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Research Article

Demonstration and evaluation of the effect of foliar application of various nutrients on the growth and yield of cotton in ecological zone of Bahawalnagar Punjab, Pakistan.

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Abstract

A field experiment was conducted to study the effect of different nutrients on the yield and yield components of cotton by foliar application. The experiment was conducted at two different farmer's field sites of Bahawalnagar District during the year 2014. The foliar application of different nutrients (NPK @625gha^{-1}, zinc sulphate @500gha^{-1} and Borax @ 500gh^{-1}) significantly affected the plant height (cm), number of mature bolls plant^{-1}, seed cotton weight boll^{-1}, and seed cotton yield ha^{-1}. The interaction between the nutrients and cotton variety was significant for plant height, number of mature bolls plant^{-1}, boll weight and seed cotton yield ha^{-1}. Foliar application of NPK @ 625gha^{-1} gave the highest and significant increase in seed cotton yield (2284 kg ha^{-1}) over zinc sulphate @500 (2112.5 kg ha^{-1}) and Borax @ 500 g ha^{-1} (1963.5 kg ha^{-1}) on cotton variety MNH-886 on both sites of farmer's field.

Keywords: different nutrients, foliar application, Bahawalnagar District, seed cotton yield.

Introduction

Cotton (*Gossypium hirsutum* L.) plays a vital role in the economy of Pakistan. It contributes to the National economy by providing raw material to the local textile industry. It is known as the "white gold" of Pakistan (Hakim *et al.* 2011). It contributes a huge share in the foreign exchange earnings of the country (Ahmad *et al.* 2011). 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). An optimum levels of micro and macro inorganic nutrients are required for normal growth (Ahmad *et al.* 2009), and supplements give improvements in yield. Fertilizers occupy pivotal position in raising seed cotton yield. An optimal yield could only be produced with the balanced application of all major nutrients in soil (Ahmad, 1998). 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).

In boosting the agricultural productivity, nitrogen is apparently the most contributing fertilizer (Touchton, 1987). 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). 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. There is heavy drain of nutrients due to more demand by varieties at certain early maturing and high yielding cotton growth stages. Nitrogen 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). 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). The less use of K fertilizer in cotton may have serious consequences. Cotton appears to be more sensitive to K deficiencies than other crops, as root system of cotton is less dense than that of other crops (Mithaiwala *et al.* 1981). Makhdum, (2003) and Malik *et al.* (1989) reported that cotton crop could benefit from higher doses of potassium fertilizers when applied at different times after sowing. Potassium is one of the most important elements in plant nutrition. Potassium increases the photosynthetic rates, CO_2 assimilation and facilitates carbon movement (Saleem, 2002). Cotton crop absorbed a large quantity of potassium indicated that it was more than both nitrogen and phosphorous intake (Brar *et al.* 1987). Fertilizer Zn use is recommended for cotton crop and alkaline soils (Rashid 2005, 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). Field crops are known to take up only 0.3% to 3.5% of the annually. Zn accumulates in the soil, because of its low mobility in the soil (Brennan 2001). 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). Boron is a unique non-metal micronutrient required for normal growth, development of plants and essential for cell structure of plants (Warington, 1923). Boron is absorbed by roots as un dissociated boric acid ($B(OH)_3$ or H_3BO_3) (Mengel & Kirkby, 1982; Marschner, 1995). Among the elements required by plants that are taken up from the soil, B is the only element that is taken up by plants not as anion, but as an uncharged molecule (Marschner, 1995; Miwa & Fujiwara, 2010). The factors affecting B uptake include soil type (texture, alkalinity/calcareousness, pH, and organic matter content), B concentration, moisture, and plant species (Welch *et al.* 1991). Boron is relatively immobile in plant, and thus its availability is essential at all stages of growth, especially during fruit/seed development (Stangoulis *et al.* 2001). 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).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. Application of B may improve the utilization of applied N in cotton plants by increasing the translocation of N compounds into the boll (Miley *et al*. 1969).

