BANGLADESH JOURNAL OF PROGRESSIVE SCIENCE & TECHNOLOGY BJPST

BJPST: 11(1): 093-098 [January, 2013] ISSN: 2305-1809 (Online version)

Available online at http:/www.bjpst.net

EFFECT OF TIME AND SPLIT APPLICATION OF NPK ON UPLAND COTTON PRODUCTION

Islam Md Kamrul[1*], Khalequzzaman[1], Khalil Md Ibrahim[3] & Akhteruzzaman Md[2]

[1]Cotton Research, Training and Seed Multiplication Farm, Sreepur, Gazipur

[2]Cotton Development Board, Khamarbari, Farmgate, Dhaka

[3]Senior Scientific Officer, Ispahani Biotech, Konabari, Gazipur

* Corresponding author: E-mail: islam.mdkamrul@gmail.com

ABSTRACT

To optimize cotton yield, NPK management strategies through fertilizer application should be focused on making the required nutrient available at different growth stages of cotton. That can be achieved by split application of NPK fertilizer at different times depending on the soil properties. The performance of 3 split and 4 different application time of NPK on seed cotton yield and yield contributing characters were studied at the farms of Cotton Development Board located at Sreepur, Gazipur; Sadarpur Dinajpur and Jagadishpur, Jessore in 2012-2013 Kharif 2 growing period. The experiment was set up in RCB design with 2 factors in 3 replications. The Analysis of Variance revealed that the interaction effect of NPK split × application time × location was found significant for fruiting branch, boll number, boll weight and seed cotton yield. In Sreepur farm, the highest seed cotton yield (2754 kg ha^{-1}) was obtained by applying 25% of NP and whole quantity of K at basal, 50% of NP at 30 DAS and 25% NP at 60 DAS In Sadarpur farm, the highest seed cotton yield (4918 kg ha^{-1}) was obtained by applying whole quantity of PK and 50% of N at basal, 25% of N at 30 DAS and 25% of N at 60 DAS. In Jagadishpur farm, the highest seed cotton yield (3169 kg ha^{-1}) was obtained by applying 25% of NP and whole quantity of K at basal, 50% of NP at 30 DAS and 25% of NP at 60 DAS. The result suggested that the time and split application of NPK should be done considering the location.

Keywords: *NPK fertilizer, upland cotton, yield*

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is a cash crop and the raw material for textile industries in Bangladesh. To meet our national requirement of raw cotton increase in cotton production is utmost important. Optimum nutritional requirement of cotton is the primary importance to boost its production (Ali and Ali, 2011). The availability of N, P, K, and water are the major constraints in cotton (*Gossypium hirsutum* L.) production in most cotton producing environments (Morrow and Krieg, 1990; Grima *et al*., 2007). Appropriate fertilizer use leads to increased crop yields and high crop recovery of applied nutrients. Some elements may be hazardous to the environment if unused in various forms such as nitrates. Efficient fertilization is therefore important in ensuring crops attain maturity within specific growing seasons (Okalebo, 1997; Sarlar *et al.,* 2012).

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). Alternatively, excess N promotes vegetative development often at the expense of reproductive development, especially at bloom or at early boll fill (Mullins and Burmester, 1990; Howard *et al*., 2001; Tewolde and Fernandez, 1997). Excess N can indirectly affect lint yield by enhancing aphid (Aphis gossypii Glover) infestation, which can complicate cotton defoliation (Cisneros and Godfrey, 2001) and can cause sticky cotton problems because of aphid honeydew secretions (University of Arizona, 1999; Slosser *et al*., 1999). Several variables, including early P accumulation, biomass, and lint yields, positively responded to P fertilization in calcareous soils (Bronson *et al*., 2003). Reiter and Kreig (2000) reported some positive and notable P effects on lint fiber quality factors, although both lint yield and lint quality were driven more by moisture availability than by P. 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 influenced cotton lint yield by affecting late season growth. The positive effect of K on lint quality characteristics have been documented in several reports (Bennet *et al*., 1965; Pettigrew and Meredith, 1997; Pettigrew, 1999; Pettigrew, 2003).

Recovery of applied inorganic fertilizers by plants is low in many soils. These lower efficiencies are due to significant losses of nutrients by leaching, run-off, gaseous emission and fixation by soil. It is also reported that between 1 to 60% N of nutrient based fertilizers such as urea is lost through ammonia volatilization (Prasertsak *et al*., 2001). To increase the efficiency of applied nutrients, application time and rate need to be synchronized with the crop demand at certain growth stage and the prevailing environment conditions.

