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INFLUENCE OF BIO-STIMULANT AND POTASSIUM SOURCES ON THE PRODUCTIVITY OF COTTON

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ABSTRACT

Bio-stimulants are formulated product of biological origin that improves plant productivity as a consequence of the novel or emergent properties of the complex of constituents. This study investigated the potential of bio-stimulant and potassium sources to improve the performance of cotton. The current study comprised of cotton cultivars i.e., CIM-573 and CIM-598, foliar spray of bio-stimulant (Moringa Leaf Extract) (MLE) alone and combined with potassium nitrate (K=2%, N=0.57%), muriate of potash (K=2%, Cl=1.5%) and potassium sulphate (K=2%, S=0.72%) keeping tap water spray as a control. The experiment was laid out in a Randomized Complete Block Design (RCBD) with factorial arrangement on a silt loam soil. Field study was conducted at Osmania Agricultural Farm, Shujabad (29.7686 °N, 71.3283 °E; 152 m asl) and Agronomic Research Area, Bahauddin Zakariya University, Multan (30.2639 °N, 71.5101 °E; 123 m asl), Pakistan during 2013. Results revealed positive effect of exogenously applied bio-stimulant and various potassium sources on the growth, yield and fiber quality of cotton cultivars at both sites. However, combined application of MLE and potassium nitrate produced significantly higher absolute and relative growth rate, leaf area index, number of green bolls, seed index, cotton seed and lint yield of Bt while plant height, fiber maturity and uniformity ratio in conventional cotton cultivar. Therefore, the present study suggests that foliar spray of MLE alone and in combination with potassium sources could be used to improve the productivity and quality of cotton. Exogenous application of MLE has a great effect on photosynthetic and enzymatic activities that appropriate the efficiency of utilizing nutrients and thereby its combined application with potassium nitrate improve the growth and seed cotton yield and quality characters in cotton.

Keywords: Bt cotton. cotton seed yield. fiber quality. Moringa leaf extract. potassium nitrate.

INTRODUCTION

Cotton (*Gossypium hirsutum* L.), the king of fibers is a prominent cash crop, grown mainly for fiber and oil seed in the temperate and tropical regions of the world (Killi *et al.*, 2005). This natural fiber used in numerous products, which range from clothing to home furnishing and medicinal products. It plays significant role in food and fiber industry and world consumption of cotton fiber is approximately 112 million bales (Campiche *et al*., 2016). Almost hundred million families from 150 countries are directly or indirectly involved in cotton trade and generated approximately $500 billion income per year (Chen *et al*., 2007).

Modern techniques in intensive production system such as effective and adequate nutrient management are one of the superlative possibilities for exploiting the cotton productivity on sustainable basis (Veeramani *et al*., 2008). Among the macronutrients, potassium has been found to be a vital element of nutrition program for high quality cotton production (Ahmed and Farooq, 2013). Its scarcity disturbs the translocation of photo-assimilates out of the cotton leaves, as absorption of nitrate, the principal form of soil nitrogen, involves in chemical energy which is consequent of photo-assimilates (Aladakatti *et al*., 2011). While potassium application improved the boll formation and its harvesting is primarily dependent on carbohydrate metabolism and their translocation from leaves to developing bolls (Sangakkara *et al*., 2000). It plays a significant part in osmoregulation, osmotic homeostasis of plants, stomatal regulation, protein synthesis, enzymatic activation, charge balance and maintenance of energy status (Cherel, 2004).

Bio-stimulants are plant extracts that encompasses a variety of bioactive compounds which enable to enhance the several physiological processes thus encourage optimum growth and development of crop plants with efficient utilization of nutrients, hence increase nutrient use efficiency and decrease the inorganic fertilizers use without affecting the quality and crop yield (Bulgari *et al*., 2015). Moringa (*Moringa oleifera*) is a well-known native tree of southern Punjab (Pakistan) and has proved as an excellent bio-stimulant being good source of essential, minerals, vitamins, antioxidant compounds and zeatin (Yasmeen *et al*., 2014). The moringa leaf extract (MLE) as a potential natural growth stimulant which is considered one of the most current alternative sources that can be used by growers as a potential supplement or substitute to chemical fertilizers (Phiri, 2010). Its foliar application plays a pivotal role in several physiological processes from seedling to senescence and enhances the productivity of crops up to 25–30% (Yasmeen *et al*., 2016).

A few studies were conducted on the influence of MLE and potassium sources on the growth, yield and fiber quality of cotton. It is hypothesized that exogenous application of MLE and sources of potassium may positively affect the growth, productivity and quality of cotton. Therefore, present study was undertaken to investigate the response of cotton cultivars to foliar spray of MLE and potassium under field conditions.

MATERIALS AND METHODS

Experimental and soil description: Field study was conducted to explore the role of bio-stimulant and potassium sources on growth and productivity of cotton cultivars at Osmania Agricultural Farm, Shujabad (29.7686 °N, 71.3283 °E; 152 m asl) and Agronomic Research Area, Bahauddin Zakariya University, Multan (30.2639 °N, 71.5101 °E; 123 m asl) during 2013.