Zn, B, Fe, Mn, and Cu application on calcareous soils is less efficient, as these nutrients remain inaccessible to plant roots due to the higher soil pH (Rashid and Ryan 2004; Sajid *et al*. 2008). 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 two different farmer's field sites. The experiment was laid out in RCBD with three replications having a net plot size of 30 ×68ft (12lines/treatment) on both sites. Three different doses of nutrients NPK @ 625 kg ha^{-1}, zinc @ 500kg ha^{-1} and borax @ 500 kg ha^{-1} were tested on cotton variety MNH-886 on both sites. The crop was sown at the 1st week of April with bed and furrow method to achieve the require plant population. The nutrients were applied to crop at three different intervals 35, 50 and 65 days after germination. Thinning was done to maintain the desired plant population when plant attained the height of 15cm. All other agronomic and plant protection practices were kept similar for all the treatments. Ten plants from each treatment were selected at random to record number of matured bolls plant^{-1} and plant height at maturity. Ten bolls were picked randomly from each treatment, weighed and averaged to record the seed cotton weight boll^{-1}. Two pickings from the whole plot for about 75 and second about 200 days after sowing were done to obtain the seed cotton yield. The seed cotton plant^{-1} (kg) was calculated after the last picking and converted to seed cotton yield ha^{-1}. Data collected was analysed statistically by using Fisher's analysis of variance technique. LSD test 0.05 at probability means (Steel and Torrie, 1997).

Results and Discussion

Yield related parameters

Plant height (cm): Nutrient doses by foliar application significantly increased plant height. Foliar application of NPK @ 625 kg ha^{-1} resulted in proportionate increase in the plant height of cotton variety MNH-886 as mentioned in Table-1. The taller plants (123.6cm) were recorded on cotton variety where 625 kg NPK ha^{-1} was applied. The height observed (117.0cm) when zinc applied @ 500kg ha^{-1}. The minimum height (112cm) was observed in case of borax @ 500 kg ha^{-1}. It is well known fact that nitrogen application boosts crop growth and development. The increased plant height is the result of flamboyant and vigorous plant growth. 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.

Table-1 Effect of different nutrients doses on yield of seed cotton and its parameters during 2014 at one site of farmer's field.

Treatments (kg ha^{-1})	Plant height (cm)	No.of boll plant^{-1}	Boll weight (g)	Yield (kg ha^{-1})
NPK = 625	123.6a	29.33a	2.85a	2109a
Zinc = 500	117.0b	25.46b	2.38b	2004b
Borax = 500	112.0c	21.00c	2.01c	1898c
Lsd (0.05)	4.02	3.32	0.31	14.95

Number of mature bolls plant^{-1}: The number of mature bolls plant^{-1} was significantly different under various levels of nutrients by foliar application as mentioned in Table-1. The highest number of mature boll plant^{-1} (29.33) was observed when NPK was applied @ 625 kg ha^{-1}. Significant differences were observed when zinc and borax was applied @ 500kg ha^{-1} both for number of mature bolls plant^{-1} i.e (25.46) and (21.00). 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-1 indicates that NPK @625kg ha^{-1} significantly influenced boll weight. Maximum boll weight (2.85 g) was recorded where NPK was applied at the rate of 625 kg ha^{-1}. The boll weight observed (2.38) when zinc applied @ 500kg ha^{-1}. The minimum boll weight (2.01) was observed in case of borax @ 500 kg ha^{-1}. The findings from our study agree with those of Sawan *et al.* (2006); who recorded increase in boll weight by increasing N rate from 95 to 143 kg ha^{-1}. 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).

Seed cotton yield kg per hectare: Data pertaining to seed cotton yield per hectare as influenced by different nutrients through foliar application as mentioned in Table-1 indicates that NPK had significant effect on the seed cotton yield per hectare. Maximum seed cotton yield per hectare (2109kg ha^{-1}) was recorded for NPK at a rate of 625 kg ha^{-1} on MNH-886 cotton variety followed by zinc @ 500kg ha^{-1} i.e (2004kg ha^{-1}). The lowest seed cotton yield (1898kg ha^{-1}) was obtained when borax was applied @ 500kg ha^{-1}. These findings agree with the findings of Howard *et al.* (2001).These results are supported by Elayan (1992) who reported that nitrogen influenced seed cotton yield ha^{-1} and decrease in seed cotton yield ha^{-1} was recorded when nitrogen was applied beyond the optimum level. Fertilizer Zn use is recommended for cotton crop and alkaline soils (Rashid 2005, Hussain *et al.* 2012).

