Boosting Seed Cotton Yields in Punjab with Potassium: A Review

By M.S. Brar and K.N. Tiwari

Cotton production in India has stagnated at a level far below its potential—the main reason being unbalanced and low rates of fertilizers. A review of key research on improved potassium (K) management practices provides a clear picture of the potential yield and economic benefits available to farmers.

India has the largest area planted to cotton in the world (8.6 million hectares [M ha]), but the country ranks third in productivity. As an example, the northern state of Punjab has 470,000 ha and an average seed cotton yield of 340 kg/ha. The case is similar for Haryana and Rajasthan where cotton is grown on 560,000 ha and 510,000 ha, respectively. The average yield in the U.S. is over 2 t/ha (FAOSTAT, 2004).

Potassium fertilizer recommendations for cotton are altogether missing in these northern states despite widespread depletion of soil K reserves, increased incidence of pest problems, and evidence showing increased crop response to K. To date, state fertilizer recommendations include only nitrogen (N) and phosphorus (P) applied at 75-30 kg N-P_2O_5/ha for non-hybrid American varieties and 150-30 kg N-P_2O_5/ha for hybrids.

Cotton's indeterminate growth habit means that nutritional stress and imbalances affect both vegetative and reproductive metabolism and ultimately limit seed cotton yield as well as fiber and seed quality. Potassium plays an important role in photosynthesis, water balance, balance between mono and divalent cations, translocation of carbohydrates, and resistance against insects and diseases. These are key factors contributing to low cotton productivity in India.

This article discusses various aspects of K application for seed cotton based on greenhouse and field studies conducted in Punjab.

Unbalanced and low rates of fertilizers have resulted in stagnate cotton yields in India.

Soil K and Cotton Response

Brar et al. (1987) examined K response in seed cotton through preliminary greenhouse studies conducted on three major cotton growing, surface soils (Samana, Fatehpur, and Tulewal series). The study found clear K deficiency symptoms when available K levels were below 36 mg/kg. Although the study did not find symptoms above this soil test level, responses to applied K were observed in soils testing 50 mg/kg.

Given the cotton plant's deep-rooting nature, the distribution of K in surface and subsurface soil horizons also has an influence on plant K uptake and yield. Sekhon (1993) conducted field research at a site with 138 mg/kg available K at the surface, yet low (54 mg/kg) available K at depth. Application of 60 kg K_2O/ha produced larger plants and a higher yield, thus signifying the cotton plant's dependence on subsurface soil horizons as well as the need to provide supplemental K under these conditions (**Table 1**).

Table 1. Effect of K application on yield and yield parameters of cotton (1993) in Gahri Bhagi soils.

Treatments, kg K_2O/ha	Yield, kg/ha	Bolls, number	Boll wt., g	Plant height, cm
0	1,808	23.1	9.3	129
30	2,047	25.5	9.5	135
60	2,139	28.0	9.5	146
120	2,157	26.0	9.4	151
C.D., 5%	245	NS	NS	13

The soil tested 138 mg/kg at the surface and 54 mg/kg for the subsurface. C.D.=critical difference

Although the size of the available K pool is most important, cotton response to applied K also depends on the quantity and intensity of the release of K from the non-exchangeable pool. Dhanwinder-Singh et al. (1990) demonstrated this by comparing soils with similar amounts of total available K, but differing levels of non-exchangeable K (**Table 2**). The study found a significant yield response with the low non-exchangeable K soil, whereas the opposite scenario revealed no yield response.

