Journal of Experimental Biology and Agricultural Sciences

<http://www.jebas.org>

ISSN No. 2320 – 8694

OPTIMIZING YIELD AND FIBER QUALITY OF COTTON UNDER MEDITERRANEAN ENVIRONMENT: MANAGING NITROGEN AND POTASSIUM NUTRITION

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Received – August 30, 2016; Revision – September 13, 2016; Accepted – October 01, 2016

Available Online – October 07, 2016

DOI: [http://dx.doi.org/10.18006/2016.4\(5S\).572.580](http://dx.doi.org/10.18006/2016.4(5S).572.580)

KEYWORDS

Potassium

Gossypium hirsutum

Cotton Seed yield

Interaction of N X K

ABSTRACT

Effective management strategies for nitrogen (N) and potassium (K) fertilizer are important to ensure optimum yield and fiber quality of cotton production. The aim of this research was to study the influence of nitrogen and potassium application on yield and fiber quality of cotton. Study was conducted in a randomized blocks in a factorial design with three replicates. The nitrogen treatments (0, 60, 120, 180, 240 kg ha⁻¹) and five K₂O rates (0, 50, 100, 150, and 200 kg ha⁻¹) are used in this study. Among the various tested combinations, the best combinations are 180 kg N ha⁻¹ along with 150 kg K ha⁻¹ and it produced the greatest seed cotton yield and gin turnout. After 120 days of plantation 72% reduction in the dry weight was reported in the nitrogen deficient treatment and these plants produced only 17 bolls per plant and it was significantly different (25 bolls) than the plant treated by 180 kg N ha⁻¹. Significant and negative correlations were reported between boll number per plant and micronaire and total dry matter yield were found at K fertilization treatments. Positive and significant correlations were determined between gin turnout and micronaire and between fiber strength and total biomass production at N fertilization. The highest fiber strength was recorded in the plant treated by the combination of 240 kg ha⁻¹ nitrogen and 50 kg ha⁻¹ potassium. For fiber length and fiber strength, no significant differences were reported among the various treatments of potassium. From the results of this study it can be concluded that combination of 180 kg ha⁻¹ nitrogen and 100 kg ha⁻¹ potassium are suitable for the production of cotton crop.

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Peer review under responsibility of Journal of Experimental Biology and Agricultural Sciences.

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1 Introduction

Availability of nitrogen affect the indeterminate growth of Cotton's (*Gossypium sps.*), regular supply of nitrogen are the basic need of for the cotton production. Since cotton production covers a wide range of environments and economic circumstances, hence yields and nutritional requirements of this vary greatly. Depending on the varietal differences agronomic practices and input requirements are also varies. Nitrogen has to be applied under all set of growing conditions because nitrogen requirements of cotton plant are different at various stages of development. A wide variety of experiments on the effect of fertility on cotton crop have been conducted worldwide under various soils conditions and fertilizer sources and with different rates and varieties (Fritschi et al., 2003; Reddy et al., 2004; Read et al., 2006). Like nitrogen fertilizer, continues removal of potassium fertilizer was also reported and a reduction in cotton productivity was reported because cotton crop appears to be more sensitive to K deficiencies (Cope, 1981).

Remarkable improvements in cotton yield and quality resulting from potassium input were reported by Mullins & Burmester (1991) and Pettigrew et al. (2005). While the N and K requirements are quite well disseminated to growers and among these two, K received less attention. To manage the efficacy of nitrogen fertilizer adequate supply of potassium is required because a strong interaction between nitrogen and potassium was reported by Johnston & Milford (2012). By understanding how nutrients work together, a better strategy can be developed for improving the productivity and deciding wiser farm investments. This will also help in minimizing the negative impacts of fertilizer. Knowledge of interactions among major plant nutrients is important in formulating balanced supply of fertilizers to crop plants. Studies with cotton have shown N and K to be sensitive nutrients and their potential interaction effects for profitable cotton production (Pettigrew et al., 2005; Kumar et al., 2011). Objective of this study was to determine the effect of nitrogen and potassium fertilizers on yield and quality parameters of cotton crop under Mediterranean environmental conditions.