Yanga *et al*. (2011) reported that lower N rate is possible for cotton high yielding by decreasing pre-plant application ratio and increasing peak-bloom application ratio. The alteration of N split ratio has a longer reproductive period, a higher speed of biomass accumulation during the fast accumulation period. On the contrary, Yanga *et al.* (2012) reported that one-time fertilization produced same cotton yield as thrice fertilization. Single fertilization had higher biomass accumulation speed during fast accumulation. One-time fertilization is practical alternative for cotton fertilization. Aquinas *et al.* (2012) reported that cotton bolls per plant increased with the increment of P doses, but were not affected by the phosphate fertilizer split application. Rasool *et al.* (2010) in a study showed that potassium doses and application times significantly affected seed cotton yield

Cotton in Bangladesh is grown in the Kharif 2 season. Excessive rainfall occurs at its early growing stages while the later growth stages suffered from water deficient. There is a greater possibility to loss of applied nutrient at early growth stages and unavailability at later growth stages. The present study was conducted to know the effect of application time and split application of NPK fertilizer in cotton yield and yield contributing characters in Bangladesh.

MATERIALS AND METHODS

An experiment was conducted to determine the upland cotton response to time and split application of NPK fertilizers at three farms of CDB viz. Sreepur, Gazipur (Madhupur Tract), Sadarpur, Dinajpur (Level Barind Tract) and Jagadishpur, Jessore (High Ganges River Flood Plain) during the Kharif 2 season of 2012-13. The status of the initial soil has been presented in Table-1. The experiment was conducted in split plot design with three replications in all locations. The treatments consisted of three levels of NPK split viz. 1) N split, P and K basal, 2) N and P split, K basal and 3) NPK split; and 4 application time viz. 1) 50% at basal + 50% at 60 days after (DAS), 2) 50% at basal + 25% at 30 DAS + 25% at 60 DAS, 3) 25% at basal + 50% at 30 DAS + 25% at 60 DAS, and 4) 50% at 30 DAS + 25% at 60 DAS + 25% at 75 DAS. Urea, TSP, MOP and gypsum were used as the source of NPKS @ 104, 45, 138 & 22 kg NPKS ha^{-1} respectively was applied according to the treatments.

The unit plot size was 4.5m × 3.6m and the plant spacing was 90cm × 45cm. Two or three seeds were sowing $hill^{-1}$. Though, after final thinning one seedling $hill^{-1}$ was allowed to grow. Intercultural operations such as weeding, thinning, gap-filling, earthling-up, irrigations, insects and pest management were done in all plots uniformly. Cotton yield contributing characters such as plant height, number of vegetative and fruiting branches $plant^{-1}$, number of effective boll $plant^{-1}$, single boll weight were recorded from 10 randomly selected plants and seed cotton yield was recorded from each plot. Statistical analysis was done by Cropstat (2007).

Table 1. Soil properties of experiment sites

Location	Soil Texture	OM (%)	pH	N (%)	P (µg g^{-1})	K (meq $100g^{-1}$)
Sreepur	Clay loam	0.81	5.37	0.06	38.6	0.16
Sadarpur	Sandy loam	1.03	5.8	0,08	6.90	0.21
Jagadishpur	Sandy loam	1.03	7.43	0,05	5.90	0.17

RESULTS

The output of Analysis of Variance (ANOVA) is presented in Table 1 to Table 5. The interaction effect of NPK split × application time × location was found significant for fruiting branch, boll number, boll weight and seed cotton yield. While the interaction effect of location × replication was found significant for vegetative branch.

Vegetative Branches $plant^{-1}$

The interaction effect of location × replication on vegetative branch is given in Figure 1. At Sreepur Farm, the number of vegetative branch $plant^{-1}$ was 1.8 for all replication, at Sadarpur farm it ranges from 2.4-2.5 while at Jagadispur farm it ranges from 1.3-2.6. Vegetative branches remain below the fruiting branches, do not directly bear fruit but can give rise to fruiting branches that produce fruit (Davidonis *et al.,* 2004; Boquet and Moser, 2003). Although vegetative branches are left undisturbed in most countries, their removal is considered beneficial to lint yield and quality because assimilates are redirected to the earlier-forming fruit on the fruiting branch (Davidonis *et al*., 2004; Bednarz *et al*., 2000).The number of vegetative branch in a cotton plant depend on genotype as well as management practices like as use of nitrogen fertilizer (Tewolde and Fernandez, 1997, Howard *et al*., 2001, Alitabar *et al*., 2013). As the all treatment contain the same genotype (CB-12) and the same quantity of N fertilizer, the number of vegetative branch per plant at Sreepur and Sadarpur Farm did not differ significantly. However, the variation at Jagadishpur farm may be due to the difference of fertility level at different replication.

