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Research Article

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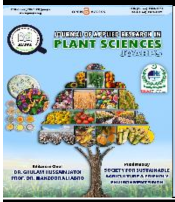

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Effect of Organic Manure and Foliar Application of Boron on Morphological and Economic Parameters of Sindh-1 and CKC-3 Cultivars of Cotton Under Semi-arid Climate

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Abstract

Cotton (*Gossypium hirsutum* L.) has a central position in agriculture, similarly it adds to Pakistan's economy as trade profit. Most of the cotton growing areas of Pakistan are deficient in organic matter due to continuous mono-cropping. Concerning these issues, a one-year field research was conducted during Kharif season in 2021 to evaluate the effect of organic manure and foliar application of boron on morphological and economic characters of CKC-3 and Sindh-1 cultivars under semi-arid climate. Treatments included soil applied farmyard manure (FYM) and foliar application of boron (B): T_1 = Control (0 FYM + 0 B), T_2 = FYM @10 tons/ha^1, T_3 = 1% B, T_4 = 2% B, T_5 = FYM @10 tons/ha^1 + 1% B, T_6 = FYM@10 tons/ha^1 + 2% B. Our results suggested that the treatment of soil applied FYM and foliar applied B @ FYM 10 tons/ha^1 + 2% B significantly ($P \leq 0.05$) influence the morphological characters including, sympodial branches per plant, opened bolls per plant, seed cotton weight per plant (g), seed cotton yield (kg ha^{-1}), lint yield per plant (g), and GOT (%) of both Sindh-1 and CKC-3 cultivars of cotton. However, CKC-3 performed better than Sindh-1 cultivar in most of the growth and yield related parameters under different treatment regimes. Hence, the optimum FYM and B foliar application levels for economical cotton production was considered to be FYM @10 tons/ha^1 + 2% boron along with recommended dose of NPK fertilizers under semi-arid climate.

Keywords: Cotton, Organic manure, Boron, morphology, Economic parameters, Semi-arid environment

Introduction

Cotton (*Gossypium hirsutum* L.) belongs to *Gossypium* genus and *Gossypieae* tribe of the *malvaceae* family, which is cultivated for natural fiber, oil seed and protein sources. Cotton is native to arid to semi-arid areas of tropic and sub-tropic regions of the world (Razzaq *et al.*, 2021). Cotton accounts 80% of the world's natural fiber production (Townsend, 2020). Cotton accounts for 1.5% in GDP and 7.1% in agriculture value addition of Pakistan (Jan *et al.*, 2020). Climate change effects such as high temperature, alteration in annual rainfall patterns, impure seed quality, imbalanced application of organic manure such as farm yard manure (FYM) and micronutrients including boron significantly reduce the quality of yield and production of cotton (Qamar *et al.*, 2020; Rashid & Rafique, 2002; Yeates, Constable, & McCumstie, 2010). The arable land of the country has been disturbed because of continuous usage of inorganic supplements to crop which consequently reduce the quality of soil to produce high quality crop yield. The FYM is a common form of organic supplement for soil which fertile the soil and results satisfying crop yield. FYM has long been used for maintaining the fertility of arable land for crop production, and is the source of multiple nutrients and organic matter for soil (Dao & Cavigelli, 2003). It has been observed that the manure improves the overall physical, chemical and biological properties of soil (Ahmed, Inoue, & Moritani, 2010). Studies also suggested that the porosity of soil, water infiltration level and structural quality was consequently improved using FYM (Fares, Abbas, Ahmad, Deenik, & Safeeq, 2008; Hati, Mandal, Misra, Ghosh, & Bandyopadhyay, 2006). Similarly, boron is important for proper growth and development of plants and is required in small amount by crop plants however, its deficiency can significantly reduce the growth and yield traits of plant, and also disturb several metabolic processes including photosynthesis and secondary metabolites regulation (Wang, Yang, Pan, Liu, & Peng, 2015). Boron deficiency problems have widely been identified in arid and alkaline soils and cause a significant decrease in crop yield by negative impact on vegetative stages (Bell & Dell, 2008; Broschat, 2005; Hajiboland, Bahrami-Rad, Bastani, Tolrà, & Poschenrieder, 2013; Patnude & Nelson, 2012; Tewari, Kumar, & Sharma, 2010). Understanding the importance of FYM and boron, present study was conducted in semi-arid region to evaluate the effect of organic manure and foliar application of boron on morphological parameters of Sindh-1 and CKC-3 cultivars of cotton to examine how these both components regulate the crop growth and yield traits.

