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Demonstration and evaluation of the effect of foliar application of zinc, boron and phosphorus on the growth and yield of cotton in ecological zone of Rahim Yar Khan

Muhammad Aslam[1], Tanweer Ahmed[2] and Mrs. Laila Yaseen[3]

[1]Senior Subject Matter Specialist (Agronomy) Department of Adaptive Research Farm, Rahim Yar Khan
[2] Director (Farms and Trainings) Adaptive Research Rahim Yar Khan
[3]Assistant Research Officer Adaptive Research Rahim Yar Khan

Keywords

Cotton,
foliar application,
RCBD,
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Abstract

A field experiment was conducted to study the effect of foliar application of zinc, boron and phosphorus on the growth and yield of cotton. The experiment was conducted at Adaptive Research Farm Rahim Yar Khan District during the Kharif season 2017-18. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Recommended dose of NPK, boron (11.3%) in the form of boric acid 495g/ha applied twice at 70 and 85 days of sowing, zinc (33%) in the form of zinc sulphate 495g/ha applied twice at 70 and 80 days of sowing, phosphorus 576g/ha applied twice after 80 and 90 days of sowing and phosphorus 1152g/ha applied twice at 80 and 95 days of sowing significantly affected the plant height, number of mature bolls plant^{-1} and seed cotton yield kg ha^{-1}. The interaction between the nutrients and cotton variety was non- significant for plant germination and boll weight plant^{-1}. Foliar application of phosphorus @1152g/ha applied twice at 80 and 95 days of sowing gave the highest and significant average increase in seed cotton yield (1959.4 kg ha^{-1}) over zinc sulphate @495(1806.6 kg ha^{-1}) and Borax @ 495 g ha^{-1} (1517.1 kg ha^{-1}) on cotton variety Bs-15during both years 2017-18.

Introduction

Cotton is the most important crop of Pakistan, cultivated on 2917 thousands hectares and is the source of large amount of foreign exchange, contributing about 5.2% of value added in agriculture and about 1.0 percent of GDP and contributes about 66% share in national oil production (Anonymous, 2015). Cotton is known as the “white gold” of Pakistan. It is the most important and economy dependent crop of Pakistan (Hakim et al. 2011). It contributes a huge share in the foreign exchange earnings of the country (Ahmad et al. 2011). It has played a significant role in agriculture, industrial development, employment, financial stability and economic viability ever since the country attained the independence. It is the most beneficial fiber and cash crop of Pakistan and earns a good fortune for the country in the form of foreign exchange (Ahmed et al. 2009).

Fertilizers occupy vital position in raising seed cotton yield. Experiments have shown that an optimal yield could only be produced with the balanced application of all major nutrients in soil (Ahmad, 1998). Optimum levels of micro and macro inorganic nutrients are required for normal growth and supplements give improvements. Low yield of cotton in Pakistan is due to many crop husbandry problems such as low or more plant population, water shortage, low seed rate, improper fertilizer management, weed infestation, insect pest and disease problems (Ahmed et al. 2009). Six micronutrients (boron, manganese, iron, copper, zinc, and molybdenum) play distinct and important roles in plant physiology and biochemical processes (Putra et al. 2012; Rab and Haq 2012). Foliar application of different nutrients (NPK @625gha^{-1}, zinc sulphate @500gha^{-1} and Borax @ 500g ha^{-1}) significantly affected the plant height (cm), number of mature bolls plant^{-1}, seed cotton weight boll^{-1}, and seed cotton yield ha^{-1} (Khalid et al. 2015). Boron is a unique non-metal micronutrient required for normal growth, development of plants and essential for cell structure of plants (Warington, 1923). Some functions of B interrelate with those of nitrogen (N), phosphorus (P), potassium (K) and calcium (Ca) in plants (US Borax, 2009). Its interaction (synergistic, antagonistic) with most of the nutrients (N, P, K, Ca, Mg [magnesium] Al [aluminum] and Zn) may be sometimes influential in regulating B availability to plants in soil. Phosphorus has been reported to increase plant height, number of monopodial/ sympodial branches plant^{-1} and number of matured bolls plant^{-1} in cotton (Soomro and Waring, 1987; Mukand et al. 1989). Zinc is one of the first micronutrient recognized as essential for plants. It is the micronutrient that most commonly limiting crop yields. Zinc is transported to plant root surface through diffusion. It aids in the synthesis of plant growth substances and enzyme systems and is essential for promoting certain metabolic reactions. It is necessary for production of chlorophyll and carbohydrates. Application of zinc to cotton crop promotes boll retention and thereby increases the seed cotton yield (Prasad and Prasad, 1994). Seed cotton weight boll^{-1} and seed cotton yield ha^{-1} have been found affected by NPK application at various doses (Nehra *et al*., 1986; Khan *et al*., 1993). Colakoglu, (1980) recommended optimum dose of 80-120 kg ha^{-1} N, 60-90 kg ha^{-1} P and 100-200 kg ha^{-1} K for optimum seed cotton yield in Turkey. There is heavy drain of nutrients due to more demand by varieties at certain early maturing and high yielding cotton growth stages. To satisfy the required level of plant nutrients, farmers in Pakistan are indispensably inclined to use commercial fertilizers. Farming of crops with high micronutrient demands on alkaline calcareous soils that are low in organic matter has made Pakistan's soils deficient in Zn (60%–70%) and B (50%–60%), with localized deficiency in micronutrients (Jiskani 2011). The alkaline and calcareous soils of Pakistan are low both in nitrogen (N) and in phosphorus (P) requiring the addition of nutrients in appropriate amounts for improving crop yields. The use of N and P fertilizers increased many fold since their introduction in the late fifties (Ahmad, 2000). The scarcity of any nutrient in the soil can be a barrier for the growth of crops even when all other nutrients are in excess in the soil (Soleymani and Shahrajabian 2012. Fertilizer Zn use is recommended for cotton crop and alkaline soils (Rashid 2004, Hussain et al. 2012); Moreover, in addition to calcareousness, high pH of the soils also decreases the availability of Zn in such soils (Donner and Lynn 1989). Boron deficiency has been realized as the second most important micronutrient constraint in crops after that of zinc (Zn) on global scale. Boron deficiency has been reported to result considerable yield reduction in annual crops (Niaz et al. 2007 and Zia et al. 2006). However, an alternative approach under such circumstances is foliar application of these nutrients (Rab and Haq 2012), for 2 reasons. First, it eliminates the effects of soil pH on the availability of these nutrients (Ali 2012). Secondly, it is more effective and less costly (Ali et al. 2007).

