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OPTIMIZATION OF SOIL K: NA RATIO FOR COTTON (*GOSSYPIUM HIRSUTUM* L.) NUTRITION UNDER FIELD CONDITIONS

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Abstract

Adequate potassium (K) supply is crucial for cotton growth and development. However, sodium (Na) can share some functions with K. In present study, we investigated the effects of replacing K with Na at different ratios on growth, ionic relations and yield as well as yield attributes of two cotton varieties differed in K use efficiency. Different levels of K and Na giving K: Na ratios of 3.5: 1 (control), 3.75: 1, 4: 1, 4.25: 1, 4.5: 1, 2.8: 1, 3: 1, 3.2: 1, 3.4: 1, 3.6: 1 were arranged in triplicates according to randomized complete block design under natural field conditions. Results revealed that maximum seed cotton yield was obtained at K: Na ratio of 3.4: 1 followed by 3.6: 1 in both cotton varieties. However, NIBGE-2 manifested greater seed cotton yield than MNH-786. The significant ($p \leq 0.05$) positive correlation was found between number of bolls plant^{-1} and seed cotton yield ($R^2 = 0.62$ for NIBGE-2 and $R^2 = 0.64$ for MNH-786) determined at different levels of K and Na. Leaf K: Na ratio also varied significantly ($p \leq 0.05$) due to main effects of K, Na, varieties and their interactions. Maximum leaf K: Na ratio was shown by NIBGE-2 with 270 kg K ha^{-1}+60 kg Na ha^{-1} at ratio of 4.5: 1 followed by 255 kg K ha^{-1}+60 kg Na ha^{-1} at ratio of 4.25: 1. Although fiber quality of both cotton varieties were markedly influenced by different ratios of K: Na, however these differences between treatments and varieties were not consistent. There was a significant positive correlation between K concentration and fiber length ($R^2 = 0.97$ for NIBGE-2 and $R^2 = 0.98$ for MNH-786). Our results suggested that cotton growth and yield could be improved by adding appropriate amounts of K and Na.

Introduction

Cotton (*Gossypium hirsutum* L.) requires potassium (K) almost equal to nitrogen (N) to give a yield of 2.23 t ha^{-1} of ginned cotton (Grimes & El-Zik, 1990; Daliparthy *et al*., 1994). Potassium nutrition of cotton appeared to be very indispensable due to its vital role in biomass production (Hassan & Arshad, 2010), leaf area expansion (Makhdum *et al*., 2007), CO_2 assimilation (Reddy *et al*., 2004), photosynthesis (Cakmak, 2005), water relations (Maathuis *et al*., 1997; Pervez *et al*., 2004), enzyme activation (Cakmak, 2005), boll weight and size, lint yield (Akhtar *et al*., 2003) and fiber quality (Ali *et al*., 2009a). Oosterhuis *et al*., (1997) reported that cotton is very sensitive to low K in soils. Potassium deficiency causes premature termination of reproductive growth (Pettigrew, 2003), low boll weight of cotton (Kerby & Adams, 1985) and premature senescence (Wright, 1999). Mullins *et al*., (1999) reported a considerable increase in fiber quality by K fertilizer addition on an irrigated soil. Bradow & Davidonis (2000) also reported that high rates of K were correlated with improved fiber whiteness, fiber maturity, micronaire and decreased fiber yellowness. K^+ has been also considered often to play a role in osmotic stress and salt toxicity remediation and some studies show inhibition of K^+ influx by NaCl (Abdul Majid *et al*., 2007). In the cytosol, K^+ is an essential activator for some enzymes and Na^+ can rarely substitute for these biochemical functions. Na^+ can compete directly for K^+-binding sites on enzymes, suggesting that the cytosolic K^+ to Na^+ ratio, rather than the absolute Na^+ concentration, is critical for tolerance (Carden *et al*., 2003; Ashraf *et al*., 2008).Although the availability of sodium (Na), as a cheap osmoticum, is generally beneficial as Na can partially replace K, particularly in its osmotic functions in the vacuole (Maser *et al*., 2002). Shirazi *et al*., (2011) conducted a study under saline-sodic field conditions to see ionic uptake pattern in different plant parts of some brassica genotypes. They concluded that the genotypes having better performance were found to have accumulating type of behavior showing comparatively higher Na contents in all plant parts than other genotypes. This suggests that these genotypes might adjust their osmotic potential through the accumulation of sodium in vacuole.