Materials and Methods

Experimental site and Plant material: The field experiment was conducted at experimental field of department of Agronomy, Sindh Agriculture University Sub-Campus Umerkot during kharif season 2021 to evaluate the effect of organic manure and foliar applications of boron on agronomical parameters of selected cotton cultivars (Sindh-1 and CKC-3) under semi-arid climate.

Experimental plot design: The experimental plot design was Randomized Complete Block Design (RCBD) with two factors, main plot was verities, and the sub plots were treatments.

Soil Physio-chemical properties of experimental field: The experiment was conducted in clay silty loam textured soil. Soil texture analysis includes 21% sand, 38% silt and 41% clay respectively. Soil chemical analysis includes EC (dSm^{-1}) 2.29, soil pH 8.0, Organic matter 0.73%, and Total Nitrogen 0.02% (Table 1).

Fertilizers management: NPK fertilizers were applied as N in the form of urea (120 Kg ha^1), P in the form of P_2O_5 (60 Kg ha^1) and K as Sulphate of Potash SOP (50 Kg ha^1). All P_2O_5 and K_2O along with 25% N were applied at the time of sowing by mixing in the soil, while remaining N was split into two splits. First split 50% N was applied at squaring and the remaining 25% at flowering stage.

Treatments: Treatments included soil applications of farmyard manure (FYM) and foliar application of boron (in the form of borex): T_1= Control (0 FYM + 0 Boron), T_2= FYM @10 tons/ha^1, T_3= 1% B, T_4= 2% B, T_5= FYM @10 tons/ha^1 + 1% B, T_6= FYM@10 tons/ha^1 + 2% B.

Table 1. Soil Physio-chemical Properties of experimental fields

Soil Test	Before sowing
Soil texture analysis	
Sand %	21
Silt %	38
Clay %	41
Soil chemical analysis	
EC (dSm^{-1})	2.29
Soil pH	8.0
Organic matter (%)	0.73
Total N %	0.02
Textural class	Clay silty loam

Agronomic management: Agronomic practices including intercultural practices, weed and insect pest management were adopted equally in the experimental field.

Traits management: A total of 10 plant samples were averaged from each treatment as described by (Arif *et al.*, 2022; Panhwar *et al.*, 2022). Ten randomly selected plants from each variety named Sindh-1 and CKC-3 were measured for average plant height (cm), Sympodial branches per plant and opened bolls per plant at maturity stage. Seed cotton was picked and weighted in grams using electric balance. After that the yield of seed cotton per plant was calculated. Seed cotton yield kg ha^1 was computed from seed cotton yield per plot. The ginning out-turn was calculated for each sample by dividing the weight of ginned lint by the initial seed cotton weight. The lint obtained from each plant was weighed in grams to calculate the lint yield per plant (g).

Statistical analysis: Statistix 8.1 software was used for the calculation of ANOVA, and the Least Significant Difference (LSD) method was used to compare the treatments as well as difference between variety and treatment. (Williams & Abdi, 2010).

Results

Plant height (cm): The morphological characteristics of crop response to nutrient and fertilizer as per their need. Similarly, the results of the study suggested different responses of soil applied FYM and foliar applications of boron on plant height (cm) in Sindh-1 and CKC-3 cultivars. The analysis showed significant difference ($p \leq 0.05$) among the treatments for plant height. For instance, in control plots (T1) containing no use of FYM and/ or boron showed 114 cm and 125.7 cm of plant height in Sindh-1 and CKC-3 cultivars. Comparing the results, it was found that T6 (FYM @10 tons/ha^{-1} + 2% B) resulted maximum plant height (133 cm) and (146.3 cm) in Sindh-1 and CKC-3 cultivars respectively. However, data showed the significant difference between different treatments as well in cultivars (Figure 1).