Table 2. ANOVA (P-values) of NPK split, application time, replication, location and its interaction on cotton yield and yield contributing characters

Variate	df	Vegetative branch	Fruiting branch	Plant height at harvest	Boll number	Boll weight	Seed cotton yield
NPK split (S)	2	0.515	0.720	0.479	0.482	0.743	0.801
Application time (T)	3	0.988	0.907	0.991	0.033	0.420	0.758
Replication R	2	0.283	0.808	0.355	0.427	0.843	0.769
Location (L)	2	0.018	0.000	0.000	0.000	0.000	0.000
S × T	11	0.680	0.997	0.893	0.210	0.554	0.989
S × R	8	0.636	0.991	0.726	0.651	0.903	0.978
S × L	8	0.059	0.000	0.000	0.000	0.000	0.000
T × R	11	0.319	0.989	0.886	0.288	0.590	0.986
T × L	11	0.350	0.000	0.000	0.000	0.000	0.000
R × L	8	0.035	0.000	0.000	0.000	0.000	0.000
S × T × L	35	0.450	0.000	0.000	0.000	0.000	0.000

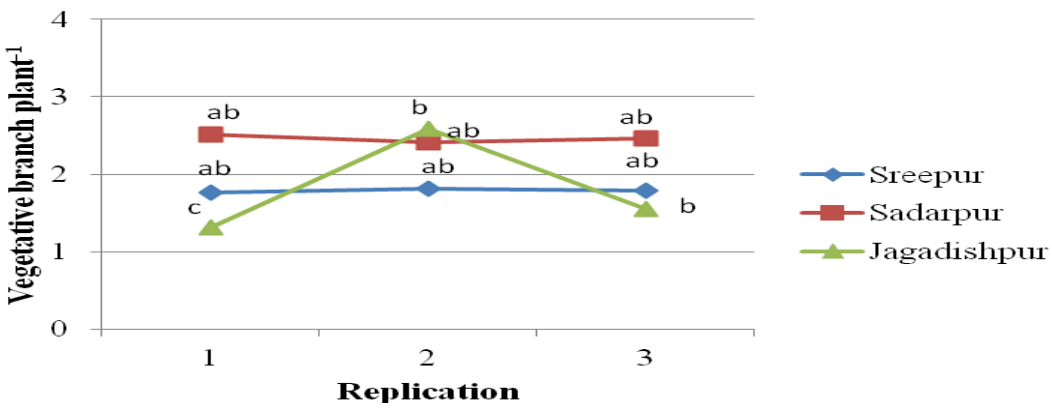

Figure 1. Location × Replication interaction effect on vegetative branch plant^{-1} (Values are means. Dissimilar letter indicates significant difference (P>0.05))

Fruiting Branches plant^{-1}

The interaction effect of NPK split × application time × location is given in Table 3. At Sreepur farm, the highest number of fruiting branch (13.8) was obtained from applying 25% of NPK at basal, 30% of NPK at 30 DAS and 60% of NPK at 60 DAS. And the lowest number of fruiting branch (11.6) was obtained from applying 50% of N and whole quantity of P and K at basal together with 25% of N at 30 Das and 25% of N at 60 DAS. At Sadarpur farm, the highest number of fruiting branch (16.6) was obtained from applying 50% of NPK at basal, 25% of NPK at 30 DAS and 25% of NPK at 60 DAS. And the lowest number of fruiting branch (13.2) was obtained from applying whole quantity of K and 50% NP at basal together with 50% of NP at 60 DAS. At Jagadishpur farm, the highest number of fruiting branch (24.0) was obtained from applying 25% of N and whole quantity of PK at basal, 50% of N at 30 DAS and 25% of NPK at 60 DAS. And the lowest number of fruiting branch (19.1) was obtained from applying 50% of NPK at 30 DAS, 25% of NPK at 60 DAS and 25% of NPK at 75 DAS.