Table-2 Effect of different nutrients doses on yield of seed cotton and its parameters during 2014 at 2nd site of farmer's field.

Treatments (kg ha^{-1})	Plant height (cm)	No.of boll $plant^{-1}$	Boll weight (g)	Yield (kg ha^{-1})
NPK = 625	140.8a	30.20a	3.00a	2459a
Zinc = 500	134.6b	26.31b	2.50b	2221b
Borax = 500	128.3c	21.56c	2.10c	2029c
Lsd (0.05)	3.28	3.41	0.29	24.21

Plant height (cm): Nutrient doses by foliar application significantly increased plant height. Foliar application of NPK @ 625 kg ha^{-1} resulted in proportionate increase in the plant height of cotton variety MNH-886 as mentioned in Table-2. The taller plants (140.8cm) were recorded on cotton variety where 625 kg NPK ha^{-1} was applied. The height observed (134.6cm) when zinc applied @ 500kg ha^{-1}. The minimum height (128.3cm) was observed in case of borax @ 500 kg ha^{-1}. It is well known fact that nitrogen application boosts crop growth and development. The increased plant height is the result of flamboyant and vigorous plant growth. 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.

Number of mature bolls $plant^{-1}$: The number of mature bolls $plant^{-1}$ was significantly different under various levels of nutrients by foliar application as mentioned in Table-2. The highest number of mature boll $plant^{-1}$ (30.20) was observed when NPK was applied @ 625 kg ha^{-1}. Significant differences were observed when zinc and borax was applied @ 500kg ha^{-1} both for number of mature bolls $plant^{-1}$ i.e (26.31) and (21.56). 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 that NPK @625kg ha^{-1} significantly influenced boll weight. Maximum boll weight (3.00 g) was recorded where NPK was applied at the rate of 625 kg ha^{-1}. The boll weight observed (2.50) when zinc applied @ 500kg ha^{-1}. The minimum boll weight (2.10) was observed in case of borax @ 500 kg ha^{-1}. The findings from our study agree with those of Sawan *et al.* (2006); who recorded increase in boll weight by increasing N rate from 95 to 143 kg ha^{-1}.

Seed cotton yield kg per hectare: Data pertaining to seed cotton yield per hectare as influenced by different nutrients through foliar application as mentioned in Table-2 indicates that NPK had significant effect on the seed cotton yield per hectare. Maximum seed cotton yield per hectare (2459kg ha^{-1}) was recorded for NPK at a rate of 625 kg ha^{-1} on MNH-886 cotton variety followed by zinc @ 500kg ha^{-1} i.e (2221kg ha^{-1}). The lowest seed cotton yield (2029kg ha^{-1}) was obtained when borax was applied @ 500kg ha^{-1}. These findings agree with the findings of Howard *et al.* (2001).These results are supported by Elayan (1992) who reported that nitrogen influenced seed cotton yield ha^{-1} and decrease in seed cotton yield ha^{-1} was recorded when nitrogen was applied beyond the optimum level. Boron deficiency has been reported to result considerable yield reduction in annual crops (Niaz *et al*. 2007 and Zia *et al*. 2006).

Table-3 Effect of different nutrients doses on yield of seed cotton and its parameters during 2014 (average of two sites).

Treatments (kg ha^{-1})	Plant height (cm)	No.of boll plant^{-1}	Boll weight (g)	Yield (kg ha^{-1})
NPK = 625	132.2a	29.76a	2.92a	2284.0a
Zinc = 500	125.8b	25.88b	2.44b	2112.5b
Borax = 500	120.15c	21.28c	2.05c	1963.5c
Lsd (0.05)	3.65	3.36	0.3	19.58

Conclusion

Application of 625kg ha^{-1} NPK on cotton variety MNH-886 produces the maximum plant height (132.2cm), No. of boll plant^{-1}(29.76), boll wt (2.92g) and seed cotton yield (2284.0kg ha^{-1}) as shown by the average results of two years as mentioned in table-3.

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