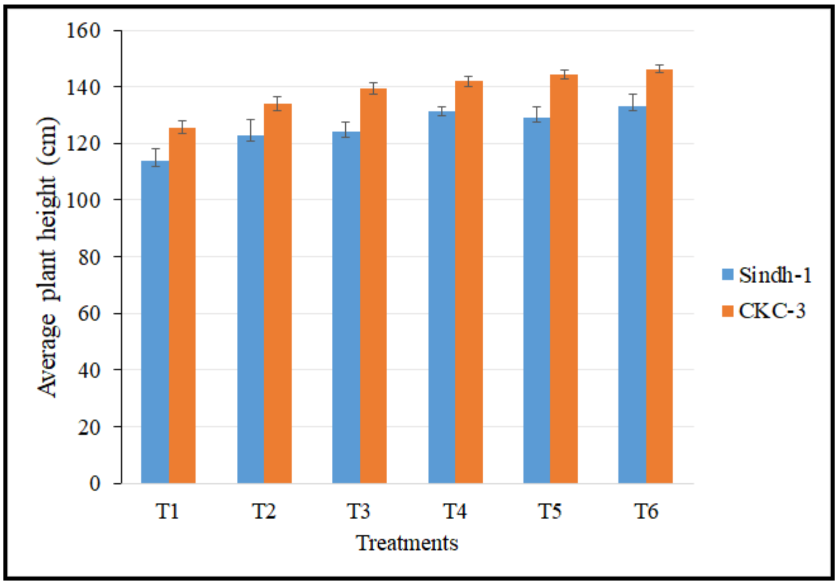

Figure 1. Average plant height (cm). The bars chart represents the plant height of Sindh-1 and CKC-3 cultivars. Treatments include T1= Control (0 FYM + 0 Boron), T2= FYM @10 tons/ha^1, T3= 1% B, T4= 2% B, T5= FYM @10 tons/ha^1 + 1% B, T6= FYM@10 tons/ha^1 + 2% B.

Sympodial branches per plant: Sympodial branches are fruit bearing, resulting in seed cotton development in plants. Soil applied FYM and foliar application of boron showed a positive impact on the growth and development of sympodial branches in Sindh-1 and CKC-3 cultivars. Results showed that CKC-3 performed better in number of sympodial branches as compare to Sindh-1 cultivar. The maximum number of sympodial branches in Sindh-1 and CKC-3 was 16.7 and 21 in response to T6= FYM@10 tons/ha^1 + 2% B, followed by 16 and 19 branches in response to T5= FYM @10 tons/ha^1 + 1% B. The lowest number of sympodial branches 12 and 15 was found in T1= Control (0 FYM + 0 Boron) respectively (Figure 2). However, FYM@10 tons/ha^1 + 2% B was considered optimum dose for sympodial branches in Sindh-1 and CKC-3 cultivars under semi-arid environment.

Open bolls per plant: Opened bolls per plant were counted at picking stage of crop. Results showed that the maximum number of opened bolls per plant in Sindh-1 and CKC-3 was 13.7 and 15.7 in response to T6= FYM@10 tons/ha^1 + 2% B, followed by 12 and 13 in both respective cultivars in response to T5= FYM @10 tons/ha^1 + 1% B. However, the minimum no. of opened bolls per plant was found in Control plots T1= Control (0 FYM + 0 Boron). These results showed that the suggested level of FYM and boron T6= FYM@10 tons/ha^1 + 2% B significantly regulate the respective trait in Sindh-1 and CKC-3 cultivars under semi-arid environment (Figure 3).