Plant height

The interaction effect of NPK split × application time × location on boll per plant is given in Table 4. In Sreepur farm the highest plant height (104 cm) was recorded from the plots that received 50% of NPK at basal, 25% of NPK at 30 DAS and 25% of NPK at 60 DAS. The lowest plant height at harvest was found in the plots with whole quantity of PK at basal, 50% of N at 30 DAS, 25% of N at 60 DAS and 25% of N at 75 DAS. In Sadarpur Farm, the highest plant height (110 cm) at harvest was obtained by applying 50% of NPK at basal, 25% of NPK at 30 DAS and 25% of NPK at 60 DAS. The lowest plant height (99.3 cm) at harvest was obtained by applying 50% of N and whole quantity of PK at basal and 50% of N at 60 DAS. At Jagadishpur Farm, the highest plant height (121.3 cm) was obtained by applying K at basal, 50% of NP at 30 DAS, 25% of NP at 60 DAS and 25% of NP at 75 DAS. The lowest plant height (103.3 cm) at harvest was obtained by applying 50% of NPK at basal, 25% of NPK at 30 DAS and 25% of NPK at 60 DAS.

Table 3. NPK split × application time × location interaction effect on fruiting branch plant^{-1}

Sreepur farm	S_1	S_2	S_3
T_1	13.1 jik	12.4 k	13.5 ijk
T_2	11.6 k	13.0 jk	13.7 g-k
T_3	12.4 k	12.6 jk	13.8 g-k
T_4	12.9 jk	13.2 ijk	13.2 ijk
Sadarpur farm			
T_1	14.4 g-k	13.2 ijk	16.4 g-h
T_2	15.4 g-j	14.1 g-k	16.6 efg
T_3	13.4 jik	14.2 g-k	15.4 g-j
T_4	13.6 h-k	16.0 f-j	16.1 f-i
Jagadishpur farm			
T_1	19.7 d	23.2 abc	22.9 abc
T_2	23.3 abc	23.5 ab	20.5 cd
T_3	24.0 a	23.3 abc	20.7 bcd
T_4	18.7 def	21.5 a-d	19.1 de

S_1- N split+ P and K basal, S_2- NP split + K basal, S_3- NPK split; T_1- 50% at basal + 50% at 60 DAS, T_2- 50% basal + 25% at 30 DAS + 25% at 60 DAS, T_3- 25% basal + 50% at 30 DAS + 25% at 60 DAS, T_4- 50% at 30 DAS + 25% at 60 DAS + 25% at 75 DAS . Values are means. Dissimilar letter indicates significant difference (P>0.05)

Table 4. NPK split × application time × location interaction effect on plant height at harvest (cm)

Sreepur farm	S1	S2	S3
T1	93.3 pq	91.3 pqr	100.7 k-n
T2	80.7 s	95.0 op	104.0 h-l
T3	99.7 mno	98.3 no	100.7 k-n
T4	88.0 r	91.1 pqr	89.7 qr
Sadarpur farm			
T1	99.3 mno	101.7 jklmn	109.3 efg
T2	107.3 ghi	105.7 ghij	110.0 d-g
T3	108.0 fgh	100.0 lmn	100.0 lmn
T4	101.3 j-n	109.0 efg	105.3 g-k
Jagadishpur farm			
T1	107.7 f-i	117.3 ab	115.0 bc
T2	114.7 bcd	118.7 ab	103.3 i-m
T3	114.3 bcd	111.3 c-f	108.7 fgh
T4	112.0 cde	121.3 a	115.0 bc

S_1- N split+ P and K basal, S_2- NP split + K basal, S3- NPK split; T_1- 50% at basal + 50% at 60 DAS, T_2- 50% basal + 25% at 30 DAS + 25% at 60 DAS, T_3- 25% basal + 50% at 30 DAS + 25% at 60 DAS, T_4- 50% at 30 DAS + 25% at 60 DAS + 25% at 75 DAS . Values are means. Dissimilar letter indicates significant difference (P>0.05)

Bolls plant^{-1}

The interaction effect of NPK split × application time × location on boll per plant is given in Table 5. In Sreepur Farm, the highest number of boll (24.7) was obtained by applying 25% of NP and the whole quantity of K at basal, 50% of NP at 30 DAS and 25% of NP at 60 DAS. The lowest number of boll (17.1) was obtained by applying 25% of NPK at basal, 50% of NPK at 30 DAS and 25% of NPK at 60 DAS. In Sadarpur farm the highest boll per plant (33.7) was obtained by applying 50% of NPK at basal and 50% of NPK at 60 DAS. The lowest number of boll (21.6) was obtained from the plot that received 50% of NP and whole quantity of K at basal, 25% of NP at 30 DAS and 25% of NP at 60 DAS. In Jagadishpur farm the highest number of boll (27.3) was obtained by applying 50% of NPK at basal and 50% of NPK at 60 DAS. The lowest number of boll (19.0) was obtained from 50% of N and whole quantity of PK at basal and 50% of N at 60 DAS.

