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Potassium Response against Incidence of Cotton Leaf Curl Virus Disease and its Effect on Seed Cotton Yield

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Abstract:
Seed cotton yield is being declined because of several environmental stresses (biotic and abiotic). Among these stresses, cotton leaf curl virus disease has caused a severe threat to the production of cotton crops in Pakistan. In this connection, a field experiment was conducted at Central Cotton Research Institute, Sakrand, Sindh for two consecutive years to determine response of potassium (K) nutrition against the infestation of CLCuV disease and seedcotton yield. The experiment was designed in randomized complete block (RCBD) with four replications. Three potassium were applied 0 (control), 50, 100, and 150 kg K_2O ha^{-1}. A basal dose of 170-60 kg N: P205 ha-1 was common to all the replications and the cultivar was Bt.CRIS-508. The results showed that yield and its related components i.e. boll formation plant-1, boll weight, and seed index were significantly improved by the addition of K application and were observed highest with the application of 150 kg K2O ha-1 on both consecutive years. Data for K concentration in different plant parts differed significantly and increased linearly with increasing K-level. Potassium concentration increased linearly with increasing K-levels. The absorption of K by various plant parts increased with a concurrent increase in varying levels of K-fertilizer. An averaged across levels, the relative K concentration in plant parts was found in decreasing in order of leaves, burs, stem, seed, and lint. Results for the incidence of CLCuV disease significantly reduced due to K levels. The K fertilizer application resulted in the reduction of CLCuV disease spread at its mild infection levels.

INTRODUCTION

Cotton is natural fibre and cash crop of Pakistan. In cotton production and consumption, Pakistan is 4th & 3rd largest in the world (Cotton Review, 2020). Biotic and a-biotic stresses both are responsible in yield reduction of cotton, with insect pests, pathogens (fungal and viral) and weeds all contributing to decreased production (USDA, 2017). However, the unbalanced use of fertilizers and CLCuV not only causing immense loss to cotton crop but also to Pakistan's economy too.

CLCuD is the most critical cotton disease amongst biotic stresses caused by CLCuV, transmitted through whitefly (*Bemisia tabaci* Genn.), it contains a single standard DNA virus which belongs to genus Begomovirus and family geminiviridoe (El-Nur, 1967; Xiong, 2004). The symptoms of disease comprises of up-ward curling of leaf margins (making cup-shape); on the lower surfaces of leaves, there is a visible thickening of the veins and enations (minor growths of the foliar surface). In the affected veins, the underside is opaque and dark green in color (Irshad *et al*., 2012; Iqbal *et al*., 2014). A well balanced fertilizer program will improve the plant's ability to recover from damage, which will reduce the susceptibility of the crop to CLCuV disease and increase the yield of cotton seed (Pervez *et al*., 2007).

CLCuV disease can be reduced through virus tolerant genotypes and proper nutrient management. Knowledge of potassium (K) nutrition and the relationship between plants and pests may assist developing strategies for setting up cotton production systems with high yields by minimizing disease incidence (Zafar and Athar, 2013). K significantly contributes in quality seed-cotton yield as an essential macro-nutrient (Wang and Chen, 2012). Cotton needs K in same amounts to that of nitrogen (Zia-ul-hassan and Arshad, 2010). K might increase the plant's resistance, because it is involved in osmoregulation, energy metabolism and high molecular compound synthesis (Kafkafi *et al*., 2001; Marschner, 2012). It affects the plant's morphology, tissues hardening increases plant resistance to certain diseases penetration and by encouraging strong root system, it tends to prevent undesirable logging of plants and helps counter the damaging effects of excessive nitrogen (Shah, 1996). On the other hand, the prices of mineral fertilizers are increasing day by day, and the growers cannot afford to purchase fertilizer in required quantities. Under-fertilization practices and imbalanced nutrition of crops therefore continues even today thereby adversely affecting the production targets.

With the above considerations in mind, the study was conducted to determine response of potassium nutrition to the infestation of CLCuV disease and seed-cotton yield.

MATERIAL AND METHODS

The experiments were conducted at Central Cotton Research Institute (CCRI), Sakrand, Sindh, Pakistan during two consecutive growing seasons, 2014-15 and 2015-16. Soil samples were taken before planting crop and the soil analysis followed as per methods prescribed by Ryan et al. (2001). The soil texture was silty clay loam, calcareous in nature and alkaline in reaction. In the fertility rating organic matter is low, nitrogen and phosphorus were scarce, and potassium was sufficient (Table 1).

Table 1. Physico and chemical characteristics of the experimental sites at pre-plant stages (0-30 cm).