Under K starvation, addition of Na promotes plant growth (Marschner, 1995). Zhang *et al*., (2006) explained that cotton growth, nutrient uptake, and yield were improved by adding appropriate amounts of K and Na. Marschner, (1995) has reported a positive relationship between the uptake and translocation of Na to the shoot and the extent of replacement of K in the plant species. Moderate salinity with adequate K nutrition did not have adverse effects on growth but at higher salt concentration, shedding and premature leaf senescence was observed (Brugnoli & Bjorkman, 1992). The findings of El-Gharib & Kadry (1983) and Salih & Halim (1985) indicated that low salinity with optimal supply of nutrients, increased the yield of seed cotton. The synergistic or antagonistic effect between K and Na depends on the amount of each element present in the soil and also on the plant type (Marschner, 1995). Increasing salinization in the agricultural soils impels to devise strategies aiming at exploring the beneficial effects of Na in different crops (Ye *et al*., 1997; Iftikhar *et al.,* 2010). Salt tolerance of cotton is related to high shoot Na (Leidi & Saiz, 1997).

Optimum K: Na ratio in tissues is required for normal physiological functioning of plant cells (Cakmak, 2005). Gareth *et al*., (1979) suggested a minimum value for K: Na ratio of 1 for normal growth of plants subjected to saline conditions. Under salinity stress, plants may accumulate more Na in their tissues by passive accumulation of Na in the roots thereby decreasing K: Na ratio in the tissues (Greenway & Munns, 1980).

In our preliminary hydroponics experiments, we found that the addition of small amounts of Na to growth medium enhanced the growth of cotton (Ali *et al*., 2009a; Ali *et al*., 2009b). The present experiment was conducted to verify the results of solution culture experiments and identify the best possible K: Na ratio for cotton nutrition under field conditions.

Materials and Methods

Growth conditions and treatments: Field experiment was conducted at Govt. Reclamation Research Station, Directorate of Land Reclamation, Irrigation & Power Department, Mianchannu (30.26° N Latitude and 72.22°E Longitude). Mean day temperature was 43±5.6°C while night temperature was 31± 8.2°C during the experiment and day length was 14 h. The relative humidity ranged from 37 to 58% and the soil was coarse-loamy, Thermiotypic Ustochrept (Anon., 1990; Anon., 1998). The soil series was Awagat as described by Anon., (1969). The soil was slightly saline with electrical conductivity of the saturation extract (ECe) 4.82 dS m^{-1}, pH 8.42 (Bigham, 1996), organic matter 0.41% (Nelson & Sommers, 1996), $CaCO_3$ 1.2%, Olsen-P 6.2 mg kg^{-1}, NH_4OAc-K 105 mg kg^{-1} (Soltanpour & Worker, 1979) and extractable Na 30 mg kg^{-1} and textural class was loamy clay.

The experimental field was divided into 60 plots according to randomized complete block design in split plot manner with three replicates. Plot size for each replication was 5m × 3m = 15m^2. Ten treatments were applied by developing required K: Na ratios after considering indigenous K, Na levels in soil. The treatments of K+Na in kg ha^{-1} with K: Na ratios were as: 210+60 (3.5: 1) i.e. control, 225+60 (3.75: 1), 240+60 (4:1), 255+60 (4.25: 1), 270+60 (4.5: 1), 210+75 (2.8: 1), 225+75 (3: 1), 240+75 (3.2: 1), 255+75 (3.4: 1) and 270+75 (3.6: 1). Control treatment represented indigenous K, Na status of soil. Potassium and sodium treatments were applied in main plots while varieties were sown in sub plots . The recommended doses of N @ 170 kg ha^{-1} as urea and P @ 57 kg ha^{-1} as single super phosphate were applied. One 3rd dose of urea and full dose of single super phosphate (SSP), full doses of K as potassium sulfate and full doses of Na as sodium sulfate were applied at the time of sowing. Remaining doses of urea were applied twice, 1/3rd at first irrigation and 1/3rd at pre-flowering stage.