Table 5. NPK split × application time × location interaction effect on boll number Plant^{-1}

Sreepur farm	S_1	S_2	S_3
T_1	20.9 e-k	19.9 g-k	18.6 ijk
T_2	20.8 f-k	22.9 c-i	21.2 e-k
T_3	18.9 g-k	24.7 c-f	17.1 k
T_4	17.3 k	18.5 jk	18.8 h-k
Sadarpur farm			
T_1	1.9 ab	32.8 a	33.7 a
T_2	24.6 c-f	21.6 e-k	23.5 c-i
T_3	24.5 c-f	22.4 d-i	21.6 e-k
T_4	23.6 c-h	24.4 c-f	22.2 e-k
Jagadishpur farm			
T_1	19.0 g-k	23.0 c-i	27.3 bc
T_2	24.0 c-f	26.7 cd	23.3 c-i
T_3	25.0 cde	25.3 cfe	22.3 d-j
T_4	22.3 d-i	24.7 c-f	23.7 c-g

S_1- N split+ P and K basal, S_2- NP split + K basal, S_3- NPK split; T_1- 50% at basal + 50% at 60 DAS, T_2- 50% basal + 25% at 30 DAS + 25% at 60 DAS, T_3- 25% basal + 50% at 30 DAS + 25% at 60 DAS, T_4- 50% at 30 DAS + 25% at 60 DAS + 25% at 75 DAS. (Values are means. Dissimilar letter indicates significant difference (P>0.05)).

Single boll weight

The interaction effect of NPK split × application time × location on Single boll weight is given in Table 6. In Sreepur farm, the highest boll weight (5.5 g) was obtained by applying 25% of NP and whole quantity of K at basal, 50% of NP at 30 DAS and 25% of NP at 60 DAS. The lowest boll weight (4.7 g) was obtained by applying 50% of N and whole quantity of PK at basal, 25% of N at 30 DAS and 25% N at 60 DAS. At Sadarpur Farm, the highest boll weight (6.1 g) was obtained by applying 50% of N and whole quantity of PK at basal, 25% of N at 30 DAS and 25% of N at 60 DAS. The lowest boll weight (5.0) was obtained by applying 50% of NP and whole quantity of K at basal and 50% of NP at 60 DAS. In Jagadishpur farm, the individual boll weight ranges between 5.5 g to 5.8 g that did not differ significantly.

Seed cotton yield

The interaction effect of NPK split × application time × location on seed cotton yield (kg ha^{-1}) is given in Table 7. In Sreepur farm, the highest seed cotton yield (2754 kg ha^{-1}) was obtained by applying 25% of NP and whole quantity of K at basal, 50% of NP at 30 DAS and 25% NP at 60 DAS. The lowest seed cotton yield (1753 kg ha^{-1}) was obtained by applying PK at basal, 50% of N at 30 DAS, 25% of N at 60 DAS and 25% of N at 75 DAS. In Sadarpur farm, the highest seed cotton yield (4918 kg ha^{-1}) was obtained by applying whole quantity of PK and 50% of N at basal, 25% of N at 30 DAS and 25% of N at 60 DAS. The lowest seed cotton yield (3765 kg ha^{-1}) was obtained by applying 50% of NP and whole quantity of K at basal, and 50% of NP at 60 DAS. In Jagadishpur farm, the highest seed cotton yield (3169 kg ha^{-1}) was obtained by applying 25% of NP and whole quantity of K at basal, 50% of NP at 30 DAS and 25% of NP at 60 DAS. The lowest seed cotton yield (2305 kg ha^{-1}) was obtained by applying 50% of NPK at 30 DAS, 25% of NPK at 60 DAS and 25% of NPK at 75 DAS.

