



Evaluation of impact of foliar sprays of potassium nitrate (KNO₃) on yield and economics of Bt cotton (*Gossypium hirsutum*) through front line demonstrations

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ABSTRACT

Cotton is one of the most important commercial fibre crops of India. Imbalance and inadequate nutrition is one of the major constraints for low productivity of cotton. Superimposition of KNO₃ (1%) over recommended dose of fertilizers through foliar applications at flowering and boll development stage is recommended in Haryana state to overcome K deficiency at later stages of crop growth and farmers are not practicing this technology due to lack of knowledge. Therefore, to highlight the impact of three foliar sprays of KNO₃ (1%) at 15 days interval starting from flower initiation stage, forty one Front Line Demonstrations were conducted at farmer's field on 16.4 ha of land area of 20 villages of Bhiwani district (Haryana) during *kharif* seasons of 2010 to 2012. The improved technology recorded a mean cotton seed yield of 24.67 q/ha which was 10.8% higher than that obtained with farmers practice/check, i.e. no spray of KNO₃ (22.27 q/ha). It fetched higher mean net monetary returns of ₹ 55053/ha with benefit: cost ratio of 2.03 in comparison to check (mean net monetary returns of ₹ 47079/ha and benefit: cost ratio of 1.91).

Key words: Bt Cotton, Potassium nitrate, Profitability, Technology gap, Yield

The area as well as production of cotton has gone up many folds with agricultural development in the country. It is grown on an area of 11.69 m ha with a production of 36.59 m bales and productivity of 532 kg lint/ha during 2013-14 as against an area of 5.88 m ha with a production of 3.04 m bales and productivity of 88 kg/ha in 1950-51. Around 95% of cotton grown domestically is Bt cotton (*Gossypium hirsutum* L.). Since last one decade, the productivity of cotton in India and Haryana has been hovering around 421 and 582 (2006-07), 486 and 681 (2012-13) and 532 and 608 kg lint/ha (2013-14), respectively. The productivity of cotton in India is still far below than that of world (767 kg/ha), china (1467 kg/ha) and Australia (1000 kg/ha).

Imbalanced and inadequate nutrition to cotton crop is considered to be one of the important production constrains. Due to early and semi-determinate habit of the Bt Cotton Hybrids, the rate of growth and rejuvenation capacity of the plant after first flush of flowering is slow. First formed squares and bolls are retained up to 90% in Bt cotton. When

there is need to have more nutritional requirement after first bearing, the plant could not cope up with the nutritional requirements and necessitates additional nutrition. Soil-applied nutrients depend on the moisture to dissolve the fertilizer and much of those nutrients become unavailable due to strong adsorption to soil particles. As a result of synchronized flowering, retention of most of the first formed bolls and reduced crop duration, there is a scope to increase productivity with foliar nutrition coupled with soil application of the fertilizers (Basavanneppa *et al.* 2009).

Potassium is required in large amounts than any other mineral element except N by cotton for normal crop growth and fibre development. It (K⁺) has substantial effect on enzyme activation, protein synthesis, photosynthesis, stomatal movement and water-relation (turgor regulation and osmotic adjustment) in plants (Marschner 1995). Increased application of K⁺ has been shown to enhance photosynthetic rate, plant growth, yield and drought resistance in different crops under water stress conditions (Sharma *et al.* 1996, Egilla *et al.* 2001). Plants adequately supplied with K⁺ can utilize the soil moisture more efficiently than K⁺ deficient plants (El-Hadi *et al.* 1997).

Cotton is major commercial fibre crop of *kharif* season in north-western India including Bhiwani district of Haryana, where it is grown on an area of about 50000 ha. Potassium uptake is more during boll formation stage in cotton i.e. why late season K deficiency has become a common phenomenon these days across regions. It has been speculated that K deficiency are related to the introduction

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of high yielding, early maturing, fast fruiting cotton varieties creating a greater demand than the plant root system is capable of supplying. Moreover, the crop also suffers from sudden/para wilt at boll formation stage, which is not a pathological problem but arise due to several factors including water and nutrients stress creating asphyxiation like condition in roots and can be more in Bt cotton plants because of higher boll retention. Foliar application of K especially late in season when soil application may not be feasible or effective, correct the deficiency quickly and efficiently (Oosterhuis 1995 and Weir 1996). In Haryana, scientists have recommended foliar applications of KNO_3 for cotton @ 1% at flowering and boll development stage. But due to lack of awareness, the technology was not adopted at mass level by the farmers of the state. Keeping in view these facts, front line demonstrations (FLDs) were conducted with farmers participatory approach on farmers' field to demonstrate effect of foliar sprays of potassium nitrate (13-00-45).