2 Materials and Methods

The experiment was carried out at the Research Farm, Cukurova University, Adana, the Eastern Mediterranean region of Turkey. Study area was located between 37° 00' 02" N latitude and 35° 18' 00" E longitude at 33 m altitude. Study was conducted for two successive growing seasons of 2010 and 2011, using the cotton cultivar SG-125 (*Gossypium hirsutum* L.). The soil of the experimental plots is classified as a Vertisol (chromoxeret) and has relatively high clay content with the predominant clay minerals smectite and kaolinite. The climate of the experimental site is typically Mediterranean with May-October growth season. Annual rainfall was reported

between 50.3 mm (2010) to 88.1 mm (2011) and mean monthly temperatures ranging between 27.6°C and 36.1°C and between 26.7°C and 34.71°C in 2010 and 2011, respectively (data not shown). Composite soil samples were taken from trial site at depths 0-30 cm in both seasons. The soil was clay loam in texture, nonsaline, slightly alkaline in reaction, and highly calcerous. Soil properties of the experimental site are given in Table 1.

Table 1 Soil characteristics of the experimental site.

Soil analysis	2010	2011
Organic matter (%)	2.05	2.12
CaCO ₃ (%)	24.3	24.5
Sand (%)	12.9	14.3
Clay (%)	48.2	54.1
Loam (%)	33.0	34.5
Texture	Clay loam	Clay loam
pH	7.5	7.6
Available nitrogen (mg kg ⁻¹)	34	22
Available phosphorus (mg kg ⁻¹)	13.4	11.8
Available potassium (mg kg ⁻¹)	178	192
Total sulfur (mg kg ⁻¹)	23.0	21.0

The experimental design consisted of randomized blocks in a factorial arrangement with three replicates. Different fields were used every year and new randomization was carried out every year and the same plots were not used next year. Five level of nitrogen viz. 0, 60, 120, 180 and 240 kg ha⁻¹, corresponding to N0, N60, N120, N180 and N240 kg N ha⁻¹) and K i.e. 0, 50, 100, 150 and 200 kg ha⁻¹ corresponding to K0, K50, K100, K150 and K 200 kg K ha⁻¹) were used in this study. The rate of N and K were established taking into account the results of previous studies conducted in Turkey's cotton regions (Colakoğlu, 1980; Tozan, 1990; Gormus & Yucel, 2002). The N and K were applied as ammonium nitrate and potassium sulfate in three equal splits viz. 1/3 at time of planting, 1/3 at early square and 1/3 at early bloom.

A buffer zone of 2 rows spacing was provided between each plot. Plants were planted on 10 May 2010 and 28 April in 2011. Plots have 4 rows of 10 m length with a 0.7 m distance. All plots received 70 kg triple superphosphate per hectare as a basal rate. Standard cultural practices such as pest management, weeding and irrigation were carried out as recommended for the study area. After 120 days of planting (DAP) plant dry matter (biomass) was measured. Five plants were selected from the inner two rows of each plot and were sampled; all the selected samples were partitioned into vegetative and reproductive organs. All samples were dried at 70°C for 48 h, all the dried samples were weighed and dry matter were estimated on the basis of per-unit-land-area. Ten plants were selected from each plot to record the number of open bolls at harvest. Seed cotton yield was determined from the two inside rows from a 4 row plots.

Table 2 Mean squares according to analysis of variance of yield, yield components and fiber traits.

S.O.V	df	Total dry matter at 120 DAP	Open bolls plant ⁻¹	Boll weight	Gin turnout	Seed cotton yield	Fiber length	Fiber strength	Micronaire
Replicate	2	1573.74	133.9	0.899	1.053	9235.3	0.038	1.851	0.183
Year (Y)	1	22841.3**	5928.**	23.537**	4.824*	8939.**	52.819	100.8**	2.089*
N rate(N)	4	541112.**	466.5**	9.239**	29.13**	13856**	3.953*	8.460*	1.650**
Y X N	4	17265.8**	66.04*	2.462*	4.082**	3015.**	2.110	1.171	0.106
K rate (K)	4	21803.0**	66.58*	3.698**	3.185**	8015.**	1.622	0.106	0.451**
Y X K	4	518.65**	24.77	1.373	0.370	813.1	0.247	0.337	0.023
N X K	16	1432.318**	28.36	1.909**	4.535**	1790.**	2.015	5.087*	0.323**
Y X N X K	16	1092.49**	42.55*	1.874**	1.870**	996.1	0.382	0.361	0.052
Error	98	210.15	20.72	0.778	0.799	798.6	1.179	2.541	0.074