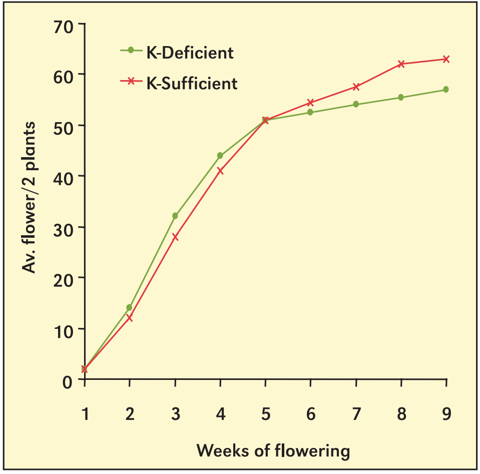
Table 2. Effect of applied K on seed cotton yield on two soils with similar amounts of available and different amounts of non-exchangeable K

Applied K_2O, kg/ha	Yield of seed cotton, t/ha	
	Site I	Site II
0	3.0	2.5
30	3.3	2.2
60	3.4	2.3
120	3.7	2.5
180	3.1	2.4
Available K, mg/kg	51.9	55.8
Non-exch. K, mg/kg	500.0	1,075.0

Flowering and Seed Yield

The cumulative rate of flowering will differ between K-deficient and K-sufficient soils. Dhanwinder-Singh et al. (1991) provided an example showing a marginally higher rate of flower development during the first 4 weeks of growth under conditions of K deficiency After that, flower development was considerably slower relative to plants grown on K-sufficient soil **(Figure 1)**. A similar trend was observed (not shown) in K-deficient soils with and without applied K, wherein flowering ceased much earlier in plots receiving no K application (Brar et al., 1987). Higher seed cotton yields are a partial reflection of this continuous improvement in flower and boll maturation throughout the season.

Figure 1. Cumulative flowering rate in soils of different K status.



Rates and Timing

Dhanwinder-Singh et al. (1991) conducted a comprehensive K delivery experiment at six coarse textured, low organic carbon (<0.40%) sites. The study found 100% basally applied K to be superior to a full application during flowering at sites I and III, while sites II and IV showed no difference between the two application timings (**Table 3**). Similar to Brar et al. (1987), yield responses to K fertilizer were significant if available K was below 52 mg/kg. Sites that were responsive to applied K showed no clear advantage for methods which split the K supply between planting and flowering.

Table 3. Effect of applied K on seed cotton yield (t/ha) at cultivators' fields in Ludhiana District, Punjab.

Treatments, kg K_2O/ha	Experimental sites I	II	III	IV	V	VI	Mean
0	1.69	2.93	2.61	3.05	1.21	2.50	2.33
30†	2.12	3.42	2.73	3.29	1.22	2.15	2.49
60†	2.46	3.44	2.85	3.41	1.39	2.26	2.64
120†	2.33	3.45	3.37	3.72	1.13	2.50	2.73
180†	2.27	3.50	3.93	3.15	1.14	2.43	2.74
30‡	2.11	3.37	3.21	3.29	1.13	2.07	2.53
60‡	1.88	3.37	2.94	3.45	1.11	2.22	2.50
120‡	1.99	3.49	3.07	3.71	0.99	2.21	2.58
60† + 60‡	1.95	3.52	3.22	3.57	1.54	2.25	2.67
120† + 60‡	2.16	3.65	3.21	3.26	1.55	2.16	2.67
C.D., 5%	0.17	0.38	0.64	0.43	NS	NS	
Avail. K, mg/kg	46.7	30.8	35.5	51.9	75.0	55.5	

†, ‡ = K applied basally and at flowering, respectively

Table 5. Seed yield and profitability for short- and long-season high yielding, American cotton varieties at different levels of applied K.

Applied K_2O, kg/ha	LH 900 Seed yield, t/ha	LH 900 Added net profit, US$/ha	F 286 Seed yield, t/ha	F 286 Added net profit, US$/ha
0	2.09	–	1.42	–
30	2.40	62.0	1.61	31.5
60	2.51	72.5	1.67	36.9
90	2.65	93.4	1.74	44.4
C.D. (5%)	0.29		0.22	

Cotton response to K fertilizer also depends on soil N availability and the amount of applied N. Milap-Chand et al. (1996) examined different N/K combinations for non-hybrids grown in the north zone and obtained their best seed yield (and profit) using 75 kg N/ha plus 50 kg K_2O/ha (**Table 4**).