MATERIALS AND METHODS

Total forty one Front Line Demonstrations were conducted at farmer's field on 16.4 hectares of land area of twenty villages of Bhiwani district (Haryana) in three years i.e. from 2010 to 2012. Bhiwani district is located between 28.19 deg. and 29.05 deg. north latitudes and 75.26 deg. and 76.28 deg. east longitudes. The district has a semi arid climate with hot and dry winds in summer, severe cold in winter and humid warm weather during monsoon. The maximum temperature sometimes exceeds 47°C in summer while temperature below freezing accompanied by frost in winter is usually experienced in the region. The average annual rainfall of the region is 300 to 400 mm. About 80 to 90% of total annual rainfall is received from south-west monsoon in the month of July to September while remaining 10 to 20% rainfall is received from north-east monsoon in the winter or spring season. The soils are light textured and generally low in available organic carbon, low to medium in available Phosphorus and medium in available potash. The soil sample of each field of FLD was analysed to test the initial fertility status in different years of study. The results of analysis of these samples showed that on an average available N, P and K ranged from 121 to 207, 9 to 15 and 128 to 186 kg/ha, respectively.

The demonstrations were conducted on 10.0, 4.0 and 2.4 ha in *kharif* seasons of 2010, 2011 and 2012, respectively. One demonstration was conducted on 0.4 ha with same area under check, i.e. farmers practice or no spray of KNO_3 . The Potassium nitrate containing 13% N and 45% K_2O (13-00-45) was supplied free of cost to the beneficiary farmers as critical input. The Bt cotton hybrids were sown in the month of May with hybrid cotton seed drill at 67.5 cm row to row spacing. All recommended package of practices were followed to raise the crops under demonstration as well as check. However in demonstration fields, potassium nitrate @ 1% (2 kg in 200 litres of water) was sprayed thrice at an interval of 15 days starting from flower initiation

stage. The yield data were recorded by picking crop in ten square meter area at each location and converted into per hectare. Economic analysis was done by calculating cost of cultivation, gross returns, net returns and B:C ratio. Gross returns were calculated on the basis of prevailing market rates of produce.

Benefit: cost (B:C) ratio was calculated using following formula:

$$\text{B:C} = \frac{\text{Gross returns (₹/ha)}}{\text{Gross cost (₹/ha)}}$$

For effective transfer of technology different extension approaches like field visits and interpersonal communication were adopted. Trainings for farmers and farm women and; field days were conducted for horizontal spread of technology. Various extension study parameters viz. technology gap, extension gap and technology index were calculated by using formula suggested by Samui *et al.* (2000).

Technology gap = Potential yield – Demonstration yield
Extension gap = Demonstration yield – Farmers yield

$$\text{Technology index (\%)} = \frac{\text{Technology gap}}{\text{Potential yield}} \times 100$$

The data was analysed statistically using Independent T – test ($T_{5\%}$) test to find out significance between means of various parameters studied.

Potassium nitrate (KNO_3) is a water soluble fertilizer in crystalline form. It contains 13% N and 45% K_2O (13-00-45). This can be applied to the crop through fertigation or foliar spray. Application of KNO_3 (2%) is a good source of nitrogen and potash nutrition for maintaining the threshold level for Bt cotton growth and development (Hosmath *et al.* 2014).

RESULTS AND DISCUSSION

The foliar sprays of potassium nitrate had significant effect on yield parameters of cotton (Table 1). The demonstration fields where potassium nitrate was sprayed thrice showed overall more number of bolls/plant (35.2) and boll weight (3.23 g) than check/ farmers practice (27.8 and 3.10, respectively) where no potassium nitrate was sprayed. The seed cotton yield per plant was also significantly higher under demonstration by 26.3, 29.8 and 40.2 per cent than the check in 2010, 2011 and 2012, respectively. Mean of three years data on boll retention revealed that 7.0% more bolls were retained in demonstration fields than their respective check fields. All these parameters contributed and ultimately resulted into higher cotton seed yield in demonstration fields than check fields. In this study, foliar application of potassium showed significant increase in number of bolls, boll weight, yield per plant and boll retention. The increase in number of bolls per plant may be because of less boll shedding. Boll shedding takes place under nutrient deficiency and drought stress in cotton. Potassium helps in maintaining plant turgor under

Table 1 Effect of foliar sprays of potassium nitrate on number of bolls/plant, boll weight, seed cotton yield/plant and boll retention in Bt cotton.

Year	No of bolls/plant		P value at 5 %	Boll weight (g)		P value at 5 %	Seed cotton yield/plant (g)		P value at 5 %	Boll retention (%)		P value at 5 %
	Demonstration	Check		Demonstration	Check		Demonstration	Check		Demonstration	Check	
2010	31.5	25.6	8.0E-14	3.06	2.98	0.0452	96.1	76.1	3.2E-26	31.9	30.2	0.0030
2011	34.0	27.6	3.1E-06	3.27	3.11	0.0019	111.1	85.6	1.1E-10	33.9	31.7	0.0125
2012	40.2	30.1	0.00043	3.35	3.20	0.0247	134.9	96.2	0.00016	35.5	33.0	0.0190
Mean	35.2	27.8		3.23	3.10		114.0	86.0		33.8	31.6	

drought conditions and enables plant to withstand drought conditions. So, plants deficient in potassium could not retain their bolls in adverse environment condition of hot climate (Waraich *et al.* 2011). In cotton, yield is directly related to boll number, boll weight and seed-cotton yield/plant. The higher seed-cotton yield with the foliar application of KNO₃ (2%) is supported by significantly increased boll weight and seed cotton yield/plant (Hosmath *et al.* 2014).