Crop husbandry: Pre-soaking irrigation was used to the experimental area to produce the favorable seedbed conditions. At workable soil moisture level, fine seedbed was prepared by cultivating the area thrice and beds were formed with bed shaper. The net plot size was 4.5 m x 4.0 m consisted of 3 beds. Delinted seeds of conventional cotton cultivar CIM-573 and Bt cultivar CIM-598 were dibbled manually on 3rd April 2013. First irrigation was applied followed by dibbling to get maximum germination percentage. Subsequent irrigations were applied depending upon crop requirement until last week of August. Recommended dose (145 and 114 kg ha^{-1}) of nitrogen fertilizer for Bt and conventional cotton cultivar, respectively, was used in 3 identical splits i.e. at the time of sowing, start of blooming and peak flowering stage. While recommended dose of phosphorus and potassium fertilizers i.e. 56 and 62 kg ha^{-1} were applied at the time of sowing. Weeds were kept controlled with foliar spray pre emergence herbicide and two hand weedings at 18 and 35 DAS. All other agronomic practices were kept similar for each experimental unit.

The trial was laid out in a completely randomized block design with factorial arrangement having 3 repeats. The current study comprised of cotton cultivars i.e., CIM-573 and CIM-598, foliar spray of Moringa Leaf Extract (MLE) alone and combined with potassium nitrate (K=2%, N=0.57%), muriate of potash (K=2%, Cl=1.5%) and potassium sulphate (K=2%, S=0.72%) keeping tap water spray as a control. Bio-stimulant and potassium sources were foliarly applied twice on 30th June and 31st July between 10:00 and 11:30 am by using a hand sprayer. The soil texture was silt loam, with pH 8.3 and 7.90, EC 0.99 and 1.11 dS m^{-1}, total nitrogen 0.021 and 0.0521%, available phosphorus 0.003 and 0.007 mg kg^{-1}, exchangeable potassium 0.180 and 0.148 mg kg^{-1} and organic matter 0.34 and 0.66% in Shujabad and Multan, respectively.

Moringa leaf extracts preparation and analysis: Moringa leaf extract (MLE) was prepared by keeping in mind its chemical composition already mentioned in the literature given in Table 1. For preparation of moringa leaf extract, two fully-grown moringa trees located at Botanical garden, Bahauddin Zakariya University, Multan were selected. Fresh leaves and tender twigs were harvested, frozen overnight and pressed in a locally fabricated machine and filtered using Whatman No. 1 filter paper (Yasmeen *et al.,* 2014). Purified extract was centrifuged at 8,000 × *g* for 15 minutes to get supernatant and further diluted with distilled water ratio of 1:30 (MLE30) and used this diluted MLE for foliar spray (Yasmeen *et al.,* 2014).

Table 1. Chemical composition analysis of MLE according to Yasmeen *et al*., (2014).

Name of nutrient element/enzymes	Values
Total soluble protein (mg g^{-1})	1.40
Super oxide dismutase (SOD)	191.86
Peroxidase (POD)	21.99
Catalase (CAT)	7.09
Total phenolic contents (mg g^{-1})	8.19
Ascorbic acid (m mole g^{-1})	0.36
Gibberellins (mg g^{-1})	0.74
Zeatin (mg g^{-1})	0.96
Nitrogen (%)	1.933
Phosphorus (%)	0.180
Potassium (%)	2.187
Calcium (%)	2.433
Magnesium (%)	0.012
Zinc (mg kg^{-1})	38.333
Copper (mg kg^{-1})	3.50
Iron (mg kg^{-1})	544.00
Manganese (mg kg^{-1})	49.667
Boron (mg kg^{-1})	21.333

Morphological and fiber quality observation: At the start of blooming, ten plants were selected randomly in each experimental unit and tagged to record the data on various quality parameters through adopting standard procedures. Growth parameters were examined five times during growing seasons at both locations. The absolute growth rate was calculated by using the equation (AGR= $W_2 - W_1/ t_2 - t_1$) of Radford (1967) and articulated in g day^{-1}. Where, W_1 is the dry weight of leaves, stem and flowers sampled at time t_1 and W_2 is the dry weight of leaves, stem and flowers sampled at time t_2. Relative growth rate is the improvement in biomass per unit dry weight per unit time and was computed by the formula

(RGR=log W_2 – log W_1/ t_2– t_1) of Radford (1967) and expressed as g day^{-1}. Where, W_1 is the dry weight of leaves, stem and flowers sampled at time t_1 and W_2 is dry weight of leaves, stem and flowers sampled at time t_2. Leaf area index was calculated at various growth stages by adopting the equation (LAI= leaf area per plant/land area covered) recommended by Sestak *et al*. (1971). Fiber maturity and uniformity ratio was recorded according to Sundaram *et al.*, 2002. The crop was harvested when the cotton bolls were about 60% opened and data regarding agronomic and yield-related traits were recorded by following standard procedures.

Statistical analysis: Analysis of variance (ANOVA) of the collected data was carried out by using the statistical software M STAT C. Difference among various treatment means were compared by DMR test at 5% probability level (Steel *et al*., 1997).

Meteorological data: The meteorological data for growth period of crop was collected from the meteorological observatory, Central Cotton Research Institute, Multan (Figure 1).