Two cotton varieties, NIBGE-2 and MNH-786 contrasting in K use efficiency (Ali *et al*., 2008) were used in the experiment. At field capacity, delinted cotton seed of the both varieties was sown @ 20 kg ha^{-1}. There was 75 cm row to row distance. Thinning was done after 10 days of emergence. After germination, the plant to plant distance was maintained at 15 cm to provide 37 plants of uniform size in each row. There were four rows in each plot. Weeding and other plant protection measures were adopted according to conventional practices, when it was necessary. Canal water with Ece, 0.31 dS m^{-1} was applied for irrigation purpose during the growth period.

Ionic relations: Eighty days after sowing, youngest fully expanded leaves were collected from main stem (fourth leaf from the top) of 10 randomly selected plants from each plot during the morning hours. Leave were washed with distilled water and dried for 48 h in a forced-air oven (EYELA WFO-600ND; Tokyo Rikaikai Co., Ltd., Tokyo, Japan) at 70ºC. The dried tissues were finely ground to 40 meshes with mechanical grinder (MF 10 IKA-WERKE, GMBH & CO. KG, Germany). Ground samples were homogenized by mixing. A 0.5 g portion of ground leaf samples were digested in 5 ml of nitric: perchloric acid mixture (3:1) following Miller (1998). The digested samples were diluted with distilled water as per requirement and K and Na in the digested samples was determined with flame photometer (Jenway PFP 7, Bibby Scientific Ltd., Jenway, Essex, England). Leaf K: Na ratio was calculated by dividing leaf K concentration with leaf Na concentration.

Fiber quality: At maturity (170 day old), seed cotton samples were collected at random from 10 plants in each plot and fiber quality characteristics were determined, like Staple length (mm) by Fibrograph model 430, USA, Fiber strength (g tex^{-1}) by Stelometer model 154, Spinlab, USA and Fiber fineness or micronaire value (µg $inch^{-1}$).

Yield and yield attributes: Yield was recorded by manual harvesting of cotton plants in each plot separately and data for yield contributing parameters such as number of bolls $plant^{-1}$ (average of five plants) and average boll weight (average of 20 bolls) were recorded.

Statistical analysis: The data obtained were subjected to statistical analysis using computer software MSTAT-C (Russell & Eisensmith, 1983) by following the methods of Gomez & Gomez (1984). Analysis of the variance was carried out according to split plot design. Duncan's multiple range tests was used for mean separation (Duncan, 1955).

Results and Discussion

Seed cotton yield: Significant ($p \leq 0.05$) differences in seed cotton yield due to rates of K and Na, varieties, as well as their interaction were found (Table 1). Maximum seed cotton yield of 2060 kg ha^{-1} was obtained with 255 kg K+75 kg Na ha^{-1} at ratio 3.4: 1 followed by 1847 kg ha^{-1} with 270 kg K+75 kg Na at ratio 3.6: 1 against the minimum (1142 kg ha^{-1}) with control at ratio 3.5: 1 in NIBGE-2. Varieties varied significantly ($p \leq 0.05$) for seed cotton yield and NIBGE-2 yielded better (1594 kg ha^{-1}) than MNH-786 (1443 kg ha^{-1}). Zhang *et al*., (2006) under field conditions examined the effects of replacing K with Na and found that highest seed cotton yield was obtained when K and Na were added at rates of 115 and 65 mg kg^{-1}, respectively in the top 20 cm of soil.

Table 1. Seed cotton yield and yield attributes of two cotton varieties grown with various rates of K and Na under field conditions (Values are the means of 3 replications).

