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YIELD AND YIELD COMPONENTS OF COTTON AS INFLUENCED BY FOLIAR APPLICATION OF N, P AND K FERTILIZERS UNDER AGRO-CLIMATIC CONDITIONS OF VEHARI, PAKISTAN

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ABSTRACT

Background Most of soils in Pakistan showed a general deficiency of nitrogen (N), phosphorus (P) and potassium (K) which is one of the major cause of poor seed cotton yield at the farmers' fields in Pakistan. Farmers only apply nutrients through soil which are prone to leaching, fixation and volatilization, so plants are unable to absorb them. It is therefore, a dire need to identify alternative methods of nutrient application to recover cotton crop nutrient deficiencies at different growth stages to harvest good yield.

Methodology A field study was conducted at the Adaptive Research Farm, Vehari, Pakistan during Kharif 2011 and 2012 on clay loam soil to assess the response of cotton (cv. MNH-886) to six different timings of foliar applications of NPK (20: 20: 20) @ 617.5 g ha^{-1}). In addition to this, recommended levels of NPK fertilizers @ 400: 114: 124 kg ha^{-1} were also applied in all treatments through soil application. The experiment was laid out using randomized complete block design (RCBD) with three replications.

Results On an average, foliar application of NPK after 60, 75, 90, 105 and 120 days after sowing (DAS) produced more number of bolls per plant (23.4), higher boll weight (3.21 g) and maximum seed cotton yield (2205 kg ha^{-1}) closely followed by foliar application of NPK at 60, 75, 90 and 105 DAS. Maximum average agronomic use efficiency (0.208 kg kg^{-1} NPK) was also noted in case of 400: 114: 124 kg ha^{-1} NPK as soil application along with foliar application of NPK after 60, 75, 90, 105 and 120 DAS having significant relationship ($R^2 = 1$) with average seed cotton yield. The lowest seed cotton yield (2072 kg ha^{-1}) was obtained from the plot where no foliar application of NPK was executed.

Conclusion To maintain profitable production, cotton producers may need to change traditional fertilization program to an integrated system consisting of soil and foliar applied nutrients.

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) plays a vital role in the economy of Pakistan. It contributes more than 60% to total foreign exchange earnings and about 8.5% to domestic edible oil needs (Anonymous 2001). Essential plant nutrients are mainly applied to soil and plant foliage for achieving maximum economic yields. Soil application method is more common. However, under certain circumstances, foliar fertilization is more economical and effective. Phosphorus is usually the limiting factor in cotton production through early boll formation, but N and K are important during early plant growth and development when soil conditions limit their uptake. The addition of N along with P applications optimizes the crop response, but too much N during late vegetative growth may inhibit and delay boll formation. The addition of K increases disease tolerance and produces better quality lint.

Now a day, soil application of macronutrients i.e. N, P and K found to be very expensive. About 55% of the farmers in the region reported shortage or unavailability of fertilizer, late supply and high price

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of fertilizers, as major production problems. In addition, the availability of these macronutrients is also affected by several environmental factors. In contrast, foliar feeding technique is a particular way of supplying these nutrients which could avoid these factors and results in a rapid absorption. Foliar feeding is more effective and less costly (Jamal et al. 2006).

Foliar fertilization has many advantages over traditional soil fertilization including; low cost of application; plant response is fast and therefore, deficiencies may be rectified quickly; no soil fixation; independent of root uptake and so may be applied when root functioning is declining or impaired; and may be mixed with other agrochemicals. Optimal NPK fertilization is an important consideration for harvesting higher cotton yield, but farmers usually overuse nitrogenous fertilizer along with insufficient dose of P and K. Improper use of NPK fertilizers is a mere wastage of resources with no positive impact on either established fields or new land just brought into production. It is established fact that optimum nutritional requirement of cotton is of primary importance to boost its production. The mineral nutrition of cotton depends on both the cotton root's ability to explore the soil and the ability of soil to supply N, P and K nutrients (Bisson et al. 1994).