Lint yield per plant (g): The different levels of soil applied FYM and foliar applications of boron showed a significant effect on lint yield per plant (g). Results suggested that the maximum lint yield per plant (g) 42.2 and 43.5 (g) was found in Sindh-1 and CKC-3 cultivars as influenced by T6= FYM @10 tons/ha-1 + 2% boron followed by T5= FYM @10 tons/ha^1 + 1% B which produced 37.9 (g) and 40.9 (g) in both cultivars. However, other applications showed decreasing trend in results as compare to mentioned applications (Figure 4, Table 2).

Seed cotton weight per plant (g): Seed cotton weight per plant is the most important component of cotton crop and has linear effect on the seed cotton yield per unit area. The maximum seed cotton weight per plant 101.2 (g) and 112.2 (g) was obtained by the application of T6= FYM @10 tons/ha-1 + 2% boron followed by 93.3 (g) and 103.6 (g) using T5= FYM @10 tons/ha^1 + 1% B in Sindh-1 and CKC-3 cultivars respectively. Results suggested that the seed cotton weight per plant trait was significantly influenced by combined application of soil applied FYM and increased level of B as 2%. Regarding other applications, results suggested a comparable difference in treatments such as in T1= Control (0 FYM + 0 Boron) and T6= FYM@10 tons/ha^1 + 2% B (Figure 5, Table 2).

Seed cotton yield (kg ha^1): The analysis of variance suggested significant difference in results for seed cotton yield (kg ha^1) as affected by different treatments of soil applied FYM and foliar applied boron. The combined application of soil applied FYM and foliar application of boron increased the seed cotton yield in Sindh-1 and CKC-3 cultivars. The maximum seed cotton yield 3154.1 (kg ha^1) and 3356.2 (kg ha^1) was obtained using T6= FYM @10 tons/ha^1 + 2% B followed by 2879.9 (kg ha^{-1}) and 3173 (kg ha^1) using T5= FYM @10 tons/ha^1 + 1% B respectively. For seed cotton yield (kg ha^1), CKC-3 cultivar performed better than Sindh-1 cultivar in most of the treatment levels. The analysis also showed a significant difference between seed cotton yield (kg ha^1) of both of the cultivars (Figure 6, Table 2).

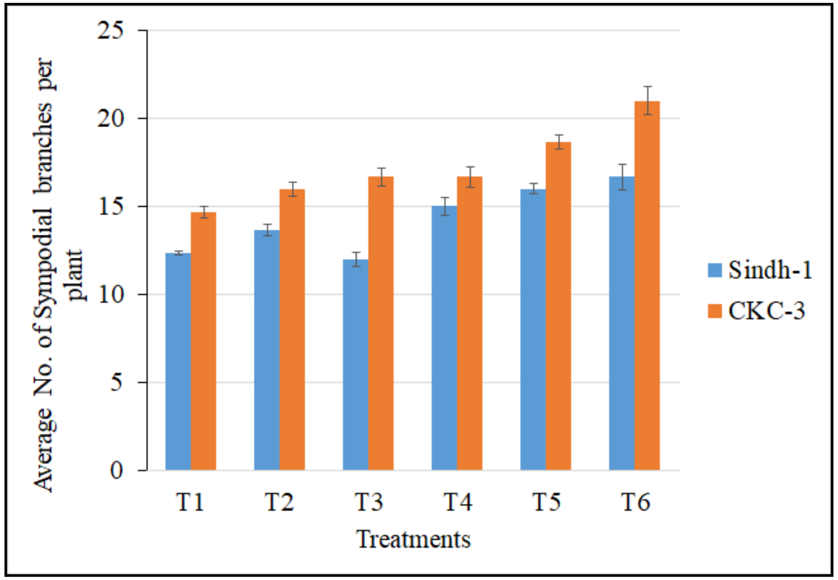

Figure 2. Average No. of sympodial branches per plant. Bars chart represents the average no. of sympodial branches in Sindh-1 and CKC-3 cultivars. Treatments include T1= Control (0 FYM + 0 Boron), T2= FYM @10 tons/ha^{1}, T3= 1% B, T4= 2% B, T5= FYM @10 tons/ha^{1} + 1% B, T6= FYM@10 tons/ha^{1} + 2% B.

