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Genetic Variation for Nitrogen Use in Cotton (*Gossypium hirsutum* L.)

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Abstract: A pot experiment was conducted to evaluate the response of six cotton cultivars to soil-applied N fertilization rates-low (50 mg N kg^{-1} soil) and adequate (175 mg N kg^{-1} soil). Substantial differences were observed among varieties and due to nitrogen level × variety interaction for accumulation of Shoot Dry Matter (SDM) and N utilization efficiency and nitrogen contents in leaf and stem. Increase in N rate in soil showed significant increase in shoot dry matter, N concentrations and contents in leaf and stem and decrease in root:shoot ratio.Cotton cultivars FH-634, CIM-1100 and S-12 showed nitrogen utilization efficiency >50 at both the nitrogen levels.

Key words: Cotton, Genotypes, Nitrogen use efficiency, contents

Introduction

Cotton is one of the main cash crops of Pakistan. It accounts for 60 per cent of total foreign exchange earning of Pakistan and fulfills the domestic needs of fibre and contributes upto 85 percent of our domestic edible oil production (Ahmed, 1993). However its average yield (1435 kg ha^{-1}) is much lower than some of other cotton producing countries of the world.

Cotton is generally grown on medium to light textured soils in Pakistan where organic matter is low and nutrients, especially nitrogen, has to be added from other sources such as chemical fertilizers. Moreover, due to high temperature and high pH nitrogen losses in the form of NH_3 are quite high (Hamid and Ahmad, 1987). In Pakistan use of plant nutrients per acre is low as compared to other countries of the world. For instance total NPK consumption during the year 1997-98 was 114 kg ha^{-1} (NFDC, 1998) which is very low compared to Netherlands, Korea and China (554, 467 and 308 kg ha^{-1}, respectively) (Anonymous, 1995).

The possibility of exploiting genetic differences for the absorption and utilization of mineral nutrients has received much attention during the past (Saric, 1987) and recently in Pakistan (Ahmad *et al*., 1998). Differential response of different varieties of a crop to N has been reported by Maples and Frizzell (1985). Keeping in view all the above facts, this experiment was conducted to identify cotton varieties which use nitrogen efficiently.

Materials and Methods

Pot experiment was conducted to test six cotton cultivars viz. NIAB-78, Karishma, FH-634, CIM-443, CIM-1100, S-12 at two levels of nitrogen i.e. low (50 mg kg^{-1} soil) and adequate (175 mg kg^{-1} soil) and same levels of phosphorous and potassium (100 mg kg^{-1} soil). The pots were filled with 10 kg normal alkaline and sandy loam textured soil. The six clean, healthy and delinted seeds were sown in each pot at watter condition of soil. All doses of N, P and K were applied before sowing of seeds except a split dose of N in adequate N level. The experiment was laid out in completely randomized factorial design with three replications.

Plants were harvested at the start of boll formation stage. Stems and leaves were separated and roots were washed out from soil with water. Dry weights were taken after oven drying at 70°C for 48 hours. Dried samples were finely ground and digested in sulphuric acid + digestion mixture (K_2SO_4, $FeSO_4$ and $CuSO_4$; 10:1:0.5) to determine nitrogen concentration by Kjeldhal method. Nutrient utilization efficiency was calculated as {1/(nitrogen concentration in shoot, mg g^{-1}) × (SDW g $plant^{-1}$)} where SDW is shoot dry weight (Siddiqi and Glass, 1981). The data was subjected to statistical analysis using MSTAT-C program (Russell and Eisensmith, 1983).