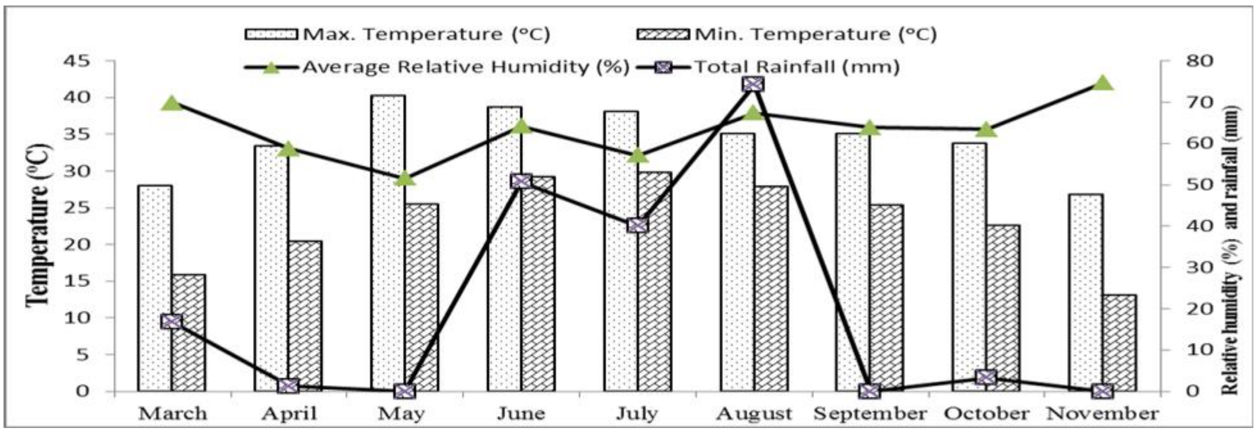

Figure 1. Meteorological data during crop period 2013.

RESULTS

Growth parameters: Exogenous application of bio-stimulant and potassium sources significantly affected absolute growth rate (AGR) at all growth stages excluding 71-100 DAS. While relative growth rate (RGR) recorded at different growth stages differed significantly at 41-70 and 101-130 DAS at both sites. Combined application of MLE and potassium nitrate produced higher growth parameters from CIM 598 against the lower were observed for CIM 573 from control plots (Figure 2 & 3).

Exogenously applied MLE and potassium sources significantly affected the LAI at all the growth stages excluding 40 and 100 DAS at both locations (Figure 4). Combined application of MLE and potassium nitrate produced higher LAI for CIM 598. While minimum leaf area index was observed for CIM 573 from control plots.

Foliarly applied MLE and potassium sources significantly affected the plant height at both sites (Figure 5). Application of MLE and potassium nitrate produced significantly taller plants of CIM 573. Whereas minimum plant height was observed in CIM-598 from control plots.

Yield parameters: Exogenously applied bio-stimulant and potassium nitrate produced significantly higher number of bolls per plant in CIM 598 against the lower was observed for CIM 573 from control plots (Figure 6).

Application of MLE and potassium sources significantly affected the seed index in both sites (Table 1). Higher seed index (8.21 g and 7.58 g) were observed for CIM 598 due to exogenous application of MLE and potassium nitrate at Multan and Shujabad, respectively. While, foliarly applied distilled water and muriate of potash produced minimum seed index (7.14 g and 7.23 g) for CIM 573.

Data regarding the cottonseed yield and lint yield differed significantly due to exogenously applied MLE and potassium sources in both sites (Table 2). Maximum cottonseed yield (1880 and 1964 kg ha^{-1}) and lint yield (1315 and 1305 kg ha^{-1}) recorded for CIM 598 with the application of MLE and potassium nitrate at Multan and Shujabad. Minimum cottonseed yield (922.6 and 1278 kg ha^{-1}) and lint yield (586.3 and 760.9 kg ha^{-1}) was observed for CIM 573 from control plots.

Fiber quality parameters: Exogenous application of MLE and potassium sources on cotton cultivars had non-significant influence on fiber maturity ratio at Multan (Table 2). However, exogenously applied MLE and potassium nitrate produced significantly higher fiber maturity ratio (0.8967) against the lower (0.8320) was observed in Bt cotton cultivar from control plots in Shujabad.