Characteristics	Values
Texture	Silty clay loam
pH	8.1
ECe (dSm^{-1})	1.07 - 1.17
$CaCO_3$ (%)	8.7 - 9.2
Organic matter (%)	0.77 - 0.79
AB-DTPA extracted $NO^{3-}N$ (mg kg^{-1})	4.61 - 4.78
AB-DTPA extracted P (mg kg^{-1})	2.64 - 3.12
AB-DTPA extracted K (mg kg^{-1})	128 – 145

Cotton cultivar Bt.CRIS-508 (*G. hirsutum* L.) was sown late May during both the years at a spacing of 75 cm between rows and 20 cm between plants. The experiments were comprised of 4 treatments laid out in RCBD with four replications. The area of each plot was 105 m^2. The details of treatments are as under: T_1 = check (control), T_2 = 50 kg K_2O ha^{-1}, T_3= 100 kg K_2O ha^{-1} and T_4= 150 kg K_2O ha^{-1}. The soils were fertilized with 170 kg N ha^{-1} as urea (in three splits), 60 kg P_2O_5 ha^{-1} as DAP (diammonium phosphate) and recommended dose of K as sulphate of potash for basal application. Weeding and inter-culturing were done in all treatments throughout the season according to the crop's need. After undertaking pest scouting, the crop was protected from insect-pest attack by spraying a suitable insecticide at the appropriate time, and the crop irrigated as needed.

Seed-cotton plot-wise yield calculated on area basis (kg ha^{-1}) and its components i.e. number of bolls per plant, boll weight, seed index on 10 random plants were recorded at maturity. Plant samples collected randomly from each treatment at maturity were brought to laboratory and partitioned into leaves, stalks, burs, seeds and lint. The biological material was dried in a forced air-oven at 70°C to a constant weight and then ground to 40 mesh in a wily type micro mill for the determination of K concentration through wet digestion method (Ryan *et al*., 2001).

The results were subjected to separate statistical analysis using the analysis of variance technique. At a 5% probability level, the difference between treatment means was assessed using the least significant difference (LSD) test (Steel and Torrie, 1997).

RESULTSAND DISCUSSION

Application of potassium fertilizer in cotton crop significantly increase the seed cotton yield from 1860 to 2338 kg ha^{-1} on the year 2013-14 and 1720 to 2620 kg ha^{-1} on the year 2014-15 and it were increased 8.5, 17.1 and 25.7 percent on 2013-14, and 5.2, 19.7 and 52.3 percent on 2014-15 when applied at 50, 100 and 150 kg K_2O ha^{-1} respectively than control (Table 2). Yield components like boll formations, boll weight and seed index were also increased with increasing the level of potassium on the both growing seasons (Table 2). The yield of seed cotton, bolls $plant^{-1}$, boll weight and seed index increased significantly with increasing levels of potassium fertilizer were also reported by Pervez et al. (2007) and Makhdum et al. (2007).

The total potassium concentration in different plant parts increased significantly with increasing levels of K fertilizer. Maximum concentration of K was observed under 150 kg ha^{-1} compared to K unfertilized treatment (Table 3). On average, higher K concentration in different plant parts was found in the order to burs (1.99%) leaves (1.72%) stalk (1.08%) seed (0.99%) lint (0.79%). Makhdum *et al.* (2007) reported that, the application of K-fertilizer caused significant increase K concentrations in various organs, viz., leaves, stem, burs, seed, and lint compared to K-unfertilized treatment and further demonstrated that, the crop receiving 150 kg ha^{-1} maintained K in different proportions in different organs at maturity. The K concentration was much higher in leaves, stems and burs compared with seed and lint. An addition of higher dose of K fertilizer (i.e. 150 kg ha^{-1}) increased K concentration of 73.7, 43.8, 43.2, 39.1, and 24.2 percent in burs, seed, stems, lint and leaves compared with control treatments respectively. These results are also in agreement with those of Oosterhuis *et al*. (2000) and Kafkafi (2001).

Table 2. Impact of potassium fertilization on seed cotton yield and its components.

Treatments	K_2O (kg ha^{-1})	Bolls $Plant^{-1}$	Boll weight (g)	Seed index (g)	Seed cotton yield (kg ha^{-1})
Season (2014-15)					
T1	0	19^{b}	3.2^{c}	8.1^{b}	1860^{b}
T2	50	21^{b}	3.4^{b}	8.3^{ab}	2019^{b}
T3	100	22.5^{ab}	3.6^{a}	8.4^{ab}	2178^{ab}
T4	150	25.5^{a}	3.7^{a}	8.6^{a}	2338^{a}
LSD Value(p<0.05)		3.4	0.1	0.6	182.5
Season (2015-16)					
T1	0	27.14^{b}	3.2	6.9	1720^{c}
T2	50	29.92^{b}	3.3	7.2	1810^{c}
T3	100	32.76^{ab}	3.4	7.8	2059^{b}
T4	150	36.54^{a}	4.5	7.9	2620^{a}
LSD Value(p<0.05)		5.88	NS	NS	195.5

Table 3. Impact of potassium fertilization on potassium concentration (%) in plant tissues at maturity.