Table 2. Yield parameters of Sindh-1 and CKC-3 cultivars as affected by different treatments of FYM and boron ***Denoted alphabets indicate the significant difference between treatments and cultivars.***

reatment	Lint yield per plant (g)		Seed Cotton weight per plant (g)		Seed Cotton Yield (kg ha^{-1})		GOT %	
	Sindh-1	CKC-3	Sindh-1	CKC-3	Sindh-1	CKC-3	Sindh-1	CKC-3
T1= Control (0 FYM + 0 B)	27.5 ± 0.34 h	30.2 ± 0.17 g	70.7 ± 0.02 h	76.3 ± 0.14 gh	2244.7 ± 0.41 h	2445.0 ± 0.22 g	33.3 ± 0.11 g	35.3 ± 0.33 e
T2 = FYM @ 10 tons/ha^{-1}	30.8 ± 0.47 g	32.9 ± 0.40 f	76.6 ± 0.12 fg	81.6 ± 0.31 ef	2554.2 ± 0.31 f	2876.2 ± 0.32 d	34.4 ± 0.26 fg	35.5 ± 0.21 e
T3 = 1% B	35.3 ± 0.39 e	33.1 ± 0.42 f	80.4 ± 0.31 fg	87.1 ± 0.11 d	2565.8 ± 0.12 f	2886.1 ± 0.21 d	35.1 ± 0.18 ef	37.4 ± 0.23 d
T4 = 2% B	34.8 ± 0.09 e	35.7 ± 0.32 e	85.4 ± 0.21 de	94.3 ± 0.12 c	2686.6 ± 0.21 e	3057.5 ± 0.31 c	35.5 ± 0.28 e	39.6 ± 0.12 c
T5 = FYM @10 tons/ha^{-1} + 1% boron	37.9 ± 0.29 d	40.9 ± 0.41 c	93.3 ± 0.11 c	103.6 ± 0.13 b	2879.9 ± 0.16 d	3173.3 ± 0.23 b	35.7 ± 0.23 e	38.8 ± 0.29 c
T6= FYM @10 tons/ha^{-1} + 2% boron	42.2 ± 0.35 b	43.5 ± 0.26 a	101.2 ± 0.13 b	112.2 ± 0.21 a	3154.1 ± 0.17 b	3356.2 ± 0.12 a	41.5 ± 0.13 c	38.3 ± 0.15 c

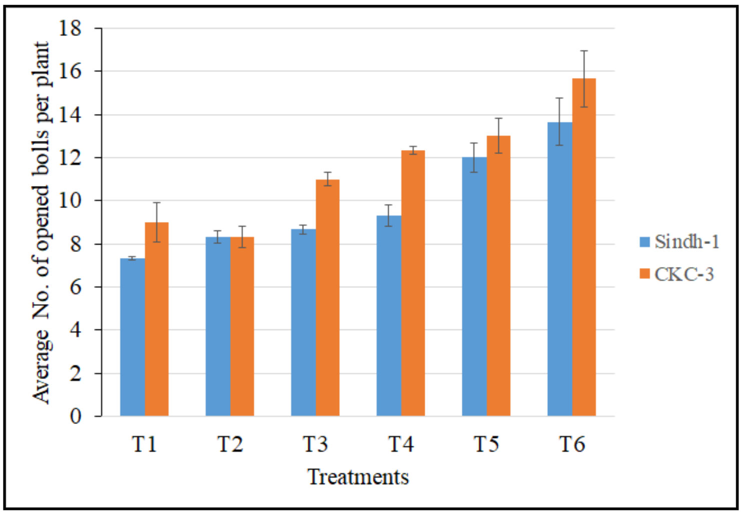

Figure 3. Average No. of opened bolls per plant. The bar chart represents the average no. of opened bolls plant^{-1} in Sindh-1 and CKC-3 cultivars. Treatments include T1= Control (0 FYM + 0 Boron), T2= FYM @10 tons/ha^{1}, T3= 1% B, T4= 2% B, T5= FYM @10 tons/ha^{1} + 1% B, T6= FYM@10 tons/ha^{1} + 2% B.