* Significant at $P < 0.05$; **Significant at $P < 0.01$

At harvesting stage, 20 ready to harvest bolls from the two central rows were collected from each plot to determine boll weight, gin turnout and fiber properties. Average boll weight was calculated by dividing the total plant seed cotton yield with respected to number of bolls per plant. Fiber analysis was conducted by using High Volume Instrumentation (HVI) method. Data were analyzed by analysis of variance and regression analysis was performed. Means were compared using LSD at 5% significance level. Appropriate regression model was selected on the basis of R^2 . The combined data showed interactions with year, thus, all the data are presented separately for each year.

3 Results and Discussion

Mean squares analysis of variance for yield, yield components and fiber traits are presented in Table 2. Significant effects were observed for total biomass, number of open bolls per plant, boll weight, gin turnout, cotton seed yield, fiber strength and micronaire. The main effects associated with N and K rate were significant for total biomass, number of open bolls per plant, boll weight, gin turnout, seed cotton yield and micronaire. Interactions between N X K have significant effect on the boll weight, gin turnout, seed cotton yield, fiber strength and micronaire. Further, interaction between Year X N was also showing a significant effect on total biomass, number of

bolls per plant, boll weight, gin turnout and seed cotton yield. Like nitrogen, interaction of Year X K also has significant effect on total biomass. Combination of all three factors (Year X N X K rate) were found significant for total biomass, number of open bolls per plant, boll weight and gin turnout.

3.1 Effect of fertilization of Total dry matter

Production of total dry matter (TDM) was significantly increased with increasing N fertilizer up to N180 and afterward a remarkable reduction was reported up to N240 in both years. Improvement of TDM was always higher in 2011 as compared to 2010 for all treatments (Table 3). Incase in the rate of K fertilizer application caused significant improvement in the value of TDM and the highest value in 2010 was observed at K200. Similarly, improvement in TDM was also recorded in 2011 at K200 but it was not statistically different from the K150 (Table3). Similar results were also reported by Yang et al. (2016), who reported that 150 kg K ha^{-1} was the best application strategy for maximum aerial biomass of cotton. Significantly positive linear relationships existed between N and K rates and total biomass accumulations in both years (Figure. 2b) and also reported a correlations between total biomass accumulation and seed cotton yield ($r=0.980^{**}$). These results are consistent with the findings of Makhdum et al. (2007) and Clement et al. (2013).

Figure 1 Interaction effects of N and K (over 2 years) on: a) cotton seed yield; b) gin turnout; c) boll weight; d) fiber strength and e) micronaire

Table 3 Effects of N and K on total dry matter and yield components.

	Total dry matter accum. (g m ⁻²)		Open bolls plant ⁻¹		Boll weight (g)		Gin turnout (%)	
N rate (kg ha ⁻¹)	2010	2011	2010	2011	2010	2011	2010	2011
0	475 ^c	464 ^c	10.7 ^d	22.1 ^d	6.5 ^b	7.2 ^b	42.8 ^b	42.4 ^c
60	578 ^d	557 ^d	11.2 ^d	23.8 ^{cd}	7.1 ^{ab}	8.0 ^a	42.2 ^{bc}	43.7 ^b
120	641 ^c	709 ^c	14.1 ^c	27.7 ^{bc}	7.3 ^a	8.1 ^a	44.2 ^a	43.4 ^b
180	810 ^a	816 ^a	21.3 ^a	30.2 ^a	7.2 ^a	7.5 ^{ab}	44.2 ^a	44.7 ^a
240	687 ^b	767 ^b	17.7 ^b	29.0 ^b	5.5 ^c	6.8 ^b	41.6 ^c	42.6 ^c
LSD _(5%)	2.55	14.30	1.16	3.93	0.56	0.73	0.67	0.65
K rate (kg ha ⁻¹)	2010	2011	2010	2011	2010	2011	2010	2011
0	605 ^c	625 ^c	13.3 ^c	24.5	6.4	6.6 ^b	43.5	43.8
50	622 ^d	646 ^b	14.1 ^{bc}	26.2	7.0	7.7 ^a	42.8	43.2
100	640 ^c	657 ^b	15.2 ^{ab}	28.8	7.0	7.7 ^a	42.7	43.3
150	653 ^b	692 ^a	15.4 ^a	27.0	6.6	7.8 ^a	43.3	43.4
200	671 ^a	693 ^a	15.9 ^a	29.4	6.4	7.7 ^a	42.7	43.0
LSD _(5%)	2.55	14.30	1.16	ns	ns	0.73	ns	ns