Data presented in Table 2 revealed that three foliar sprays of potassium nitrate @ 1% (at 15 days interval starting from flower initiation stage) increased seed cotton yield by 2-3 q/ha during the study period. Overall 10.8% (mean of three years) increase in yield of cotton was observed under demonstration fields over check (no spray of Potassium nitrate). Foliar application of nutrients is highly beneficial as crop benefits are achieved when roots are unable to meet the nutrient requirement of crop at a critical stage (Ebelhar and Ware 1998). Brar *et al.* (2008) reported improvement in seed cotton yield with foliar application of Potassium nitrate irrespective of soil status and soil applied potassium. Kaur *et al.* (2011), Sekhon and Singh (2013), Channakeshva *et al.* (2013) and Hosmath

et al. (2014) also observed increase in seed cotton yield with foliar sprays of potassium nitrate. The technology gap ranged from 7.20 q/ha to 3.00 q/ha in 2010 and 2012, respectively. Overall, a technology gap of 5.32 q/ha was observed over a period of three years under study. In contrast to technology gap which narrowed down during 2010 to 2012, the extension gap increased from 2.00 q/ha in 2010 to 3.00 q/ha in 2012. This may be attributed to the better crop management and scientific supervision of demonstration fields. The technology index was reduced from 24.0 in 2010 to 10.0% in 2012 which shows the impact of technology under demonstration i.e. foliar applications of Potassium nitrate. Similar findings regarding impact of FLDs on technology gap, extension gap and technology index have been reported by Samant (2015) in rice.

Perusal of data presented in Table 3 revealed that the highest gross (₹ 125250/ha) as well as net returns (₹ 75747/ha) were fetched in demonstration fields in 2012 which may be attributed to highest yield and market prices of cotton in 2012 as compared to previous years under study. Likewise B:C ratio was also maximum 2.53 and 2.37 during

Table 2 Productivity, technology gap, extension gap and technology index in Bt cotton as influenced by foliar sprays of potassium nitrate.

Year	Seed cotton yield (q/ha)			P value at 5 %	Increase in yield over check (%)	Technology gap (q/ha)	Extension gap (q/ha)	Technology index (%)
	Potential	Demonstration	Check					
2010	30.00	22.75	20.75	0.0001	10.0	7.20	2.00	24.0
2011	30.00	24.25	22.05	0.0417	10.0	5.75	2.20	19.2
2012	30.00	27.00	24.00	0.0285	12.5	3.00	3.00	10.0
Mean	30.00	24.67	22.27		10.8	5.32	2.40	17.7

Table 3 Cost of cultivation, gross returns, net returns and B:C ratio in Bt cotton as influenced by foliar sprays of potassium nitrate.

Year	Cost of cultivation (₹/ha)		Gross returns (₹/ha)		Net returns (₹/ha)		B:C ratio	
	Demonstration	Check	Demonstration	Check	Demonstration	Check	Demonstration	Check
2010	57000	54000	102375	93375	45375	39375	1.80	1.73
2011	57900	55400	101938	92663	44038	37263	1.76	1.62
2012	49503*	47152	125250	111750	75747	64598	2.53	2.37
Mean	54801	52184	109854	99263	55053	47079	2.03	1.91

Market price of cotton: ₹ 4500, 4200 and 4650 per q in 2010, 2011 and 2012 respectively. *Cost of cultivation during 2012 was low due to less incidence of insect – pest and disease as compared to 2010 and 2011.

2012 in demonstration and check fields, respectively. The mean of three years data shows that a hike of ₹ 2617/ha in cost of cultivation due to additional cost of potassium nitrate resulted into increase of ₹ 7974/ha in net returns of demonstration (₹ 55053/ha) over net returns of check (₹ 47079/ha). The average B:C ratio of three years was also higher (2.03) under demonstration than that recorded under check (1.91). Sekhon and Singh (2013) have also reported additional income or increase in net returns with the foliar applications of nutrients.

Farmers feedback

Foliar sprays of KNO₃ not only increases the seed cotton yield but also improves its quality. The colour and glaze of lint of cotton produced with foliar spray of KNO₃ is quite better and fetch more price in the market than the cotton produced without potassium application. It also acts as drudgery reduction technology as requires less force in picking of cotton from bolls and even small staple of lint is not left on bolls after picking thus avoid yield reduction.

Based on three years study it may be concluded that foliar application of potassium nitrate in cotton at late crop growth stages, i.e. flowering onwards is helpful in improving plant's ability to withstand various biotic and abiotic stresses. This practice not only increased the yield but also improved quality of produce and fetched more remuneration per unit area. Thus the farmers should adopt this technology at mass level.

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