However, soil tests carried out in Pakistan showed a general lack of N, a wider spread deficiency of P and an occasional deficiency of K (Wahhab 1985). Low per acre use of plant nutrients and their low use efficiency are important yield limiting factors for cotton crop. The availability of N, P, K and water are the major constraints in cotton production in most cotton producing environments (Morrow and Krieg 1990). Nitrogen is generally considered a yield limiting factor in both dryland and irrigated cotton production systems that requires focus on optimizing lint yield and avoiding under and over applications that reduce quality (Hutmacher et al. 2004). Deficiency of N in cotton can reduce both vegetative and reproductive growth and induce premature senescence leading to potential yield loss (Gerik et al. 1994). Several factors, including soil type, affect cotton response to P. The critical level of P is a function of actual concentration of the labile pool that in turn determines the available P at a given time during the growth of cotton (Crozier et al. 2004). Potassium fertilization increased cotton yield by 9% in 2 year of a 3 year study (Pettigrew 2003).

Keeping in view the above discussion, a study was designed to evaluate the effect of soil and foliar applied N, P and K in splits on seed cotton yield and its components.

MATERIALS AND METHODS

A field study was conducted to assess the response of cotton against six different timings of foliar applications of NPK fertilizer (20: 20: 20) @ 617.5 g ha^{-1}) at the Adaptive Research Farm, Vehari, Pakistan during Kharif 2011 and 2012 on clay loam soil. Experiment was comprised of the following treatments plan; T1: Control (Recommended level of NPK fertilizers @ 400: 114: 124 kg ha^{-1}), T2: Foliar application at 60 DAS (days after sowing), T3: Foliar application at 60 and 75 DAS, T4: Foliar application at 60, 75 and 90 DAS, T5: Foliar application at 60, 75, 90 and 105 DAS, T6: Foliar application at 60, 75, 90, 105 and 120 DAS. The experiment was carried out according to randomized complete block design (RCBD) with three replications while, plot size was 135 m^2 having dimension 9.0 m x 15 m. Well adopted high yielding cotton variety (cv. MNH-886) was sown during second fortnight of March on a well prepared seed bed at 75 cm row to row and 30 cm plant to plant distances. Full dose of P as a single superphosphate (SSP) and K as sulfate of potash (SOP) was applied at planting and N as urea was applied in six equal splits. Pre-emergence weedicide (Pendimethaline and Acetachlore @ 2.5 and 1.25 L ha^{-1}) was applied to eradicate weeds. All required agronomic practices and plant protection measures were carried out uniformly.

Soil samples were collected from 0-30 cm depth before application of fertilizer during each season. The physicochemical properties of the experimental soil were determined according to methods recommended by Ryan et al. (2001). The values demonstrated that soil was medium to heavy textured, alkaline in reaction, free of excessive soluble salts, low in organic matter, nitrogen and phosphorus (Table 1). The potassium level was inadequate to capture an economic yield. The seed cotton was harvested plot wise and finally converted into kg per hectare. Ten plants from each treatment were selected at random for counting number of bolls per plant and 25 bolls were collected from each treatment for boll weight determination. The average

Table 1 Physico-chemical properties of the soil to be used for experiment

Physicochemical properties	Values
pH	8.35-8.46
ECe (dS m^{-1})	0.98-1.27
$CaCO_3$ (%)	3.7-4.0
Organic matter (%)	0.54-0.68
Available phosphorus (mg kg^{-1})	5.66-6.85
Available potassium (mg kg^{-1})	116-129
Textural class	Clay loam

maximum temperature (39.42ºC and 40.07ºC), minimum temperature (24.30°C and 23.76ºC) and total rainfall (170.18 mm and 133.20 mm), during 2011 and 2012, respectively were recorded during the crop growth period. The data regarding yield and yield components were subjected to statistical analysis and treatments differences were determined using LSD (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