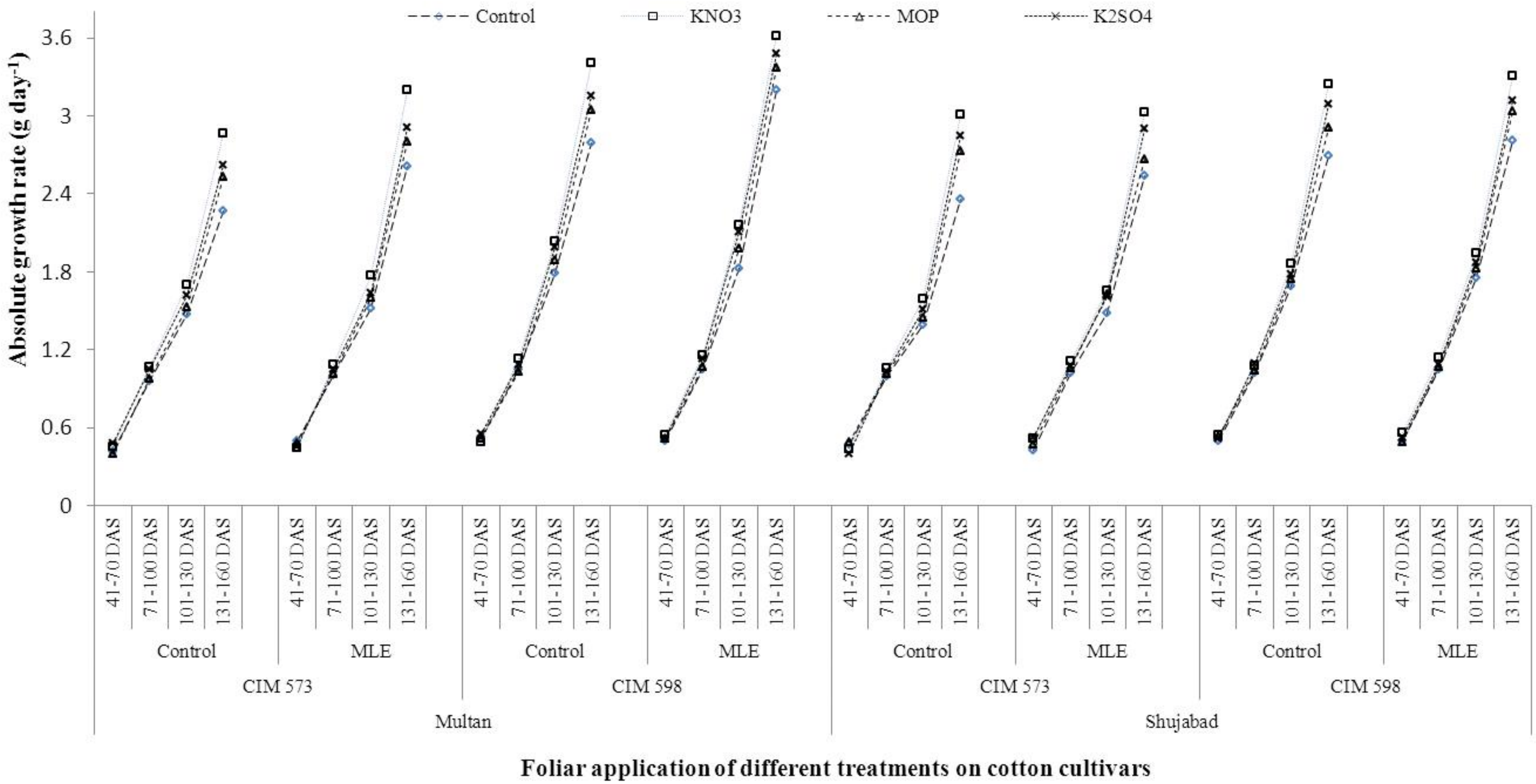

Figure 2. Influence of of bio-stimulant and potassium sources on absolute growth rate (g day^{-1}) of cotton cultivars in Multan and Shujabad
Where F_1= foliar spray of tap water, F_2= foliar spray of MLE, K_1= foliar spray of tap water, K_2= foliar spray of KNO_3, K_3=foliar spray of MOP, K_4= foliar spray of K_2SO_4