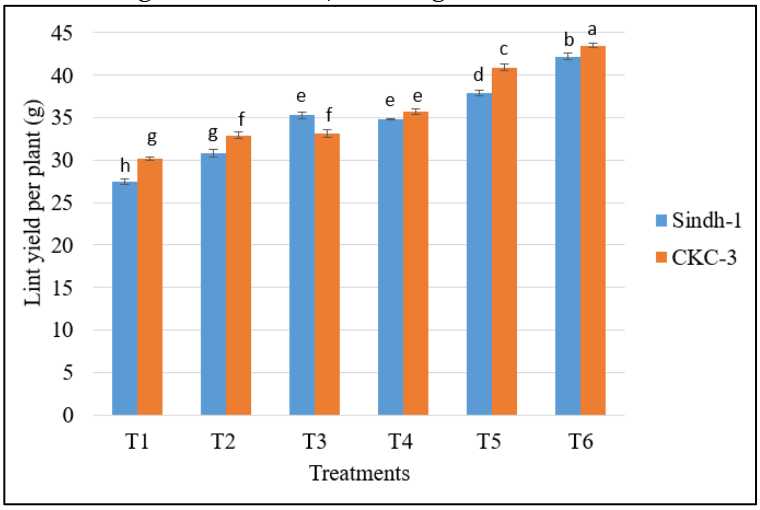

Figure 4. Lint yield per plant (g). Bar chart represents the average of lint yield per plant (g) in Sindh-1 and CKC-3 cultivars. Treatments include T1= Control (0 FYM + 0 Boron), T2= FYM @10 tons/ha^{1}, T3= 1% B, T4= 2% B, T5= FYM @10 tons/ha^{1} + 1% B, T6= FYM@10 tons/ha^{1} + 2% B.

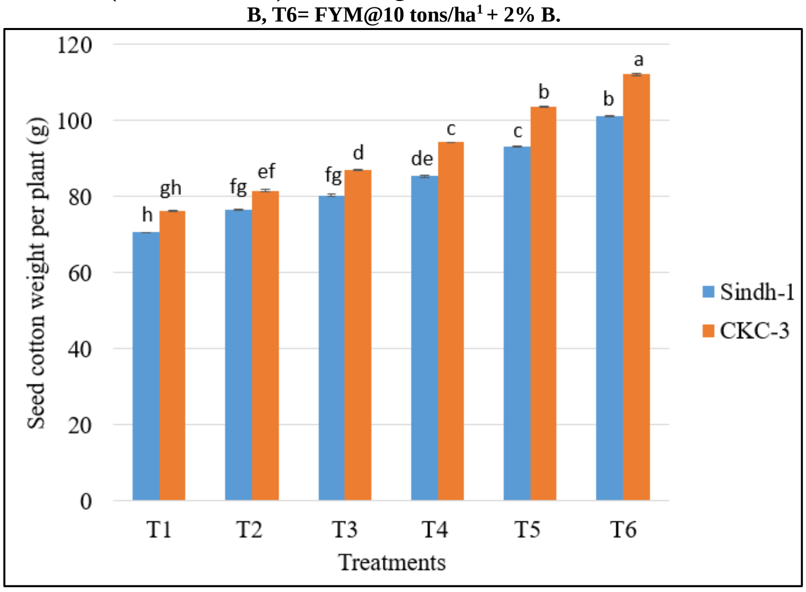

Figure 5. Seed cotton weight per plant (g). Bar chart represents the average of Seed cotton weight per plant (g) in Sindh-1 and CKC-3 cultivars. Treatments include T1= Control (0 FYM + 0 Boron), T2= FYM @10 tons/ha^{1}, T3= 1% B, T4= 2% B, T5= FYM @10 tons/ha^{1} + 1% B, T6= FYM@10 tons/ha^{1} + 2% B.