The results indicated that seed cotton yield and its components differed significantly ($p \leq 0.05$) at various NPK application times during 2012 (Tables 2). Maximum seed cotton yield (2158 kg ha^{-1}) was obtained from foliar application of NPK 20: 20: 20 at 60, 75, 90, 105 and 120 DAS followed by foliar application of NPK 20: 20: 20 at 60, 75, 90, and 105 DAS that gave seed cotton yield 2145 kg ha^{-1} in comparison to control treatment. Minimum seed cotton yield (2061 kg ha^{-1}) was produced where no foliar application of NPK was applied. Different NPK application times also influenced number of bolls and boll weight significantly ($p \leq 0.05$). Higher number of bolls per plant was recorded 23 and maximum boll weight (up to 3.18 g) was also obtained with foliar application of NPK 20: 20: 20 at 60, 75, 90, 105 and 120 DAS followed by number of bolls per plant (22.2) and maximum boll weight (3.12 g) at foliar application of NPK 20: 20: 20 at 60, 75, 90, and 105 DAS. Minimum number of bolls per plant (19.4) and boll weight (2.70 g) were noted where no foliar application of NPK was executed. The data for the year 2011 showed similar results as obtained in 2012 where foliar application of NPK 20: 20: 20 at 60, 75, 90, 105 and 120 DAS was executed and stood first in seed cotton yield (2252 kg ha^{-1}), number of bolls per plant (23.8) and boll weight (3.25 g) (Table 3). Significant relationship ($R^2 = 0.93$) was found between average seed cotton yield and number of bolls per plant (Figure 1) elucidated that seed cotton yield was linearly increased with increase in boll number.

Average data of two crop seasons also showed similar trend regarding seed cotton yield, number of bolls, boll weight and agronomic use efficiency (Table 4). Foliar application of NPK 20: 20: 20 at 60, 75, 90, 105 and 120 DAS excelled in seed cotton yield (2205 kg ha^{-1}) followed by foliar application of NPK 20: 20: 20 at 60, 75, 90, and 105 DAS (2178 kg ha^{-1}). About 5.98% increase in seed cotton yield was recorded in crop where foliar application of NPK 20: 20: 20 at 60, 75, 90, 105 and 120 DAS was applied as compared to crop where no foliar application of NPK was carried out. The results further revealed that yield contributing components i.e. bolls per plant (23.4) and boll weight (3.21 g) were also higher in said treatment. The results are in consonance with

Table 2 Effect of foliar application of NPK on yield and yield attributes of cotton in the agro-climatic conditions of Vehari, Pakistan during kharif 2012

Treatments	Yield (kg ha^{-1})	Number of bolls $plant^{-1}$	Boll weight (g)
T1: Control (Recommended NPK)	2061f	19.4f	2.7f
T2: Foliar application at 60 DAS	2088e	20.6e	2.92e
T3: Foliar application at 60 and 75 DAS	2110d	21.2d	2.99d
T4: Foliar application at 60, 75 and 90 DAS	2125c	21.6c	3.08c
T5: Foliar application at 60, 75, 90 and 105 DAS	2145b	22.2b	3.12b
T6: Foliar application at 60, 75, 90, 105 and 120 DAS	2158a	23a	3.18a
LSD value ($p \leq 0.05$)	10.87	0.12	0.035

Means not sharing a common letter in column are significant at 5% probability level

Table 3 Effect of foliar application of NPK on yield and yield attributes of cotton in the agro-climatic conditions of vehari, Pakistan during kharif 2011

Treatments	Yield (kg ha^{-1})	Number of bolls $plant^{-1}$	Boll weight g)
T1: Control (Recommended level of NPK)	2084f	20.2f	2.83f
T2: Foliar application at 60 DAS	2113e	21.4e	2.94e
T3: Foliar application at 60 and 75 DAS	2147d	21.6d	3.02d
T4: Foliar application at 60, 75 and 90 DAS	2179c	22c	3.14c
T5: Foliar application at 60, 75, 90 and 105 DAS	2211b	22.4b	3.12b
T6: Foliar application at 60, 75, 90, 105 and 120 DAS	2252a	23.8a	3.25a
LSD value ($p \leq 0.05$)	11.7	0.14	0.046

Mean values not sharing a common letter in column are significant at 5% probability level