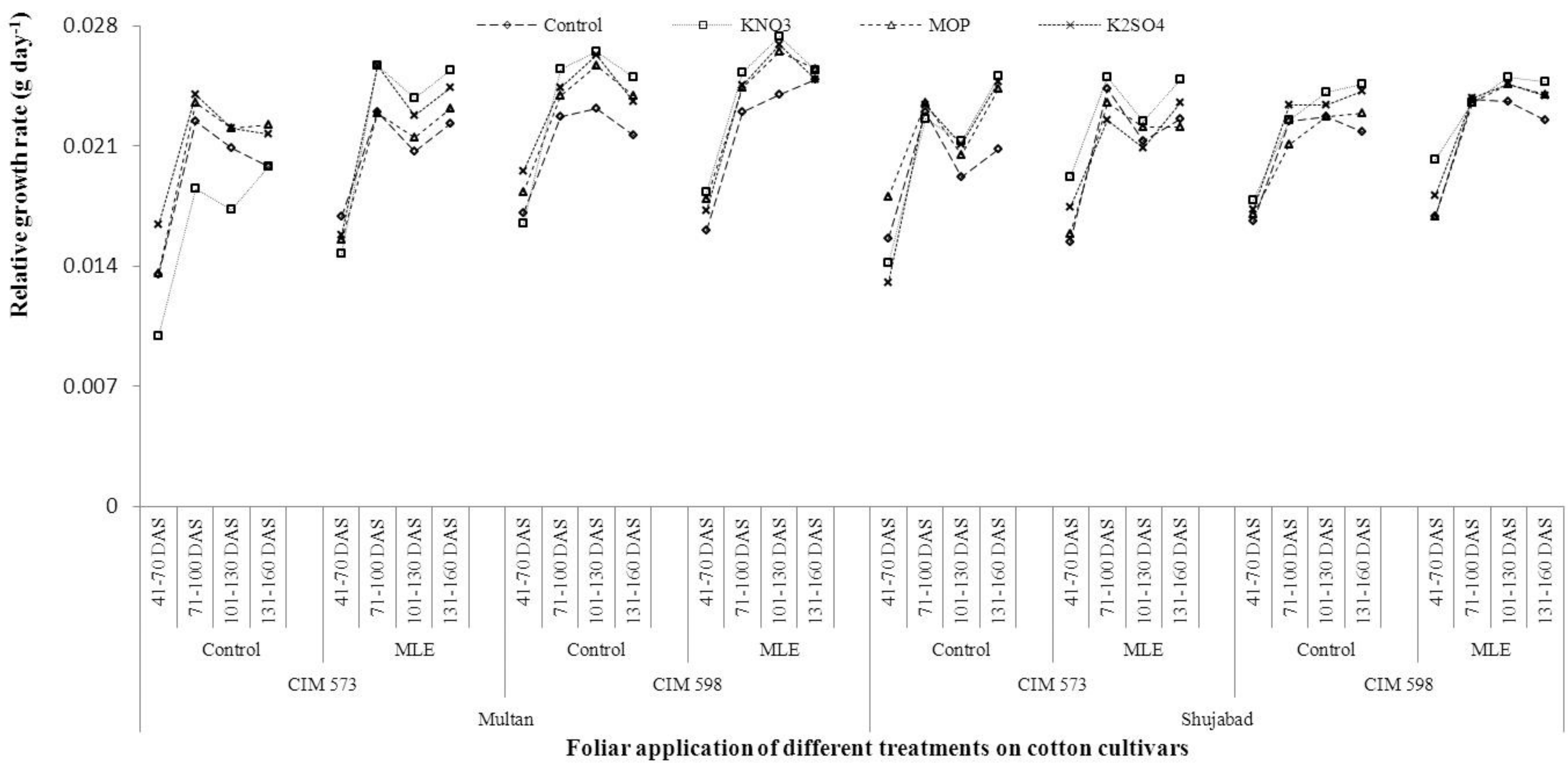

Figure 3. Influence of of bio-stimulant and potassium sources on relative growth rate (g g^{-1} day^{-1}) of cotton cultivars in Multan and Shujabad
Where F_1= foliar spray of tap water, F_2= foliar spray of MLE, K_1= foliar spray of tap water, K_2= foliar spray of KNO_3, K_3=foliar spray of MOP, K_4= foliar spray of K_2SO_4

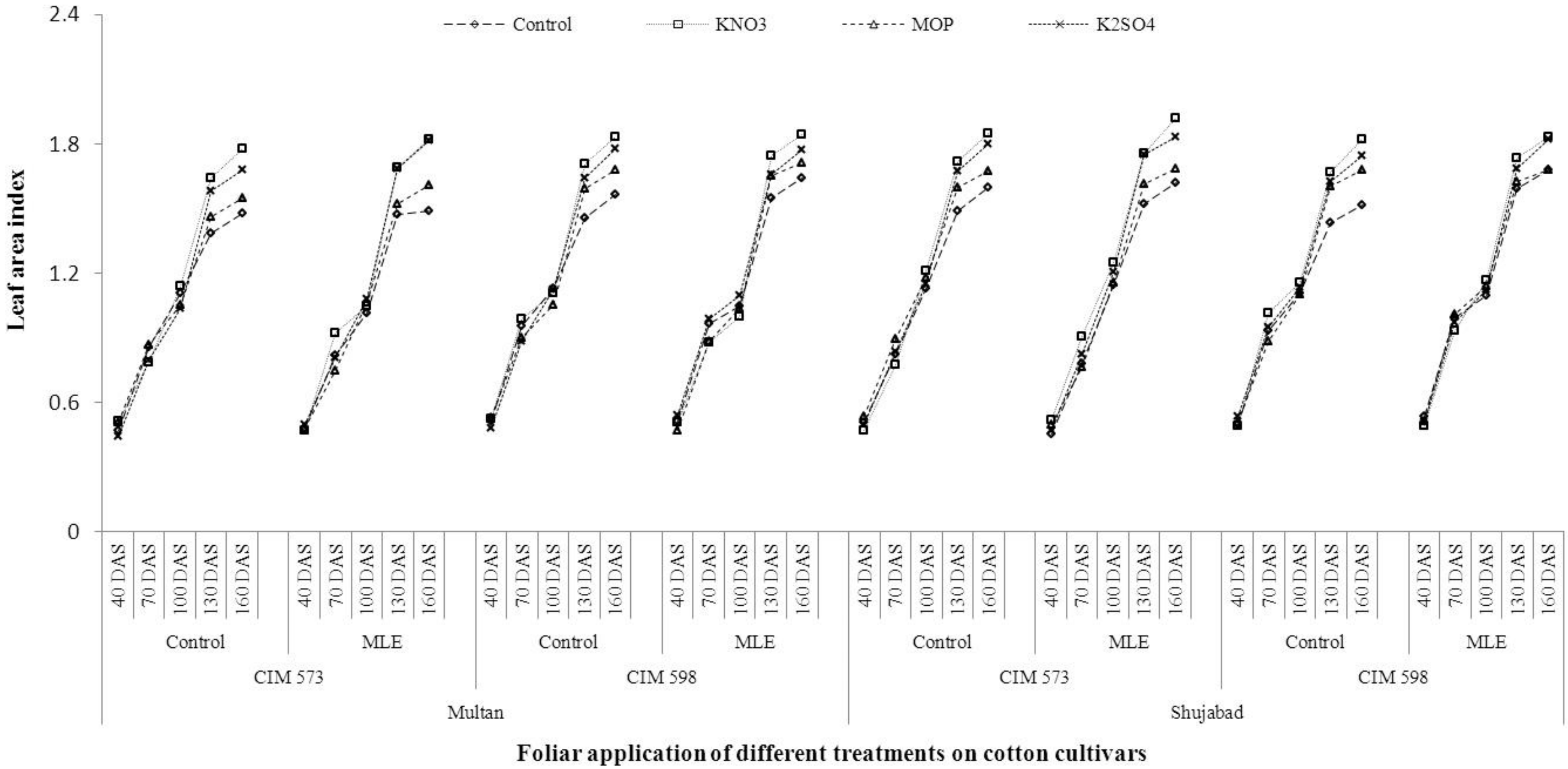

Figure 4. Influence of of bio-stimulant and potassium sources on leaf area index of cotton cultivars in Multan and Shujabad
Where F_1= foliar spray of tap water, F_2= foliar spray of MLE, K_1= foliar spray of tap water, K_2= foliar spray of KNO_3, K_3=foliar spray of MOP, K_4= foliar spray of K_2SO_4