Table 6. NPK split × application time × location interaction effect on individual boll weight (g)

Sreepur farm	S_1	S_2	S_3
T_1	5.2 c-h	4.8 gh	5.0 e-h
T_2	4.7 h	5.4 b-f	5.2 c-h
T_3	5.0 e-h	5.5 b-e	5.1 d-h
T_4	4.8 gh	5.1 d-h	4.9 fgh
Sadarpur farm			
T_1	5.3 b-g	5.0 e-h	5.4 b-f
T_2	6.1 a	5.0 e-h	5.4 b-f
T_3	5.3 b-f	5.7 ab	5.6 a-d
T_4	5.3 b-f	5.7 ab	5.7 ab
Jagadishpur farm			
T_1	5.6 a-d	5.7 abc	5.7 abc
T_2	5.7 abc	5.6 abc	5.5 bcd
T_3	5.6 a-d	5.8 ab	5.8 ab
T_4	5.7 abc	5.6 abc	5.8 ab

S_1- N split+ P and K basal, S_2- NP split + K basal, S_3- NPK split; T_1- 50% at basal + 50% at 60 DAS, T_2- 50% basal + 25% at 30 DAS + 25% at 60 DAS, T_3- 25% basal + 50% at 30 DAS + 25% at 60 DAS, T_4- 50% at 30 DAS + 25% at 60 DAS + 25% at 75 DAS . (Values are means. Dissimilar letter indicates significant difference (P>0.05)).

Table 7. NPK split × application time × location interaction effect on seed cotton yield (kg ha^{-1})

Sreepur farm	S_1	S_2	S_3
T1	2138 ij	2142 hij	2175 hij
T2	2167 hij	2354 ghij	2395 ghij
T3	2291 ghij	2754 fghi	2201 hij
T4	1753 j	1768 j	2226 ghij
Sadarpur farm			
T1	3888 cd	3765 de	4609 abc
T2	4918 a	3837 de	4341 abcd
T3	4238 abcd	3861 cde	4197 abcd
T4	4125 bcd	4681 ab	4444 abcd
Jagadishpur farm			
T1	2695 fghi	2346 ghij	2984 fg
T2	2634 fghi	2901 fghi	2911 fgh
T3	2552 fghi	3169 ef	2737 fghi
T4	2366 ghij	2389 ghij	2305 ghij

S_1- N split+ P and K basal, S_2- NP split + K basal, S_3- NPK split; T_1- 50% at basal + 50% at 60 DAS, T_2- 50% basal + 25% at 30 DAS + 25% at 60 DAS, T_3- 25% basal + 50% at 30 DAS + 25% at 60 DAS, T_4- 50% at 30 DAS + 25% at 60 DAS + 25% at 75 DAS (Values are means. Dissimilar letter indicates significant difference (P>0.05)).

DISCUSSION

Cotton (*Gossypium hirsutum* L.) yields may be limited unless adequate amounts of all required nutrients are accumulated in the plant during its growth. Most soils where cotton is grown commonly have deficiencies of at least one nutrient (e.g. N, P or K) that requires addition of fertilizers to optimize production (Braud, 1974; Hearn, 1981; Mullins and Burmester, 2010). Uptake of nutrients via the roots is governed by nutrient transport to the root surface and absorbed with the water as part of the transpiration stream; or become concentrated in the xylem sap due to a facilitated (protein transporter) or an active uptake process that requires metabolic energy to overcome a concentration gradient (Bassirirad, 2000). Nutrients are taken up throughout the growing season and in proportion with the demand for nutrients as dictated by the developing crop biomass and boll load. The rates of nutrient uptake increase at flowering through fruiting, and then slow as the bolls mature (Mullins and Burmester, 2010).

The characteristics of the soil itself have a large impact on the availability and loss of applied nutrients in cotton soil. Potassium and ammonium are bind to the negatively charged clay colloids in the soil. Anions nitrate is not held in the soil by any method and is actively repelled by the clay (Kennedy, 1992) and is completely mobile in soil water (Tisdale *et al*, 1985). For phosphorus in the form of phosphate, the most significant soil characteristics influence on its retention in the soil solution are pH, clay mineral content and types, the amount of organic matter and the amount P in the parent materials of the soil (Davis *et al.*, 2005). Nutrients such as potassium and phosphate tend to move with the sediment as they are bound to the soil colloids (Sims and Sharpley, 2005). Any of these transport pathways can cause significant losses of nutrient from the soil solution (Addiscott, 2005). Besides the prevailing weather has profound effect on soil nutrient loss. It had been reported that nitrogen and phosphorus losses from soil media increase during rainy seasons when precipitation and runoff were large (Ian, 2005; Kleinman, 2002).