Treatments	K_2O (kg ha^{-1})	Leave	Stem	Burs	Seed	Lint
Season (2014-15)						
T1	0	1.52^{c}	0.95^{b}	1.71^{c}	0.68^{c}	0.61^{c}
T2	50	1.71^{bc}	0.99^{b}	1.93^{b}	0.89^{b}	0.69^{bc}
T3	100	1.85^{b}	1.15^{a}	2.15^{a}	0.98^{b}	0.83^{ab}
T4	150	2.16^{a}	1.21^{a}	2.28^{a}	1.18^{a}	0.87^{a}
LSD value (p<0.05)		0.23	0.13	0.19	0.18	0.14
Season (2015-16)						
T1	0	1.31^{b}	0.85^{c}	1.56^{c}	0.88^{b}	0.69^{c}
T2	50	1.43^{b}	1.03^{b}	1.88^{b}	0.92^{b}	0.75^{bc}
T3	100	1.78^{a}	1.19^{ab}	2.11^{ab}	1.15^{a}	0.91^{ab}
T4	150	1.97^{a}	1.25^{a}	2.32^{a}	1.21^{a}	0.98^{a}
LSD value (p<0.05)		19	0.16	0.21	0.13	0.20

In case of CLCuV incidence and severity data recorded at end of September from each treatment and computed for disease index are shown in Table 4. The level of disease index remained low (1.37 to 2.37) in season 2013-14 as compared to season 2014-15 (6.0 to 19.8).The maximum CLCuV incidence was recorded in K-unfertilized treatment (3.5 and 24 %) and minimum noted where applied 150 kg K_2O ha^{-1} (2.5 and 10 %) during season 2013-14 and 2014-15, respectively. The intensity of disease was reduced by 0 to 28.6 percentage on 2013-14 and 29.2 to 58.3 percentage on 2014-15 by the addition of 50 to 150 kg K_2O ha^{-1}. Similarly Pervez et al. (2007) reported that, the application of potassium fertilizer resulted in reduction of spread of CLCuV disease at its mild infestation level. The intensity of disease was reduced by 12 to 38 percent by the application of 62.5 to 250 kg K ha^{-1}. The decreasing trend in disease virulence showed the plant’s capacity to resist an infection towards CLCuV disease, through well balanced fertilizer practice.

Table 4. Impact of potassium fertilization onCLCuVdiseaseincidence, severity and disease index.

Treatments	**K_2O (kg ha^{-1})**	**Disease (%)**	**Severity**	**Index**
Season (2014-15)				
T1	0	3.5	2.71	2.37
T2	50	3.5	2.14	1.87
T3	100	3.0	2.30	1.72
T4	150	2.5	2.20	1.37
Season (2015-16)				
T1	0	24	3.30	19.80
T2	50	17	3.00	12.75
T3	100	14	2.85	9.80
T4	150	10	2.40	6.00

Disease Severity: 0 = Complete absence of symptoms, 1 = Small scattered vein thickening, 2 = Large groups of veins involved, 3 = All veins involved, 4 = All veins involved and severe curling.
Disease Index = Disease percentage x Disease severity/maximum severity value (4)

Perrenoud (1990) after the review of 2449 references observed that the addition of K significantly reduced the prevalence of nematodes by 33%, viruses by 41%, insect and mites by 63%, bacteria by 69%, and fungal disease by 70%. In the meantime, K boosted the production of plants infested with nematodes by 19%, viruses by 78%, insects and mites by 36%, bacteria by 57%, and fungal diseases by 42%. According to Wang *et al*. (2013) in a K-adequate plant, the synthesis of high-molecular-weight compounds (which includes proteins, starches and cellulose) was significantly increased, in that way depressing the concentrations of low-molecular-weight compounds i.e. soluble sugars organic acids, amino acids and amides, in the plant tissues. These low-molecular-weight compounds are vital for the insect attack and development of disease, so lower concentrations, thereby, leave plant less susceptible to disease and pest attacks in potassium sufficient plants (Marschner, 2012). Potassium enhances phenol amount, which play a crucial role in the resistant development in plants (Prasad *et al*., 2010). Mengel and Kirkby (1978) reported that K encourages the development of outer walls in epidermal cells, thus preventing disease infestation. Besides, potassium influenced the plant metabolism greatly;consequently, plant's resistance against diseases may be favored by changes in metabolism associated with high plant potassium content.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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