Treatments (Kg ha^{-1})		Seed cotton yield (kg ha^{-1}) (mean ± SD)		Number of bolls plant^{-1} (mean ± SD)		Boll weight (g boll^{-1}) (mean ± SD)	
K+Na	Ratio	NIBGE-2	MNH-786	NIBGE-2	MNH-786	NIBGE-2	MNH-786
225 + 60	3.75: 1	1430 g ± 19.05	1313 h ± 60.02	19.2 f ± 1.56	15.2 jk ± 0.53	2.85 ns ± 0.087	2.65 ± 0.078
240 + 60	4: 1	1532 ef ± 12.49	1414 g ± 71.71	22 de ± 1.91	15.8 i j ± 1.59	3.11 ± 0.157	2.73 ± 0.110
255 + 60	4.25: 1	1724 c ± 27.51	1575 e ± 12.29	26.2 a ± 0.92	17.2 hi ± 1.11	3.52 ± 0.312	2.81 ± 0.154
270 + 60	4.5: 1	1797 b ± 13	1636 d ± 9.64	24.4 bc ± 0.72	16.2 hij ± 0.80	3.42 ± 0.223	3.45 ± 0.154
210 + 60 Control	3.5: 1	1142 j ± 6.245	1052 k ± 24.02	17.6 gh ± 1.04	14.4 kl ± 0.20	2.75 ± 0.095	2.40 ± 0.590
225 + 75	3: 1	1484 f ± 26.91	1323 h ± 38.69	23.2 cd ± 0.92	16.2 hij ± 1.11	3.27 ± 0.079	2.92 ± 0.223
240 + 75	3.2: 1	1717 c ± 30.2	1505 f ± 8.888	21.2 e ± 1.06	18.8 fg ± 0.87	3.62 ± 0.111	3.11 ± 0.140
255 + 75	3.4: 1	2060 a ± 14.53	1838 b ± 25.24	24.8 b ± 1.22	19.0 f ± 0.20	3.76 ± 0.156	3.32 ± 0.130
270 + 75	3.6: 1	1847 b ± 29.14	1646 d ± 35.17	21.4 e ± 1.06	16.2 hij ± 0.92	3.42 ± 0.181	2.78 ± 0.178
210 + 75	2.8: 1	1206 i ± 22.72	1132 j ± 13	17.4 h ± 0.87	13.6 l ± 0.40	2.50 ± 0.349	2.24 ± 0.118
Mean		**1594 a**	**1443 b**	**21.74 a**	**16.26 b**	**3.22 a**	**2.84 b**

Means with different letter(s) differ significantly according to Duncan's Multiple Range Test ($p \leq 0.05$)

Table 2. Fiber quality of two cotton varieties grown with various rates of K and Na under field conditions (Values are the means of 3 replications).

Treatments (Kg ha^{-1})		Micronaire (µg inch^{-1}) (mean ± SD)		Fiber strength (g tex^{-1}) (mean ± SD)		Fiber length (mm) (mean ± SD)	
K + Na	Ratio	NIBGE-2	MNH-786	NIBGE-2	MNH-786	NIBGE-2	MNH-786
225 + 60	3.75: 1	4.71 ns ± 0.057	4.62 ± 0.040	22.43 ns ± 0.76	21.60 ± 2.00	27.70 ns ± 2.14	27.33 ± 0.21
240 + 60	4: 1	4.61 ± 0.305	4.52 ± 0.117	21.93 ± 0.97	21.73 ± 1.03	27.67 ± 1.15	27.37 ± 0.06
255 + 60	4.25: 1	4.55 ± 0.592	4.60 ± 0.403	23.30 ± 0.65	22.20 ± 0.64	27.93 ± 0.60	27.33 ± 0.21
270 + 60	4.5: 1	4.93 ± 0.069	4.55 ± 0.429	24.37 ± 0.71	22.33 ± 0.56	28.03 ± 0.15	27.77 ± 0.75
210 + 60 Control	3.5: 1	4.50 ± 0.229	4.40 ± 0.175	20.23 ± 0.80	20.47 ± 1.81	21.50 ± 0.36	20.32 ± 0.07
225 + 75	3: 1	4.60 ± 0.217	4.95 ± 0.600	21.17 ± 1.15	20.63 ± 0.65	26.50 ± 1.15	25.57 ± 0.15
240 + 75	3.2: 1	4.98 ± 0.272	5.12 ± 0.090	22.37 ± 0.56	21.43 ± 1.15	26.90 ± 0.56	26.47 ± 0.31
255 + 75	3.4: 1	5.08 ± 0.210	4.98 ± 0.040	22.27 ± 0.56	21.67 ± 2.02	26.77 ± 0.74	26.53 ± 0.81
270 + 75	3.6: 1	5.04 ± 0.074	4.34 ± 0.210	21.47 ± 0.72	21.27 ± 0.64	27.37 ± 0.75	27.03 ± 0.21
210 + 75	2.8: 1	4.14 ± 0.113	4.04 ± 0.020	21.43 ± 1.15	20.77 ± 0.80	20.32 ± 0.23	20.12 ± 0.19
Mean		**4.78 a**	**4.68 a**	**22.10 a**	**21.41 b**	**26.07 a**	**25.58 b**