Ammonia volatilization after urea application is the most likely mechanism responsible for variation in urea performance in acidic soils (Stevens *et al*., 1989; Prasertsak *et al*., 2001; He *et al*., 2002). Ammonia volatilization after urea hydrolysis is the common mechanism for decreasing urea efficiency (Fenn and Hossner, 1985). In acid soils large amounts of P need to be applied in order to raise concentrations of available soil P to an adequate level (Sanchez and Uehara, 1980; Haynes and Mokolobate, 2001). The availability of potassium decreases with the decrease in soil pH from neutral to slightly acidic and strongly acidic in reaction (Pandey *et al.,* 2013).

The experiment soil of Sreepur and Sadarpur Farm is acidic while it is slightly alkaline in Jagadishpur Farm. The texture of the soil varied from one to another (table 1). The three farms located at 3 different agro-ecological zones with distinct climatic variability particularly in the pattern and quantity of rainfall in the cotton growing period. That substantially affects the nutrient availability and loss from applied nutrients at the three studied farms. As a consequence cotton yield and yield contributing characters respond differently to NPK split and time of application.

CONCLUSION

The effect of NPK split and application time in cotton yield and yield contributing characters were studied at three locations in Bangladesh. Cotton need different nutrient amounts and ratios at different growth stages. In order for the nutrients to be available when the plant needs them, fertilizers should be applied at the right timing. Besides, the locations affect the timing and frequency of fertilizer application. Thus, to optimize the yield advantage from the applied fertilizer, NPK split and application time should be location specific.

REFERENCES

Addiscott TM. 2005. Nitrate, Agriculture and the Environment. Oxfordshire, UK, CABI Publishing.

Ali L and Ali M. 2011.Relationship of yield and yield components of cotton with P and K. J. Agric. Res., 49(1):11-17.

Alitabar RA, Salimbeck R, Alishah O and Amdarkhor SAA. 2013. The effects of nitrogen and row spacing on growth and yield of cotton varieties. International Journal of Agriculture: Research and Review, 3(1):120-125.

Aquinas LA, Berger PG, Neves JCL, Lima TC and de Aquino RFAB. 2012. Phosphorus split application on irrigated cotton. Tropical Agricultural Research, 42(1):1-8.

Bassirirad H. 2000. Kinetics of nutrient uptake by roots: responses to global change. New Phytol. 147: 155-169.

Bednarz CW, Bridges DC and Brown SM. 2000. Analysis of cotton yield stability across population densities. Agron. J. 92:128-135.

Bennett OL, Rouse RD, Ashley DA and Doss BD. 1965. Yield, fiber quality and potassium content of irrigated cotton plants as affected by rates of potassium. Agron. J. 57:296-299.

Braud M. 1974. The control of mineral nutrition of cotton by foliar analysis. Cotton Fibers Trop.29:215-225.

Bronson KF, Keeling JW, Booker JD, Chua TT, Wheeler TA, Boman RK and Lascano RJ. 2003. Influence of landscape position, soil series and phosphorus fertilizer on cotton lint yield. Agron. J. 95:949-957.

Crozier CR, Walls B, Hardy DH and Barnes JS. 2004. Response of Cotton to P and K Soil Fertility Gradients in North Carolina. J. Cotton. Sci. 8:130-141.

Davidonis GH, Johnson AS, Landivar JA and Fernaandez CJ. 2004. Cotton fiber quality is related to boll location and planting date. Agron. J. 96:42-47.

Davis RL, Zhang H, Schroder JL, Wang JJ, Payton ME and Zazulak A. 2005. Soil characteristics and phosphorus level effect on phosphorus loss in runoff. Journal of Environmental Quality 34(5): 1640-1650.

Donohue I, Styles D, Coxon C and Irvine K. 2005. Importance of spatial and temporal patterns for assessment of risk of diffuse nutrient emissions to surface waters. Journal of Hydrology, 304: 183-192.

Fenn LB and Hossner LR. 1985. Ammonia volatilization from ammonium or ammonium-forming nitrogen fertilizers. Adv. Soil Sci., 1: 124-169.

Girma K Teal RK, Freeman KW, Boman RK and Raun WR. 2007. Cotton Lint Yield and Quality As Affected by Applications of N, P, and K Fertilizers. The Journal of Cotton Science 11:12–19.

Haynes RJ and Mokolobate MS. 2001. Melioration of Al toxicity and P deficiency in acid soils by additions of organic residues: a critical review of the phenomenon and the mechanisms involved. Nutrient Cycling in Agroecosystems 59: 47–63.

He ZL, Calvert DV, Alva AK, Li YC and Banks DJ. 2002. Clinoptilolite zeolite and cellulose amendments to reduce ammonia volatilization in a calcareous sandy soil. Plant Soil, 247: 53-260.