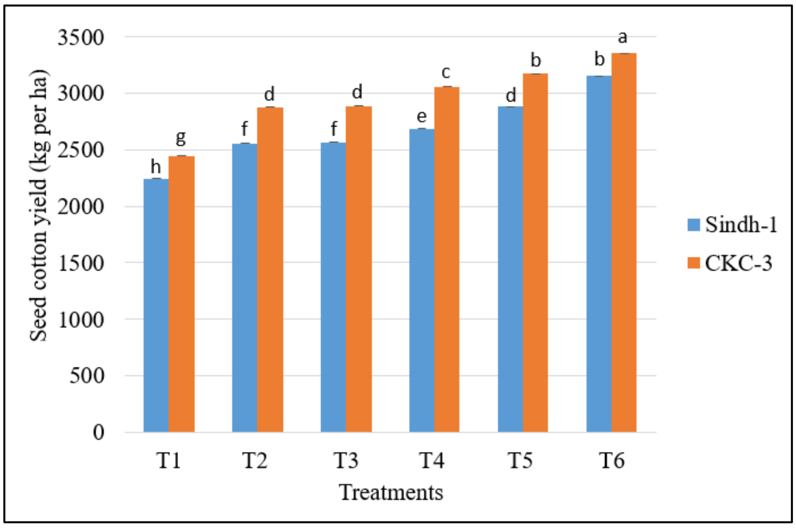

Figure 6. Seed cotton yield (kg per ha). Bar chart represents the average of Seed cotton yield (kg per ha) in Sindh-1 and CKC-3 cultivars. Treatments include T1= Control (0 FYM + 0 Boron), T2= FYM @10 tons/ha[1], T3= 1% B, T4= 2% B, T5= FYM @10 tons/ha[1] + 1% B, T6= FYM@10 tons/ha[1] + 2% B.

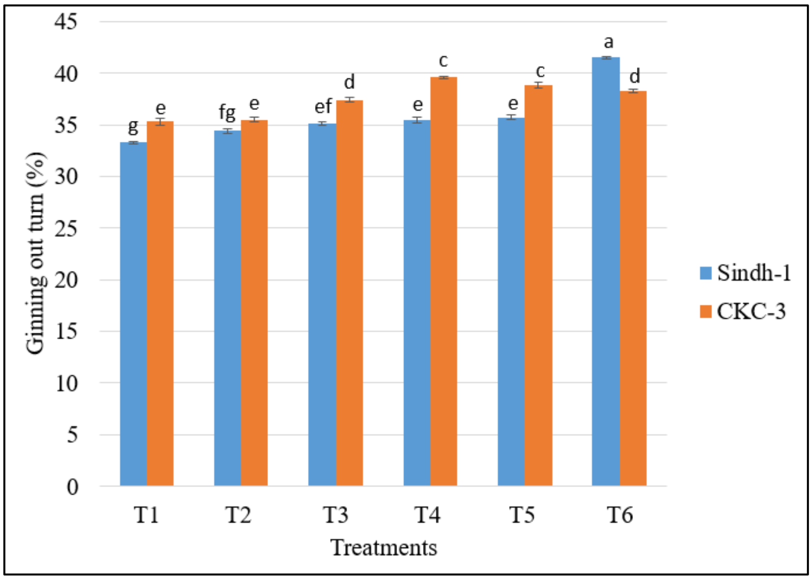

Figure 7. Ginning out turn (%). Bar chart represents the average of Ginning out turn (%) in Sindh-1 and CKC-3 cultivars. Treatments include T1= Control (0 FYM + 0 Boron), T2= FYM @10 tons/ha[1], T3= 1% B, T4= 2% B, T5= FYM @10 tons/ha[1] + 1% B, T6= FYM@10 tons/ha[1] + 2% B.