Keeping in view the above mentioned facts, the present study was carried out to investigate the effect of foliar application of nutrients on the growth and yield of cotton.

Materials and Methods

This experiment was conducted at Adaptive Research Farm during 2017-18. The experiment was laid out in RCBD with three replications having 5 net plot size of 15 ×30ft. Five different doses of fertilizer were checked out i.e recommended dose of NPK, boron (11.3%) in the form of boric acid 495g/ha applied twice at 70 and 85 days of sowing, zinc (33%) in the form of zinc sulphate 495g/ha applied twice at 70 and 80 days of sowing, phosphorus 576g/ha applied twice after 80 and 90 days of sowing and phosphorus 1152g/ha applied twice at 80 and 95 days of sowing. The crop variety BS-15 was sown in the month of May delinted with commercial H_2SO_4 before sowing. Required irrigations were applied and weeds were controlled through weedicides. Insecticides were applied to control the sucking insects (Whitefly, Thrips, Jassid, & Mites) and boll worms (Pink boll worm). All other agronomic practices were kept normal and uniform for all the treatments. Plant population/m^2 was counted after three weeks of sowing. Plant height (cm) of randomly selected plots from each plot was measured at the time of last picking and average height was calculated. The total number of bolls on the randomly selected plants picked at the time of each picking was counted. Thus total number of bolls on the plants was obtained by summing up the bolls picked during all pickings and average of number of bolls per plant was calculated. For boll weight (g), three samples each of 100 seeds from each plot were weighted and finally averaged. Average boll weight (g) was calculated by dividing the total plants seed cotton yield with respective number of bolls per plant. Seed cotton picked from selected plants during all the pickings was 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. Data collected on different parameters were analyzed statistically by using M STAT-C programme (Anonymous,1986) for analysis of variance and means were separated using Fisher's protected least significant difference (LSD) test at 5% probability level (steel et al. 1997).

Results and Discussion

Plant population (m^{-2})

Data concerning average number of germination counts is shown in Table 2 during both years 2017 and 2018. Statistical analysis of the data revealed that the effect foliar applications of various nutrients have non significant results on germination counts for the both growing seasons. Average maximum germination counts were recorded as 6.0 in T_5 where Phosphorus was applied @1152g/ha twice at 80 and 95 days for the both kharif season 2017-18. On the other hand, lowest value was recorded as 4.5 where recommended dose of NPK was applied.

Plant height (cm):

Foliar application of various nutrients has significantly increased plant height. Foliar application resulted in proportionate increase in the plant height of cotton variety BS-15 as mentioned in Table-2. The taller plants (150cm) were recorded on cotton variety where Phosphorus was applied @1152g/ha twice at 80 and 95 days followed by zinc (33%) in the form of zinc sulphate 495g/ha applied twice at 70 and 80 days of sowing i.e (146cm) during both years 2017-18. The lowest height observed (131.5cm) where recommended dose of NPK was applied. These results are in agreement with those of Rochester et al. (2001) that plant height in cotton is related to nitrogen, phosphorus and potash applications.