Means followed by the same letter are not significantly different at $P = 0.05$

These results may be reported because of adequate supplies of N and K which has significant effect on plant dry matter production. Plants with low supply of these nutrients show lower dry matter production, which impacts the production and allocation of photosynthates to the reproductive organs. The way cotton plant allocate photosynthates between vegetative and fruit growth in response to K nutrition critically affect the cotton yield potential. Significant reductions in total dry matter production with nitrogen deficiency were reported by Lokhande & Reddy (2015) and Fritschi et al. (2003). In this concern, another study revealed a significant effects of nitrogen sources and rates on dry matter in different crops and environments (EL Sabagh et al., 2016). Contradictory findings were reported by Pettigrew & Meredith (1997) those who reported that total plant dry matter was not altered by N and K fertilization.

3.2 Number of open bolls per plant

Number of open bolls per plant increased significantly with increasing the rates of N application but this increment was reported only up to N 180 kg/ha and thereafter sudden reduction was reported for both the years. The treatment containing N180 had statistically higher number of open bolls per plant (21.2 and 30.3) for both years, respectively (Table 3). Although number of bolls increased significantly with increasing rates of K fertilizer in 2010 but this improvement was not significantly different from 2011 (Table 3). A significant difference was reported between K150 and K200 treatments in case of open bolls per plant. Highest N rate reduced the number of open bolls; possibly because of high N levels in soil can cause excessive vegetative growth, which generally is detrimental to lint quality, and yield (McConnell et al., 1995). Boll number is closely connected with the formation of fruiting sites and nitrogen application could promote boll production, as evident from the significant relationship between the boll number per plant and N and K applications (Figure. 2c). No significant differences through K application were reported by Mert et al. (1999) and Karademir et al.

(2006). Zhao et al (2001) reported that declining trends under K deficient conditions for boll number and biomass similar to results of present study.

3.3 Boll weight

Statistically highest boll weights were reported in the plots receiving 60, 120 and 180 kg N ha⁻¹. Boll weights were found to increase by 9.2 to 11.1% with increasing N from 0 to 60 kg ha⁻¹ in 2010 and 2011, respectively. Lowest boll weight was reported from the treatment containing N240 in both years but in 2011 no significant difference was reported between the treatment N0 and N240 (Table 3). Total boll weight was declined in N-deficient and N240 treatments because of less number of bolls produced and retained. K applications did not significantly affect boll weight in 2010, whereas it increased significantly in response to all K fertilizer applications over the K0 treatment in 2011 but no statistical differences were observed with the increment of K from K50 to K200 treatments. Nitrogen availability influenced biomass remobilization to the boll and affected boll growth. Decrease in boll weight in treatment containing K0 treatment was due to early abscission of leaves and carbohydrates accumulated in main stem leaves, so late formed bolls developed incompletely. Adding K increased maximum boll filling compared to treatments without K fertilizer, displaying the essential role of K in metabolism of carbohydrates, which is directly related to the fiber components and in remobilizing assimilates to the bolls. The increase in boll weight is correlated positively with the increase in K fertilization rate (Kumar et al., 2011).

3.4 Gin turnout

Result of gin turnout showed a significant improvement on the application of nitrogen. Among various tested N application rate highest gin turnout was reported from the treatment containing N120 and N180 and these two are significantly than the other N treatments and N240 which produced the lowest gin turnout.