Means with different letter(s) differ significantly according to Duncan's Multiple Range Test ($p \leq 0.05$)

They further explained that cotton growth, nutrients absorption, and yield were improved by adding appropriate amounts of K and Na in soil. Main effects of K, Na rates, varieties and their interaction produced significantly ($p \leq 0.05$) different number of bolls plant^{-1} (Table 1). Enhanced number of bolls plant^{-1} (26.2) were produced with 255 kg K+60 kg Na at ratio 4.25: 1 followed by 24.8 with 255 kg K+75 kg Na at ratio 3.4: 1 in NIBGE-2 against the minimum (17.6) observed with control at ratio 3.5: 1. Highest numbers of bolls plant^{-1} were manifested with NIBGE-2 compared to MNH-786. Non-significant differences in boll weight were observed among treatments with respect to K, Na rates and varieties interaction. However, NIBGE-2 exhibited maximum boll weight (3.22 g boll^{-1}) compared to MNH-786 (2.84 g boll^{-1}). Hassan & Arshad (2010) concluded after conducting K-deficient solution culture study that the enhanced biomass accumulation of NIBGE -2 under K efficiency stress is related to their efficient photosynthetic apparatus and root system, appeared to be the most important morphological markers while breeding for K-use efficient cotton genotypes.

According to Brugnoli & Bjorkman (1992), moderate salinity with adequate nutrition did not have adverse effects on growth. However, other researchers (El-Gharib & Kadry, 1983; Salih & Halim, 1985**)** indicated that low salinity with optimal supply of nutrients increased the yield of seed cotton. The present investigation determined changes in seed cotton yield and yield components due to K and Na rates. The observed data is consistent with the reports that K deficiency causes premature termination of reproductive growth (Roy, 2000; Pettigrew, 2003) and low boll weight (Kerby & Adams, 1985). It was suggested that highest seed cotton yield obtained by both varieties was due to the addition of K with Na @ 255+75 kg ha^{-1}. There was a significant positive correlation (R^2= 0.62, 0.64, n=10) between number of boll plant^{-1} and seed cotton yield for both varieties (Fig. 1). The increase in yield could mainly be attributed to increase in boll weight as evident in Fig. 2.

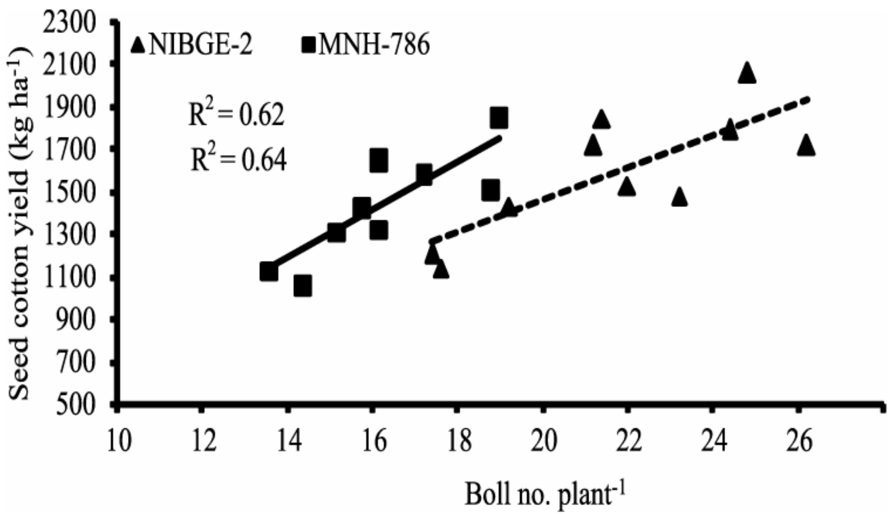

Fig.1. Relationship between seed cotton yield and boll number for both varieties.