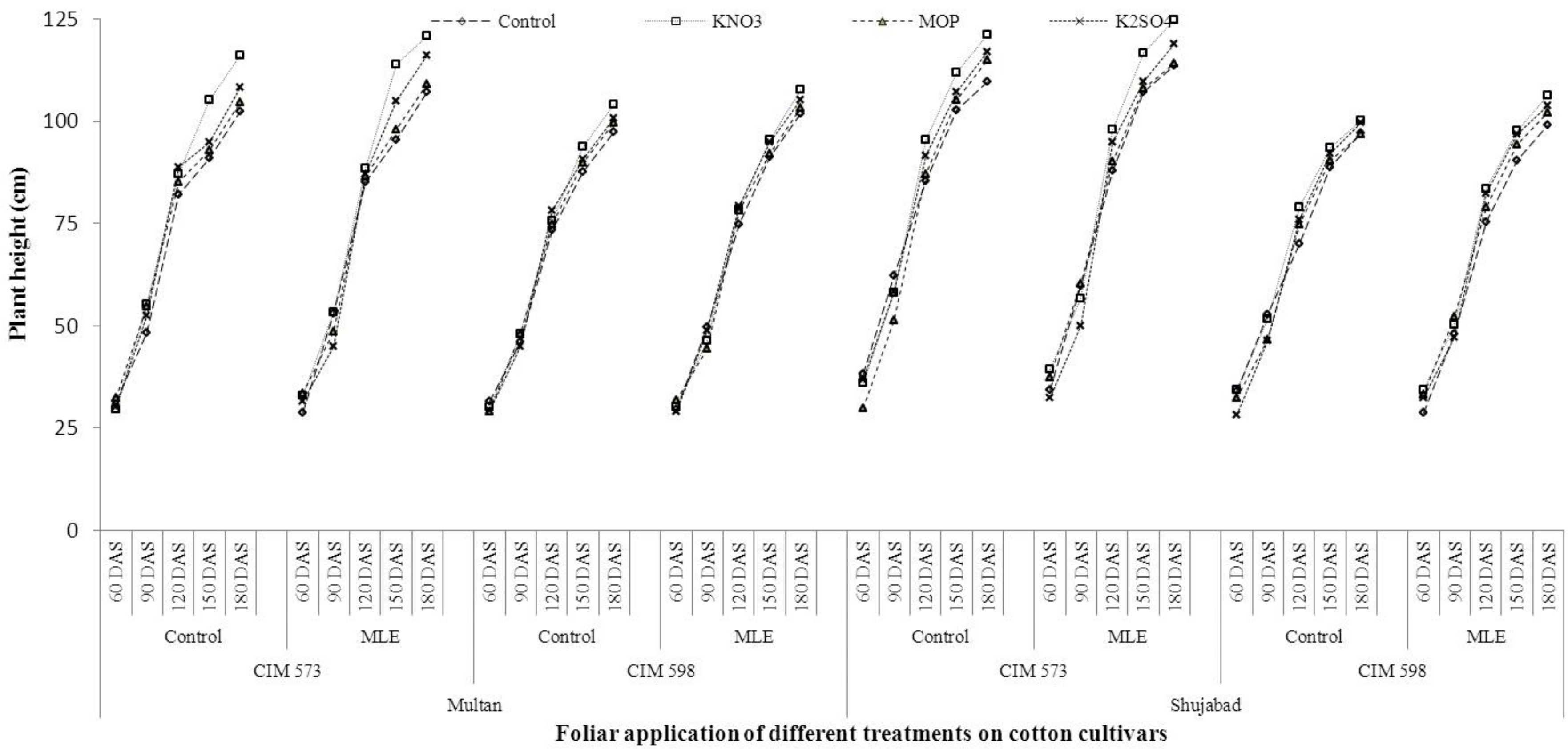

Figure 5. Influence of of bio-stimulant and potassium sources on plant height (cm) of cotton cultivars in Multan and Shujabad.
Where F_1= foliar spray of tap water, F_2= foliar spray of MLE, K_1= foliar spray of tap water, K_2= foliar spray of KNO_3, K_3=foliar spray of MOP, K_4= foliar spray of K_2SO_4