Table 4 Effects of N and K on yield and fiber quality traits.

	Seed cotton yield (kg ha ⁻¹)		Fiber length (mm)		Fiber strength (g tex ⁻¹)		Micronaire	
N rate (kg ha ⁻¹)	2010	2011	2010	2011	2010	2011	2010	2011
0	1611 ^c	1796 ^c	29.5	27.7 ^b	29.5 ^b	28.1	5.44 ^b	5.04 ^b
60	2603 ^d	2345 ^d	30.3	28.9 ^a	30.6 ^a	28.9	5.43 ^b	5.18 ^b
120	3119 ^b	2988 ^b	29.4	28.9 ^a	30.5 ^a	29.4	5.70 ^a	5.64 ^a
180	3674 ^a	3373 ^a	29.6	28.7 ^a	30.8 ^a	29.0	5.74 ^a	5.53 ^a
240	2840 ^c	2573 ^c	29.7	28.2 ^{ab}	31.2 ^a	29.0	5.30 ^b	5.03 ^b
LSD _(5%)	145.5	186.2	ns	0.88	0.82	ns	0.22	0.18
K rate (kg ha ⁻¹)								
0	2497 ^c	2439 ^c	29.5	28.2	30.6	29.0	5.35 ^{ab}	5.63
50	2640 ^c	2563 ^{bc}	29.7	28.3	30.7	28.8	5.41 ^a	5.61
100	2797 ^b	2611 ^{abc}	29.5	28.4	30.6	28.8	5.38 ^a	5.57
150	2942 ^{ab}	2810 ^a	29.9	28.6	30.4	28.8	5.10 ^c	5.41
200	2971 ^a	2653 ^{ab}	29.8	28.9	30.4	29.1	5.19 ^{bc}	5.38
LSD _(5%)	14.55	186.2	ns	ns	ns	ns	0.18	Ns

Means followed by the same letter are not significantly different at $P = 0.05$

A similar trend was reported in 2011 also and the highest gin turnout was reported from the treatment N180 while lowest gin turnouts were reported from the N0 and N240 plots (Table 3). No significant effect of potassium fertilizer was reported on gin turnout at both years. In this respect, findings of present study are contradictory to the findings of Cassman et al. (1990) and Pettigrew (1999) those who reported a significant improvement in gin turnout on the application of potassium fertilizer.

3.5 Seed cotton yield

Like other treatments, here also highest seed cotton yield was reported on the application of nitrogen fertilizer @ 180 kg N ha⁻¹ and this was significantly different from the all other nitrogen treatments while the lowest seed cotton yield was reported from the fertilizer rate 240 kg N ha⁻¹. These results are in agreement with the findings of Berberoğlu & Karaltın (2001) and Karademir et al. (2006) those who reported a reduction in the seed cotton yield on the higher nitrogen fertilizer application. On the application of potassium, a significant improvement was reported in cotton seed yields and this improvement was reported maximum in the plots treated with 150 to 200 kg K ha⁻¹ as compared to the control, 50 and 100 kg ha⁻¹ treatments in 2010. In 2011, the trends are slightly different and all the tested level are almost at par to each other and no significant difference was reported among them (Table 4).

The higher seed cotton yield at N180 may be due to the cumulative effect of higher number of bolls per plant and continued availability of nutrients. Nutrient deficiency or insufficient supply of fertilizers might provide insufficient assimilates and this lead to the formation of square or small boll abortion and reduced number of boll per plant. According to Wu et al. (1998) nitrogen is an essential nutrient in producing plant dry matter, thus influencing boll development, increasing the number of bolls and weight. Production of photosynthates required for achieving higher yields becomes inefficient under K deficit conditions.