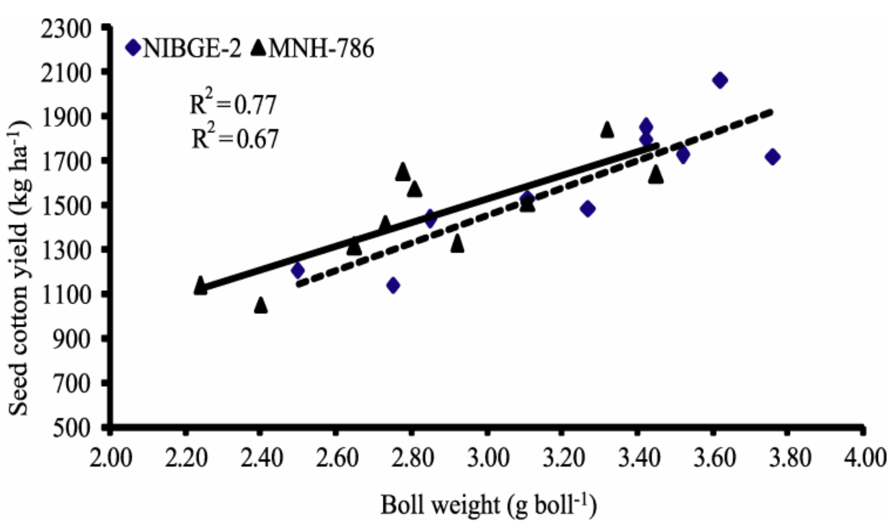

Fig. 2. Relationship between seed cotton yield and boll weight for both varieties.

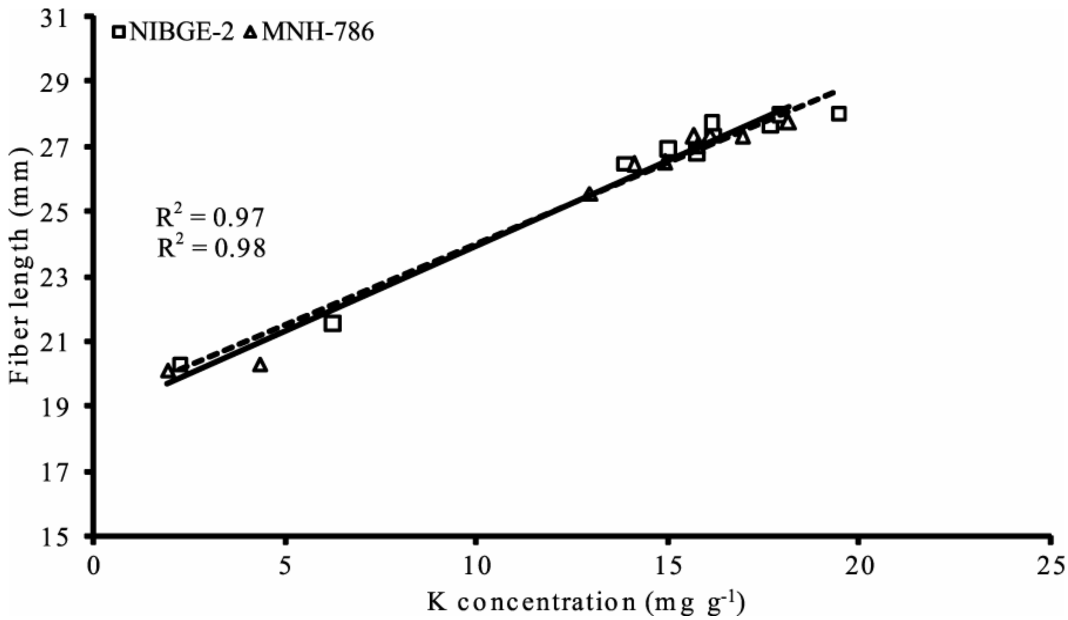

Fig. 3. Relationship between K concentration and fiber length (mm) for both varieties.