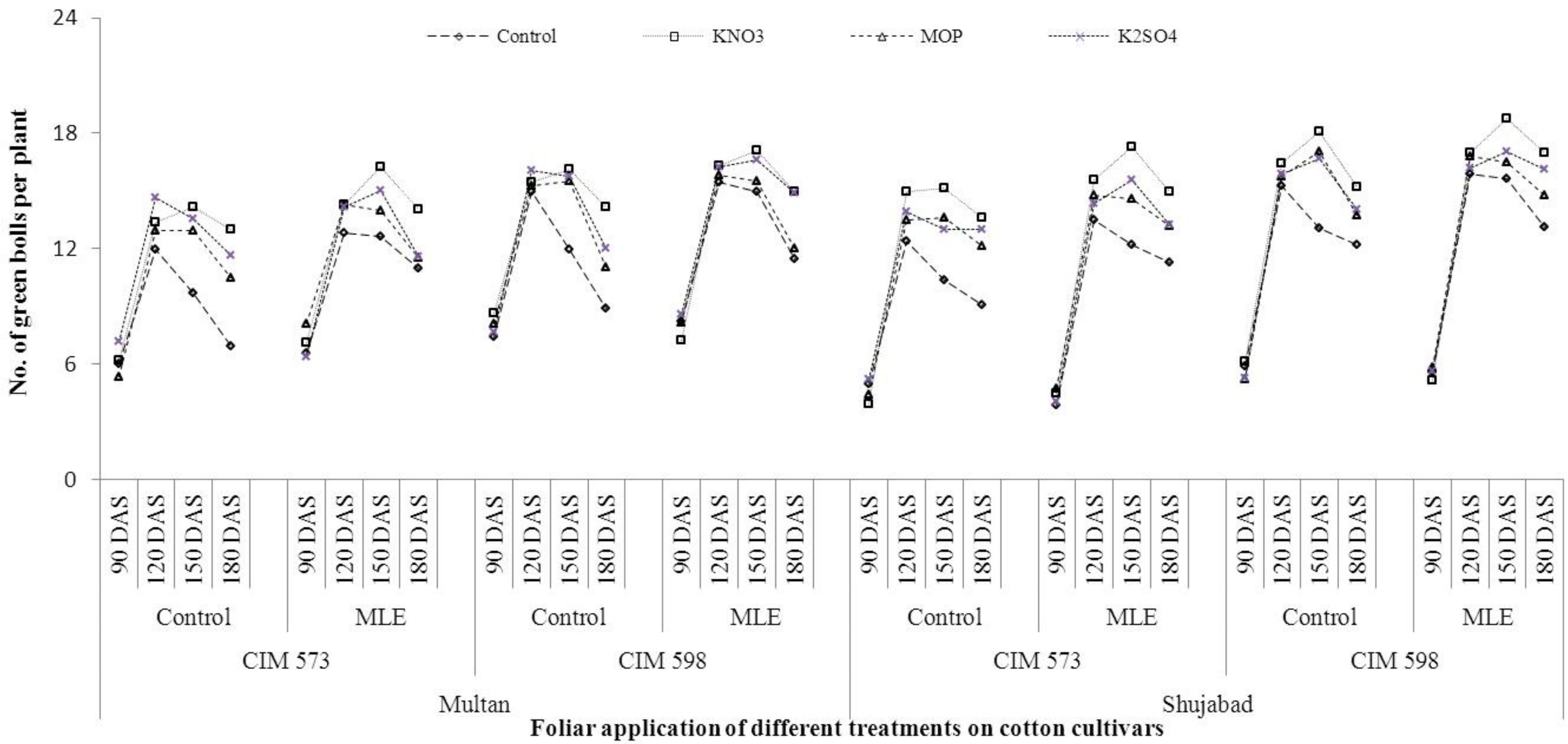

Figure 6. Influence of of bio-stimulant and potassium sources on number of green bolls per plant of cotton cultivars in Multan and Shujabad.
Where F_1= foliar spray of tap water, F_2= foliar spray of MLE, K_1= foliar spray of tap water, K_2= foliar spray of KNO_3, K_3=foliar spray of MOP, K_4= foliar spray of K_2SO_4

Table 2. Influence of of biostimulant and potassium sources on yield and fiber quality parameters of cotton cultivars in Multan and Shujabad.

Treatments		**Seed index (g)**		**Cotton seed yield (kg ha^{-1})**		**Lint yield (kg ha^{-1})**		**Fiber maturity ratio**		**Fiber uniformity ratio**	
Cotton cultivar	Foliar spray	Multan	Shujabad	Multan	Shujabad	Multan	Shujabad	Multan	Shujabad	Multan	Shujabad
CIM 573	F_1K_1	7.14 e	7.24ab	922.6 h	1278. c	586.3 g	760.9d	0.88	0.89ab	85.45 a	85.22 b
	F_1K_2	7.71 ae	7.38 ab	1236.dh	1580. ac	832.4 df	1037.ad	0.88	0.88ab	85.98 a	85.75ab
	F_1K_3	7.53 be	7.23 b	1033.gh	1356.bc	717.1 fg	850.5cd	0.89	0.89ab	85.80 a	85.88ab
	F_1K_4	7.62 be	7.33 ab	1152.eh	1443.bc	731.7 fg	992.8 ad	0.90	0.90a	86.22 a	86.06ab
	F_2K_1	7.39ce	7.27 ab	1130.fh	1356.bc	758.3eg	903.9bd	0.89	0.88ab	85.80 a	85.70b
	F_2K_2	8.04 ab	7.43 ab	1429.cf	1727.ac	977.3bd	1090.ad	0.89	0.90a	86.88 a	87.05a
	F_2K_3	7.6 be	7.4 ab	1379.cf	1558. ac	876.2 df	945.5bd	0.89	0.89ab	86.00 a	85.67b
	F_2K_4	7.68 ae	7.34 ab	1352.cg	1562.ac	927.4be	1060.ad	0.89	0.88ab	86.68 a	85.94ab
CIM 598	F_1K_1	7.30 de	7.39 ab	1180.eh	1479.ac	811.7df	874.6cd	0.84	0.84ab	81.87 c	82.20 c
	F_1K_2	7.82 ad	7.56ab	1683.ac	1838.ab	1108. b	1217.ab	0.84	0.83b	83.05bc	82.95c
	F_1K_3	7.69 ae	7.45ab	1471.ce	1571.ac	976.5bd	968.1bd	0.84	0.84ab	82.51bc	82.64c
	F_1K_4	7.67 ae	7.42 ab	1544.bd	1694.ac	1071.bc	1085.ad	0.84	0.84ab	82.82bc	82.49c
	F_2K_1	7.48 be	7.41 ab	1402. cf	1484. ac	893.1 cf	972.1 bd	0.85	0.84ab	82.66bc	82.39c
	F_2K_2	8.21 a	7.58 a	1880. a	1964. a	1315. a	1305. a	0.84	0.84ab	82.94bc	82.81c
	F_2K_3	7.92 ac	7.45 ab	1622.ac	1612. ac	1091. b	1079.ad	0.84	0.84ab	83.05bc	82.95c
	F_2K_4	7.97 ac	7.42 ab	1796.ab	1769.ac	1283. a	1171.ac	0.84	0.85 ab	83.42b	83.08c
LSD 0.05*p*		0.50	0.29	291.3	419.99	170.41	281.76	n.s	0.023	1.29	1.20