3.6 Fiber quality

With the exception of micronaire in 2010, fiber quality parameters was unaffected by the application of potassium, while fiber length and strength values were reported similar in both the studied years, respectively (Table 4). Results (except for micronaire) of present study were generally inconsistent with previous reports (Cassman et al., 1990; Pettigrew, 1999) those who reported a significant effect of K fertilization on lint quality. Fiber length and strength were significantly lower for the plots without nitrogen application as compared to the plots treated with nitrogen. Plot treated with N60 produced 1.2 mm longer fibers. Results of nitrogen application show similarly with the findings of Wang et al. (2012) those who suggested that both N deficiency and excess N can reduce the accumulation of nutrients in fiber cells which caused reduction in the fiber length. Similarly, Fritschi et al. (2003) reported increased fiber length with increasing N applications. According to Zhao et al. (2010) increase in the level of nitrogen can boost the fiber grade in terms of length and strength of cotton fiber.

Higher micronaire values were associated with the N120 and N180 while the lower values were reported from the treatment containing N60, N240 and N0. Higher K rates (150-200 kg ha⁻¹) resulted in reduction in micronaire values while the micronaire values of K0, K50 and K100 are not statistically different in 2010 (Table 4). Fiber length response to fertilizer N at the experiment site supports results of previous research which suggest N applications have positive impact on fiber length (Bauer & Roof, 2004; Read et al., 2006). In present study application of lower N given higher fiber length, it is possibly due to lower biomass production. Keller (1997) reported that the low micronaire was offset by a relatively high number of bolls per plant. Further, it was reported that fiber quality of was low for the plants grown under low N concentrations while it was reported higher on the optimum supply of nitrogen. Reason behind this may be a positive correlation between the nitrogen application and carbohydrate supply during boll development (Tewolde & Fernandez, 2003).

Figure 2 Relationships between K rates and (a) cotton seed yield; (b) biomass production; (c) boll number per plant and (e) micronaire; N rates and (b) biomass production; (c) boll number per plant; and (d) fiber strength during t2010 and 2011 years.

Cotton which is over-fertilized with N often has lower micronaire because it creates a condition of low carbohydrate in relation to boll demand. Bauer & Roof (2004) and Read et al. (2006) reported that N-deficient can reduced fiber length, strength and micronaire values in cotton plant. Potassium is directly involved in the physiology of fiber elongation and thickening, thus K deficiency reduces micronaire, strength and length. The effect of potassium on fiber quality has been reported inconsistent across the study period. Pettigrew (2003) found that plants grown at 0 kg K ha⁻¹ produced lint with low micronaire and no fiber strength differences among different K treatments. Pettigrew et al. (1996) reported a drastic reduction in the length and micronaire quality on K deficiency.

3.7 Effect of N and K interaction on cotton

A significant interaction effects were reported for seed cotton yield, gin turnout, boll weight, boll numbers per plant, fiber strength and micronaire. This N*K effects was also supported by significant linear regression coefficients. Significantly higher yield was reported in the treatment containing 60 kg N ha⁻¹ without K and it shows superiority over the nitrogen and potassium control (Table 2, Figure. 1a). It was observed cotton seed yields were significantly increased with the application of 180 kg N combined with either 100 or 150 kg K ha⁻¹. The highest N application (240 kg ha⁻¹) tended to decrease yields. Potassium applications increased yields with N in both years. The linear K regression coefficient for seed cotton yield was

significant in 2010 but not in 2011 (Figure. 2a). Among various tested combinations, the interaction between N180 and K0 had the greatest gin turnout while the lowest gin turnout was related to the interaction of N240 and K150 treatments (Figure. 1b). Maximum boll weights were obtained from N120 along with K50 to K200 treatments and also N180 along with K50 to K100 treatments. Further, Minimum boll weight was recorded at combination of N60 and K200 treatment (Figure. 1c). Maximum fiber strength values were related to the interaction between N60 and K200 treatments, and also the interaction between N240 and K0 treatments (Figure. 1d). Similarly, highest micronaire value was recorded at N120 and N180 together with K100 treatments while the lowest micronaire value was obtained at the highest N and K rate treatments (Figure. 1e).