Fiber quality: Main effects of K, Na rates, varieties and their interaction on micronaire value (µg inch^{-1}) were non-significant (Table 2). Although, the micronaire of the varieties increased (higher values of micronaire represented lower fineness) with the addition of Na in soil medium, yet the differences between varieties were inconsistent. Fiber strength value (g tex^{-1}) was also varied non-significantly ($p \leq 0.05$) due to main effects of K, Na rates and varieties interaction. Both cotton varieties differed significantly ($p \leq 0.05$) in their fiber strength value (g tex^{-1}) (lower value for MNH-786) under different rates of K and Na (Table 2). Maximum fiber strength value of 22.10 g tex^{-1} was shown by NIBGE-2 compared to MNH-786. Previous studies also reported the effects of limited nutrient availability on cotton fiber development (Bradow & Davidonis, 2000; Gerik *et al*., 1998). Non significant ($p \leq 0.05$) differences in fiber length (mm) were observed due to main effects of rates of K and Na and varieties interaction (Table 2). Overall, NIBGE-2 performed better for fiber length (26.07 mm) than MNH-786 (25.58 mm). Increase in fiber length and fiber fineness had been observed in upland cotton under soil salinity of 0.42% (Ye *et al.,* 1997). These fiber quality responses and growth under K deficient conditions were similar to those found by earlier workers (Cassman *et al.,* 1990; Pettigrew *et al*., 1996). Low micronaire cotton (<3.5 µg inch^{-1}) would have a thin cell wall with a smaller amount of cellulose in the fiber cell. Added K would increase metabolic processes related to secondary wall thickening (Bradow & Davidonis, 2000). Pettigrew (2003) found that plants grown at 0 K produced lint with low micronaire, but values were not less than 3.8. Gerik *et al*., (1998) studied the consequences of limited nutrient availability on cotton fiber development. Potassium stress directly influenced fiber quality as evident in present study that low K concentration in cotton leaf i.e.5.32 mg g^{-1} produced low quality fiber when both varieties were grown at K+Na 210+60 kg ha^{-1}.

Ionic relations: The interaction between K, Na rates and varieties influenced K concentration non-significantly ($p \leq 0.05$) in cotton (Table 3). However, the cotton variety NIBGE-2 had more K concentration (14.07 mg g^{-1}) than MNH-786. Main effects of K, Na rates, varieties and their interaction varied significantly ($p \leq 0.05$) with respect to Na concentration in leaves (Table 3). Maximum Na concentration of 26.07 mg g^{-1} was observed in NIBGE-2 followed by 21.20 mg g^{-1} in MNH-786 with 210 kg K+75 kg Na ha^{-1}. Minimum Na concentration of 3.17 and 4.50 mg g^{-1} was exhibited with 270 kg K+60 kg Na ha^{-1} by NIBGE-2 and MNH-786, respectively. Leidi & Saiz (1997) observed the correlation of high shoot Na with salt tolerance of cotton. Leaf K: Na ratio differed significantly ($p \leq 0.05$) due to main effects K, Na rates, varieties and their interaction (Table 3). Maximum K: Na ratio of 6.16 was found with K+Na (270+60) kg ha^{-1} and higher ratio was manifested by NIBGE-2 compared to MNH-786. K: Na ratio attributed to K/Na exchange across the plasmalemma of root cortex cells and selective uptake of K (Jeschke & Wolf, 1988). Gareth *et al*., (1979) suggested a minimum value for K: Na of 1 for normal growth of plants subjected to saline conditions. Some treatments exhibited K: Na ratio less than 1, that accounted for passive accumulation of Na in the roots and shoots and thereby causing the K: Na ratios low in both the tissues (Greenway & Munns, 1980). Reddy & Zhao (2005) reported that critical leaf K for biomass and stem growth was 12 g kg^{-1} and for leaf area expansion the critical value was 17 g kg^{-1}. In this study, leaf K concentrations of 6.30 and 4.33 mg g^{-1} in NIBGE-2 and MNH-786, respectively were observed with 210+60 kg ha^{-1} K+Na and it was less than that of critical value. The increase in fiber length was attributed to increase in K concentration in leaves of both varieties as indicated in Fig. 3. There was significant positive relationship (R^2=0.97 and 0.98 n=10) between K concentration and fiber length for NIBGE-2 and MNH-786 respectively.

Table 3. Leaf K concentration, Na concentration and K: Na ratio of two cotton varieties grown with various rates of K and Na under field conditions (Values are the means of 3 replications).