Hearn AB. 1981. Cotton nutrition. Field Crop Abstracts. 34:11-34.

Howard DD, Gwathmey CO, Essington ME, Roberts RK and Mullen MD. 2001. Nitrogen fertilization of no-till cotton on loess derived soils. Agron. J., 93:157–163.

Kennedy IR. 1992. Acid Soil and Acid Rain, John Wiley and Sons Limited.

Kleinman PJA, Sharpley AN, Moyer BG and Elwinger GF. 2002. Effect of Mineral and Manure Phosphorus Sources on Runoff Phosphorus. Journal of Environmental Quality, 31(6):2026-2033.

Mullins GL and Burmester CH. 2010. Relation of growth and development to mineral nutrition. In: J.M. Stewart, D.M. Oosterhuis, J.M. Heitholt, and J.R. Mauney (eds.). Physiology of Cotton. pp. 97-105. Springer, New York.

Okalebo JR. 1997. Maize Response to Three High Analysis Phosphate Fertilizers in Some Soils of East Africa. Part 1. Effects on growth. E. Afr. Agric. For. J., 43: 75-83.

Pandey S, Thapa KB and Oli IB. 2013. Correlations of Available Phosphorus and Potassium with Soil pH and Organic Matter Content at Different Soil Reactions Categories in Soils of Western Development Region, Nepal. Journal of Chemical, Biological and Physical Sciences, 3(1):128-133.

Pettigrew WT. 2003. Relationships between insufficient potassium and crop maturity in cotton. Agron. J. 95:1323-1329.

Pettigrew WT. 1999. Potassium deficiency increases specific leaf weights and leaf glucose levels in field-grown cotton. Agron. J. 91:962-968.

Pettigrew WT and Meredith Jr WR. 1997. Dry matter production, nutrient uptake, and growth of cotton as affected by potassium fertilization. J. Plant Nutr. 20:531-548.

Prasertsak P, Freney JR, Saffiga PG, Denmead OT and Prove BG. 2001. Fate of urea nitrogen applied to a banana crop in the wet tropics of Queensland. Nutrient Cycling in Agroecosystems, 59: 65-73.

Prasertsak P, Freney JR, Saffiga PG, Denmead OT and Prove BG. 2001. Fate of Urea Nitrogen Applied to a Banana Crop in the Wet Tropics of Queensland. Nutrient Cycl. Agroecosyst., 59: 65-73.

Rasool G, Chattha TH and Ali MA. 2010. Response of cotton (*Gossypium Hirsutum* L.) to various levels and times of potash application. J. Agric. Res., 48(1):81-85.

Reiter JS and Kreig DR. 2000. Texas research shows fertigation is a viable option to save cotton growers both time and money on fertilizer inputs. Fluid J. 8 (2):20-22.

Sanchez PA and Uehara G. 1980. Management considerations for acid soils with high phosphorus fixation capacity. In: Khasawneh, F.E., Sample, E.C. and Kamprath, E.J. (eds). The Role of Phosphorus in Agriculture, pp. 263–310. American Society of Agronomy, Madison, Wisconsin.

Sarker A, Kashem A and Osman KT. 2012.Influence of city finished compost and nitrogen, phosphorus and potassium (NPK) fertilizer on yield, nutrient uptake and nutrient use efficiency of radish (*Raphanus sativus* L.) in an acid soil. International Journal of Agricultural Sciences, 2 (12):315-321.

Stevens RJ, Laughlin RJ and Kilpatrick DJ. 1989. Soil properties related to the dynamics of ammonia volatilization from urea applied to the surface of acidic soils. Fertil. Res., 20: l-9.

Tewolde H and Fernandez CJ. 1997. Vegetative and reproductive dry weight inhibition in nitrogen and phosphorus deficient Pima cotton. J. Plant Nutr., 20:219–232.

Tisdale SL, Nelson WL and Beaton JD. 1985. Soil Fertility and Fertilizers. New

Yanga G, Tanga H, Niea Y and Zhanga X. 2011. Responses of cotton growth, yield, and biomass to nitrogen split application ratio. European Journal of Agronomy, 35(3):164–170.

Yanga G, Tanga H, Tongb J, Niea Y and Zhanga X. 2012. Effect of fertilization frequency on cotton yield and biomass accumulation. Field Crops Research, 125:161-166.

York City, United States Of America, Macmillian Publishing Company.