3.8 Correlation Coefficients at N and K Fertilization Treatments

Positive relationships were found between total dry matter and fiber strength ($r=0.947^*$) and boll number per plant ($r=0.908^*$) in 2010 and 2011, respectively. A positive correlation was reported between gin turnout and micronaire ($r=0.984^{**}$) in 2010 at nitrogen fertilization treatments while a negative relationships were found between micronaire and seed cotton yield ($r=-0.935^*$), total dry matter ($r=-0.942$), fiber length ($r=-0.910^*$) and boll number per plant ($r=-0.886^*$). Vegetative growth and plant biomass were decreased under K deficient

conditions (Kerby & Adams, 1985), because potassium plays an important role in photosynthesis, accumulation and allocation of carbohydrates (Reddy & Zhao, 2005). Micronaire is linearly related to the sufficient amount of carbohydrate supply for developing bolls provided by canopy photosynthesis (Bauer et al., 2000).

Similarly, a positive correlation was reported between total dry matter and seed cotton yield ($r=0.980^{**}$). Positive relationships were found between boll number per plant and seed cotton yield ($r=0.963^{**}$) and total dry matter ($r=0.990^{**}$) in 2010. Makhadm et al. (2007) reported positive significant correlations between seed cotton yield and total dry weight under the addition of K fertilizers in this manner results of present study are in agreement with the findings of these researchers. Negative relationships were found between micronaire and total dry matter ($r=-0.882^{*}$) and boll number per plant ($r=-0.986^{**}$) at K fertilization treatments in 2011. Higher boll loads or large number of bolls, create a greater demand for assimilates of each boll and increased competition may decrease the amount of cellulose available for each fibre and consequently lower the fibre micronaire (Kelly et al., 2008).

In 2011, significant correlation was found between total biomass production and seed cotton yield ($r=0.900^{*}$); between fiber length and total biomass production ($r=0.928^{*}$). Significant and negative correlations were reported between micronaire and total biomass production ($r=-0.882^{*}$), boll number per plant and micronaire ($r=-0.986^{**}$) at K fertilization treatments. Findings of this study are contradictory to the findings of Clement et al. (2013), those who reported that there was no significant relationship between total biomass and fiber-quality parameters. The supply of potassium rates according to the linear regression model, increased seed cotton yield which varies from 2640 to 2971 kg ha⁻¹ and showing an increase of 10.2% with the higher potassium rate compared to the lowest rate in 2010 (Figure. 2a). Fritsch et al. (2003) described a quadratic relationship between micronaire and N treatment at one site and linear functions at the other site. Cotton biomass production response to N rates is linear which indicating that application of highest N rate did not maximize the biomass (Figure. 2b) under the conditions of this experiment. A linear relationship between total dry matter accumulation and K rate was observed in 2010 and 2011. These strong relationships indicated a trend toward greater dry matter accumulation and partitioning into developing bolls with increasing N and K applications. As evident from this study showed overall lower plant assimilates levels caused lower total biomass which would help in the explaining the lower yields and poorer fiber quality in K plots.

The number of bolls per plant varied with the nitrogen and potassium rates, as in the linear regression model, increasing with the nitrogen and potassium supply from 60 to 180 kg N ha⁻¹ and from 50 to 150 kg K ha⁻¹, respectively (Figure. 2c). Different K rates varied as regards the micronaire values, as in the linear regression model (Figure. 2e), the micronaire values

decreased (from 5.4 to 5.1) as the potassium rates increased from 50 to 150 kg ha⁻¹ in 2010. N rates also resulted in a linear response of fiber strength (Figure. 2d), which is in accord with Fritsch et al. (2003), who reported a significant effect of N on fiber strength. Fiber micronaire also revealed a linear reduction with increase the K levels ($r^2 = 0.92$, Figure. 2e), indicating negative association with K treatments.

Conclusions

Overall evaluation of the findings indicates that the best combination is 180 kg N along with 100 kg K ha⁻¹ appeared most appropriate and suitable for achieving higher yield and yield attributes in cotton. Positive yield responses to K applications suggested the importance of K application to the cotton crop in clay loam soil for optimum growth and high yield in the present study conditions, where conventional management practices have usually applied excessive amounts of N while not considering K fertilization because it is thought that the soils of Turkey are rich in K and no need application of K fertilizer. Consequently, it can be suggested that N180 and K100 or K150 kg ha⁻¹ can be suitable fertilizer management practice for cotton production in experimental and similar environments.

Conflict of interest

Authors would hereby like to declare that there is no conflict of interests that could possibly arise.

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