Where F_1= foliar spray of tap water, F_2= foliar spray of MLE, K_1= foliar spray of tap water, K_2= foliar spray of KNO_3, K_3=foliar spray of MOP, K_4= foliar spray of K_2SO_4

Foliar application of MLE and potassium sources significantly affected the fiber uniformity ratio at both sites (Table 2). Exogenously applied MLE and potassium nitrate produced significantly higher fiber uniformity ratio (86.88 and 87.05) against the lower (81.87 and 82.20) was observed in Bt cotton cultivar from control plots at Multan and Shujabad.

DISCUSSION

Application of bio-stimulants in agriculture modified the plant constituents and improved the growth parameters; increased quantitative and qualitative yield attributes (Rademacher, 2015). Among various bio-stimulants, moringa leaf extract (MLE) possess highly content of essential, minerals, vitamins, antioxidant compounds and zeatin. This diverse composition indicates that MLE can be used as a plant bio-stimulant for promoting crop growth and productivity (Arif *et al*., 2019).

In our study, exogenous application of bio-stimulant and potassium sources enhanced the growth parameters of cotton cultivars. However, exogenously applied MLE and potassium nitrate produced significantly higher absolute and relative growth rate and leaf area index compared to other potassium sources and control. This might be due to existence of growth promoting hormones and essential minerals in MLE and potassium nitrate that enhanced the photosynthesis and enzyme activity (Sangakkara *et al*., 2000), which leads to a higher photo-assimilate production in the plants tissue (Yasmeen *et al*., 2013). These photo-assimilates with more transported from the leaves ensured higher accessibility of assimilate for the sink tissues which indicated that the leaf area index is the basic factor for enhancing the cotton productivity (Pettigrew, 2003). The difference in growth parameters between cotton cultivars credited to the use of various types of genetic material and effective exploitation of natural resources and inputs (Wang *et al*., 2014). Similarly, exogenously applied bio-stimulant and potassium sources improved the plant height of cotton cultivars. Foliar spray of MLE and potassium nitrate produced taller plants, which might be due to the improved photosynthesis and boosted the cell division and enlargement (Yasmeen *et al*., 2018). Taller plants from CIM 573 might be due to the variation in genetic material and effective exploitation of resources (Yasmeen *et al*., 2016).

Higher green bolls and seed index with the foliar spray of MLE and potassium sources significantly improved the cotton productivity. Application of these treatments might have assisted in enhancing photosynthetic activity, contributing and translocation of photo-assimilates to amplify carbohydrate during boll development stage (Yasmeen *et al*., 2016). MLE being enriched source of nutrients and growth stimulating hormone zeatin that enhanced the process of photosynthesis, which improves the blossoming and fruit formation (Moyo *et al*., 2011). While potassium positively contributed in the condensation of simple sugars form, in complex carbohydrates and their translocation to the reserve organs (Dewdar and Rady, 2013). Potassium is also essential for effective translocation and conversion of sugars into starch, which improved boll weight and ultimately cottonseed and lint yield (Dewdar and Rady, 2013). Likewise, dominance in genetic material of CIM 598 that warped into higher number of reproductive branches and bolls per plant with more seed index and produced higher cotton seed and lint yield (Yasmeen *et al*., 2016).

Application of potassium have significant role in fiber development and improved cell elongation; therefore, its application improved the fiber attributes of both cotton cultivars (Aladakatti *et al*., 2011). However, present results exhibited variations in the response of fiber attributes to exogenously applied bio-stimulant and potassium sources. As indeterminate growth habit of cotton, and differences in genetic material in development rate, may the reason of indecisive fiber properties (Gormus and Yucel, 2002). As the distinct bolls may just be beginning fiber elongation; while others initiating the fiber thickening and some may be absolutely mature on the same day.

Conclusion: The present study suggests that foliar spray of MLE alone and in combination with potassium sources could be used to improve the productivity and quality of cotton. Exogenous application of MLE has a great effect on photosynthetic and enzymatic activities that appropriate the efficiency of utilizing nutrients and thereby its combined application with potassium nitrate improve the growth and seed cotton yield and quality characters in cotton.

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