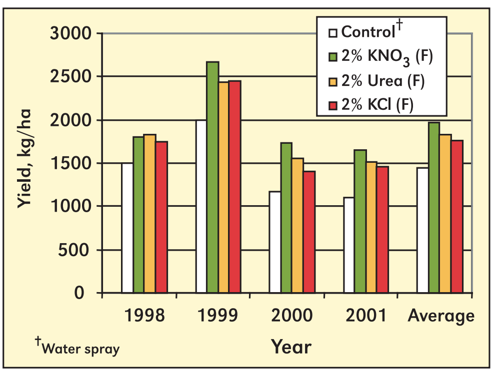


Figure 2. Effect of foliar application of nutrients on the yield (kg/ha) of seed cotton.

Foliar K Sources

The benefits of foliar-applied K and N sources, used in addition to recommended rates of basal N and P, were examined in 4 years of field experimentation (Brar and Brar, 2003). All plots received a uniform application of 75 kg N plus 30 kg P_2O_5/ha, which was followed by three mid-season foliar applications spaced at weekly intervals. Potassium nitrate (KNO_3) solution produced the highest average yield increase of 36% over the control (**Figure 2**). Foliarly applied solutions containing either urea or potassium chloride (KCl) produced significant, but lesser yield increases of 27% and 22%, respectively. Researchers noted that all test soils were unable to meet the high daily N and K requirements during flowering and boll development, hence the effectiveness of these supplemental foliar N and K applications.

Cultivar Selection

Inadequate mid-season K supply capacity was also highlighted in a study comparing high yielding American cultivars and responses to applied K (Milap-Chand and Kapoor, 1995). In particular, the short duration LH 900 variety was more responsive than the longer duration F 286 variety, a response attributed to a higher K demand per unit of time that exceeded soil supply capacity (**Table 5**). Despite this, seed yields as well as net profits were higher for the well-fertilized, short duration cultivar, which demonstrates their suitability to conditions in northwestern India.

Table 4. Yield (kg/ha) of high-yielding American seed cotton varieties and profitability at various combinations of applied N and K in cotton production.

Applied N, kg/ha	Applied K_2O, kg/ha 0	25	50	Added net profit, US$/ha 0	25	50
25	1,639	1,695	–	–	6.7	–
50	1,720	1,808	1,869	14.4	28.0	35.8
75	1,829	1,937	2,027	34.8	52.8	66.8
100	–	1,900	1,977	–	34.9	46.1

The inclusion of K for farmer fertilization schedules should be considered mandatory if a competitive, high yielding, seed cotton production system is desired for the states of northwestern India.

Dr. M.S. Brar is the Senior Soil Chemist and Professor in the Department of Soils, Punjab Agricultural University, Ludhiana, India. Dr. K.N. Tiwari is Director, PPIC-India Programme, Gurgaon, Haryana.

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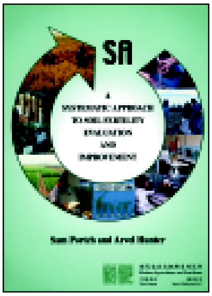
Minor Corrections to Book: *A Systematic Approach to Soil Fertility Evaluation and Improvement*



Corrections to graphs on two pages of the publication *A Systematic Approach to Soil Fertility Evaluation and Improvement* have been identified. The book, authored by Dr. Sam Portch and Dr. Arvel Hunter and produced in cooperation with Canpotex (Hong Kong) Limited, became available in 2002.

For individuals with copies of the publication, corrected graphs for pages 14 and 57 are available as PDF files by visiting this website: **>www.ppi-ppic.org/sabook<.** Those without internet access may contact the PPIC office in Saskatoon, Saskatchewan; telephone (306) 652-3535, fax (306) 664-8941, e-mail: gsulewski@ppi-ppic.org.

The 62-page book is written in six sections, each focusing on a different aspect of the systematic approach for soil fertility evaluation and improvement. It is available on request.