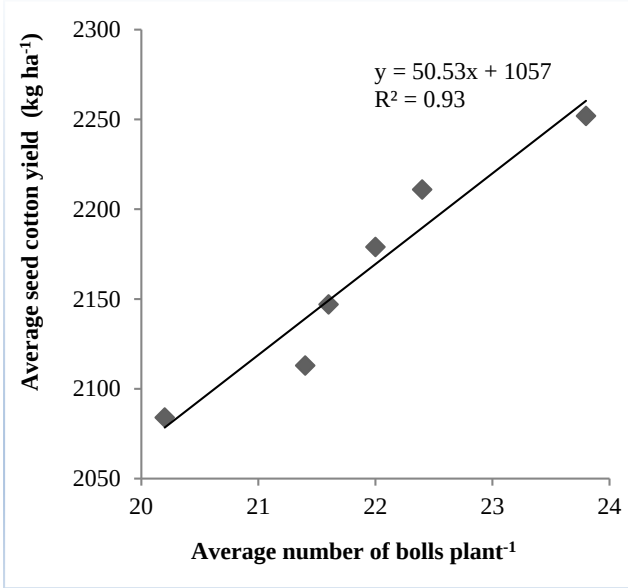

Figure 1 Relationship between average seed cotton yield and average number of bolls

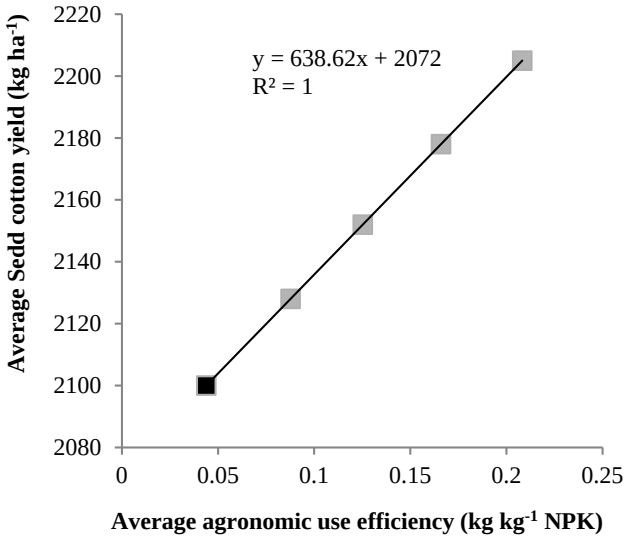

Figure 2 Relationship between average seed cotton yield and average agronomic use efficiency

Table 4 Effect of foliar application of NPK on yield and yield attributes of cotton in the agro-climatic conditions of Vehari, Pakistan during kharif 2011-2012

Treatments	Yield (kg ha^{-1})	Number of bolls plant^{-1}	Boll weight (g)	AUE (kg kg^{-1} NPK)
T1: Control (Recommended level of NPK)	2072f	19.8f	2.765f	-
T2: Foliar application at 60 DAS	2100e	21e	2.93e	0.043
T3: Foliar application at 60 and 75 DAS	2128d	21.4d	3.005d	0.087
T4: Foliar application at 60, 75 and 90 DAS	2152c	21.8c	3.11c	0.125
T5: Foliar application at 60, 75, 90 and 105 DAS	2178b	22.3b	3.12b	0.165
T6: Foliar application at 60, 75, 90, 105 and 120 DAS	2205a	23.4a	3.215a	0.208
LSD value ($p \leq 0.05$)	19.8	0.22	0.026	

Means not sharing a common letter in column are significant at 5% probability level, AUE: Agronomic use efficiency

number of researchers (Jamal et al. 2006; Abd El-Mohsen and Ahmed (2015). The results are also in line with Gerik et al. (1994), Pettigrew (2003) and Crozier et al. (2004).

CONCLUSION

The results of this study showed that foliar application of NPK 20: 20: 20 at 60, 75, 90, 105 and 120 DAS plus recommended NPK as soil application is important for higher seed cotton yield. Increase in boll weight was mainly due to translocation of various metabolites such as sugar, cellulose etc. triggered by the enzymatic activation for increased photosynthetic efficiency which led to increase in seed cotton yield.

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