Treatments ($Kg\ ha^{-1}$)		K concentration ($mg\ g^{-1}$) (mean ± SD)		Na concentration ($mg\ g^{-1}$) (mean ± SD)		K: Na ratio (mean ± SD)	
K + Na	Ratio	NIBGE-2	MNH-786	NIBGE-2	MNH-786	NIBGE-2	MNH-786
225 + 60	3.75: 1	16.13 ns ± 0.643	15.67 ± 0.611	8.80 k ± 0.917	10.20 ij ± 0.700	1.84 ef ± 0.129	1.54 gh ± 0.060
240 + 60	4: 1	17.70 ± 1.277	16.10 ± 0.265	6.60 m ± 0.656	7.87 kl ± 0.321	2.69 d ± 0.267	2.05 e ± 0.085
255 + 60	4.25: 1	17.90 ± 0.794	16.93 ± 0.404	5.47 n ± 0.306	6.93 lm ± 0.513	3.28 c ± 0.144	2.45 d ± 0.222
270 + 60	4.5: 1	19.43 ± 0.723	18.13 ± 0.306	3.17 o ± 0.306	4.50 n ± 0.265	6.16 a ± 0.413	4.04 b ± 0.275
210 + 60 Control	3.5: 1	6.30 ± 0.265	4.33 ± 0.252	10.33 ij ± 0.153	11.23 hi ± 0.252	0.61 kl ± 0.018	0.39 lm ± 0.027
225 + 75	3: 1	13.93 ± 0.586	12.97 ± 0.321	17.87 d ± 0.416	19.97 c ± 1.644	0.78 jk ± 0.027	0.65 kl ± 0.039
240 + 75	3.2: 1	15.03 ± 0.451	14.10 ± 0.600	11.50 h ± 0.500	15.57 e ± 0.153	1.31 hi ± 0.087	0.91 jk ± 0.033
255 + 75	3.4: 1	15.80 ± 0.300	14.90 ± 0.458	12.73 g ± 0.643	14.37 f ± 0.321	1.24 hi ± 0.087	1.04 ij ± 0.054
270 + 75	3.6: 1	16.20 ± 0.300	15.77 ± 0.252	9.83 j ± 0.764	11.77gh ± 0.681	1.66 fg ± 0.156	1.34 hi ± 0.081
210 + 75	2.8: 1	2.27 ± 0.208	1.93 ± 0.153	26.07 a ± 0.917	21.20 b ± 1.201	0.07 n ± 0.009	0.11 mn ± 0.009
Mean		**14.07 a**	**13.08 b**	**10.75 b**	**12.85 a**	**1.97 a**	**1.45 b**

Means with different letter(s) differ significantly according to Duncan's Multiple Range Test ($p \leq 0.05$)

Two mechanisms were implicated in the absorption of K and Na (Rains & Epstein, 1967). The first mechanism attributed to high affinity for K and was not effective for Na in the presence of K. This mechanism was available for Na absorption after K was completely depleted. The second mechanism was not highly selective in transporting Na as well as K and operated at high Na and K concentrations. The results for K: Na ratio are in conformity with Zhu *et al*., 1998; Tester & Davenport, 2003). Higher K: Na ratio in younger leaves was interpreted as an indication of potassium re-absorption/translocation from the xylem (Pitman, 1984). Thus variation in K/Na selectivity of xylem transport from roots to the leaves proved to be one important cause of inter-specific differences in cotton varieties. NIBGE-2 effectively retained Na^+ in primary roots, suggesting preference for K towards leaves during xylem transport. Increase in plant growth by adding non toxic amount of Na to a root medium low in K was due to the sparing action of Na on K, which induced redistribution of K from places of relative abundance to those of deficiency. NIBGE-2 showed relative high Na substitution capacity for K and yielded better than MNH-786 (Ali, *et al*., 2009b).

Conclusion

Potassium application @ 255 kg ha^{-1}(actual incorporation of 45 kg K ha^{-1} in addition to indigenous status of K in soil (i.e. 210 kg ha^{-1} or 105 ppm) along with Na @ 75 kg ha^{-1}(actual application of 15 kg Na ha^{-1} in addition to indigenous status of Na in soil (i.e. 60 kg ha^{-1} or 30 ppm) significantly ($p \leq 0.05$) increased seed cotton yield, boll number and boll weight in both cotton varieties. The variety NIBGE-2 produced relatively heavier and increased number of bolls $plant^{-1}$ compared to MNH-786 under various K, Na rates. The variety NIBGE-2 was capable to maintain higher leaf K: Na ratio and good fiber quality, suggesting that the varieties with such characteristics could be expected to perform better in slightly saline soil. The characteristics of such variety should be included in a breeding program to develop cotton varieties with higher yield potentials. The beneficial role of Na could only be seen on slightly saline soil by adding modest amount of Na into soil to explore the beneficial effect of sodium because it substitute some of non –specific functions of K with deficient K status. Finally we can recommend the modest amount of sodium (15 kg ha^{-1}) with low amount of K (45 kg ha^{-1}).

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