No. cotton bolls per plant:

Foliar application of various nutrients significantly affected on no. of cotton bolls/plant. Foliar application resulted in proportionate increase in the number of cotton bolls/plant as mentioned in Table-2. The greater no. of bolls/plant (31.0) was recorded where Phosphorus was applied @1152g/ha twice at 80 and 95 days followed by zinc (33%) in the form of zinc sulphate 495g/ha applied twice at 70 and 80 days of sowing i.e (28.5) during both years 2017-18. The lowest height was observed (23) where recommended dose of NPK was applied. These results are similar as described by Khan et al. (1993).

Boll weight (g):

Average boll weight is one of the major components of seed cotton yield in cotton. Data given in Table-2 indicates the non significant influence of boll weight. Maximum boll weight (3g) was recorded where Phosphorus was applied @1152g/ha twice at 80 and 95 days during both years 2017-18. The minimum boll weight (2.3) was observed in case where recommended dose of NPK was applied. The findings are agreed with those of Sawan et al. (2006).

Seed cotton yield kg ha^{-1}:

Data pertaining to seed cotton yield per hectare as influenced by foliar application of various nutrients as mentioned in Table-2 indicates that foliar application of various nutrients zinc, boron and phosphorus has significant effect on the seed cotton yield per hectare. Maximum seed cotton yield per hectare (1959.4kg ha^{-1}) was recorded where Phosphorus was applied @1152g/ha twice at 80 and 95 days followed by zinc (33%) in the form of zinc sulphate 495g/ha applied twice at 70 and 80 days of sowing i.e (1806.6) during both years 2017-18. The lowest seed cotton yield (1426.5kg ha^{-1}) was obtained where recommended dose of NPK was applied during both years 2017-18. These findings agree with the findings of Howard et al. (2001). Foliar application of different nutrients (NPK @625gha^{-1}, zinc sulphate @500gha^{-1} and Borax @ 500g ha^{-1}) significantly affected the plant height (cm), number of mature bolls plant^{-1}, seed cotton weight boll^{-1}, and seed cotton yield ha^{-1} (Laila et al. 2015). Fertilizer Zn use is recommended for cotton crop and alkaline soils (Rashid 2004 and Hussain et al. 2012).

Table 1: The effect of foliar application of boron, zinc and phosphorus on the growth and yield of cotton during 2017 and 2018.

Year	Treatments	Average germination counts (m^{-2})	Average plant height (cm)	No. of Bolls/plant	Boll weight (g)	Average seed cotton yield (kg/ ha)
2017	T_1	4.6c	133e	22.5e	2.37c	1320.7e
	T_2	5.3b	138d	24.2d	2.95b	1423.5d
	T_3	6.0a	148b	28.0b	3.10b	1688.2b
	T_4	5.0b	143c	26.1c	2.98b	1572.4c
	T_5	6.0a	152a	30.2a	3.18a	1838.6a
LSD(0.05)		**Non-significant**	**3.76**	**1.80**	**Non-significant**	**48.50**
2018	T_1	4.5c	130d	23.6e	2.3e	1532.3e
	T_2	4.8b	136c	25.3d	2.5d	1610.8d
	T_3	5.5a	144b	29.1b	2.7b	1925.1b
	T_4	5.0b	141c	27.5c	2.6c	1780.2c
	T_5	6.0a	148a	31.8a	2.9a	2080.2a
LSD(0.05)		**Non-significant**	**1.79**	**1.43**	**Non-significant**	**74.03**

Table 2: Average values of all parameters from 2017-2018

Treatments	Average germination counts (m^{-2})	Average plant height (cm)	No. of Bolls/plant	Boll weight (g)	Average seed cotton yield (kg/ ha)
T_1	4.5d	131.5e	23.0e	2.3d	1426.5e
T_2	5.0c	137d	24.7d	2.7c	1517.1d
T_3	5.7b	146b	28.5b	2.9b	1806.6b
T_4	5.0c	142c	26.8c	2.7c	1676.3c
T_5	6.0a	150a	31.0a	3.0a	1959.4a

Conclusions

The results concluded that foliar application of zinc, boron and phosphorus effects on seed cotton yield and other growth parameters. It has significantly ($p<0.05$) affected germination, plant height, boll weight and yield during both years of the study. Phosphorus 1152g/ha applied twice at 80 and 95 days has improved seed cotton yield (1959.4kg/ha) over 2 years in comparison with other applications of zinc and boron ie (1806.6 and 1517.1kg/ha). Therefore under ecological zone of Rahim Yar Khan, foliar application of phosphorus 1152g/ha applied twice at 80 and 95 days for cotton crop can be recommended for better production.

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