Discussion

Cotton crop is important cash crop of Pakistan which accounts for 55% of all foreign exchange earning of the country (Rana, Ejaz, & Shikoh, 2020). However, this crop has been experiencing down-falls due to climate change affects all over the globe. The production of crops usually depends on various inputs such as fertilizers and nutrients and environmental factors including soil type, proper amount of irrigation, temperature, and so on (Chandra, Pardha-Saradhi, Maikhuri, Saxena, & Rao, 2021; Rasheed *et al.*, 2022). Present study was conducted to evaluate the effect of soil applied FYM and foliar applications of boron on growth and yield parameters of two cultivars including Sindh-1 and CKC-3. Applications of organic manure such as FYM in crop soil has major role for agriculture sustainability. Organic manure increases the quality of soil properties including soil texture, water holding capacity, nutrient availability such as N, P, K as well as S, and conserve the soil moisture respectively (Palm, Gachengo, Delve, Cadisch, & Giller, 2001). Similarly, boron is required at all growth stages of cotton for proper growth and development of plant. Study suggested that the boron plays significant role for fiber improvement in cotton (Qamar *et al.*, 2020). The analysis results of growth parameters of Sindh-1 and CKC-3 suggested that the elevated level of treatments such as T6= FYM @10 tons/ha-1 + 2% B was most effective to growth stages including plant height (cm), Sympodial branches per plant, and Opened balls per plant. Previous study also suggested that the soil applied farm yard manure and compost significantly increase the plant height (cm), sympodial branches, bolls per plant in transgenic and BT cotton (Jan *et al.*, 2020). Studies also suggested that the FYM and boron significantly increase the boll bearing branches in cotton crop as well as improve the plant height (GEBALY, 2011; Kassem, Hamoda, & Emara, 2009; Qamar *et al.*, 2020; Sawan, Mohamed, Sakr, & Tarrad, 2000). A comparative observation in present study also suggested that the FYM and boron significantly improve the growth characteristic of CKC-3 than that of Sindh-1. These results might suggest that the CKC-3 is more responsive perform better in given treatments in semi-arid climate. The foliar applied boron along with zinc improve the number of bolls per plant, seed cotton yield, boll weight and lint yield respectively (Görmüş, 2005; Soomro, Anjum, Soomro, Memmon, & Bano, 2001). The yield traits of Sindh-1 and CKC-3 cultivars were also significantly improved using soil applied FYM and foliar applied boron. The results suggested that T6= FYM @10 tons/ha-1 + 2% B significantly regulate lint yield per plant (g), seed cotton weight per plant (g), seed cotton yield (kg ha^{-1}) and ginning out-turn in both Sindh-1 and CKC-3 cultivars. These results indicate that the T6= FYM @10 tons/ha^{-1} + 2% B might be an appropriate dose for both cultivars under semi-arid climate for proper growth and yield improvement. It was found that the yield parameters significantly response to combined applications of FYM and boron as compared to single use of soil applied manure or foliar applied boron. Study suggested that the boron improve the seed cotton yield per plant, GOT%, as compare to control treatments (Qamar *et al.*, 2020). On the other hand, the deficiency of boron and organic manure negatively affect cotton growth and yield traits (Gupta & Solanki, 2013; Islam, Khalequzzaman, & Kaikobad, 2014; Zhao & Oosterhuis, 2003).

Conclusions

Study was conducted to evaluate the effect of organic manure and foliar application of boron on morphological and economic parameters of Sindh-1 and CKC-3 cultivars under semi-arid climate. It was concluded that the combined application of soil applied FYM along foliar application of boron at the rate of FYM @10 tons/ha^{-1} + 2% B increase and might improve the morphological and economic traits of Sindh-1 and CKC-3 cultivars under semi-arid environment. However, CKC-3 was found better performing in growth and yield attributes than Sindh-1 in response to suggested treatment under semi-arid environment. \

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