of foliar nutrients that improved the yield-attributing characters and yield ultimately led to higher net returns and benefit: cost ratio. Increased leaf and petiole K concentrations, accompanied by higher yields and net revenues, have been reported from foliar applications of KNO_3 (Howard *et al.*, 1998). Though the gross returns were higher in the treatment that received 100 : 50 : 0 (RDNP) + 2% KNO_3 foliar spray at 70, 90 and 110 DAS, the benefit: cost ratio (2.6) was lower compared to rest of the treatments because of higher input cost compared to RDNP.

The results of the experiment indicated that the treatment receiving recommended dose (RD) of N & P (100:50/kg) and 150% RD of K (75 kg/ha) with foliar application of 2% KNO_3 at 70, 90, and 110 days after sowing was found optimum for higher yield, net returns, benefit: cost ratio and better fibre quality of Bt cotton.

Table 2. Effect of soil applicaton of NPK fertilizers and foliar application of KNO_3 on economics of Bt cotton in Vertisol (pooled data of 2012–14)

Treatment	Total cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	Benefit: cost ratio
T_1, 100 : 50 : 0 (RDNP)	32,524	90,754	58,230	2.8
T_2, 100 : 50 : 50 (RDF)	33,962	1,01,517	67,555	3.0
T_3, 100 : 50 : 62.5 (RDNP + 125% RDK)	34,322	1,15,554	81,232	3.4
T_4, 100 : 50 : 75 (RDNP+ 150% RDK)	34,687	1,21,273	86,586	3.5
T_5, 100 : 50 : 0 (RDNP) + 2% KNO_3 spray at 70, 90 and 110 DAS	35,449	91,744	56,295	2.6
T_6, 100 : 50 : 50 (RDF) + 2% KNO_3 spray at 70, 90 and 110 DAS	36,887	1,10,293	73,406	3.0
T_7, 100 : 50 : 62.5 (RDNP + 125% RDK) + 2% KNO_3 spray at 70, 90 and 110 DAS	37,247	1,34,343	97,095	3.6
T_8, 100 : 50 : 75 (RDNP+ 150% RDK) + 2% KNO_3 spray at 70, 90 and 110 DAS	37,612	1,37,282	99,670	3.7
T_9, 100 : 50 : 50 (RDF) + water spray at 70, 90 and 110 DAS	33,962	1,04,789	70,827	3.1
SEm±	–	1,016.5	1,016.5	0.03
CD (P=0.05)	–	3,047.6	3,047.6	0.09

FYM, 5 t/ha; RDF, 100 : 50 : 50 kg; N : P_2O_5 : K_2O/ha

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