Results and Discussion

Growth parameters: There were wide variations among cotton varieties to exploit the same growth environment for biomass production. The differences were found more pronounced at adequate supply of nitrogen than at low level of nitrogen. Shoot Dry Matter (SDM), which is considered the most sensitive and responsive plant parameter to nutrient supply ranged from 9.96 g $plant^{-1}$ to 15.26 g $plant^{-1}$ at adequate level of nitrogen. However, root dry matter at both N-levels and SDM at low N level showed less conspicuous differences among the varieties. FH-634 accumulated maximum while CIM-443 the minimum SDM at adequate level of nitrogen. Under low level of nitrogen FH-634, CIM-1100, CIM-443, S-12 and NIAB-78 produced more shoot dry matter than Karishma. There was about 27 percent decrease in SDM when nitrogen concentration was decreased from 175 mg kg^{-1} soil to 50 mg kg^{-1} soil in the growth medium.

Average root dry matter (RDM) at low N supply was higher as compared to RDM produced by the varieties at adequate N supply. However, the differences in RDM were non significant for N levels and variety × nitrogen level interaction while differences among varieties were significant. Variety FH-634 produced the highest RDM at both N-levels. Minimum RDM was produced by NIAB-78 at the adequate N-level and CIM-443 gave the lowest RDM at low N level. Different root growth led to differential root:shoot ratio which is a useful mechanism for efficient nutrient utilization from nutrient stressed growth medium (Agren and Ingestad, 1987). Averaged over all varieties there was about 35 percent decrease in root:shoot ratio with the increase in nitrogen concentration. There were significant differences in root:shoot ratio between N-levels but differences due to varieties and interaction were non significant. Matin (1997) also reported similar results in solution culture.

Nitrogen Concentrations and Contents: Both nitrogen concentrations and contents in leaf and stem decreased significantly with the decrease in nitrogen supply (Table 1). The effects of varieties and variety × nitrogen level interaction were significant for total N-content and non significant for nitrogen concentrations.

Differences in nitrogen utilization efficiencies were significant due to varieties and nitrogen level × variety interaction (Table 2). At both levels of nitrogen i.e. low and adequate, cotton varieties showed significant differences for nitrogen use. However, nitrogen utilization efficiency was influenced non significantly by nitrogen levels which indicates other low requirement of N or adaptability of cotton varieties to N deficiency stress because nutrient utilization efficiency in efficient varieties increased with the decreas in nutrient concentration in growth medium

Table 1: Shoot and root dry weights and root:shoot ratios of six cotton varieties at low and adequate levels of nitrogen

Variety	Shoot dry matter (g Plant^{-1})		Root dry matter (g plant^{-1})		Root:shoot ratio	
	Low	Adequate	Low	Adequate	Low	Adequate
NIAB-78	8.15^{NS}	12.30 bc	2.76NS	2.65NS	0.34	0.21NS
Karishma	8.11	11.36 c	3.19	2.76	0.39	0.24
FH-634	9.81	15.26 a	3.80	3.69	0.38	0.24
CIM-443	9.13	9.96 d	2.68	2.74	0.29	0.27
CIM-1100	9.72	13.51 b	3.56	3.06	0.36	0.22
S-12	9.00	13.10 b	2.89	3.08	0.32	0.23
Mean	9.98 B	12.26 a	3.15	2.99NS	0.35A	0.23B

Table 2: Concentrations and contents of nitrogen in leaf and stem and utilization effeciencies of six cotton varieties at low and adequate levels of nitrogen

Variety	N conc. In leaf (mg g^{-1})		N content in leaf (mg plant^{-1})		N conc. In stem (mg g^{-1})		N content in stem (mg plant^{-1})		Utilization efficiency (g^2 mg^{-1})	
	Low	Adequate	Low	Adequate	Low	Adequate	Low	Adequate	Low	Adequate
NIAB-78	19.60^{NS}	24.47^{NS}	103.65^{NS}	288.07ab	16.33^{NS}	19.60^{NS}	46.91ab	84.02b	0.45b	0.51a
Karishma	19.13	28.00	103.64	211.99b	15.87	18.67	42.82b	70.72b	0.46b	0.48b
FH-634	18.67	26.00	108.36	223.58b	16.80	19.60	67.42a	135.11a	0.55a	0.66a
CIM-443	17.27	29.40	97.03	176.77c	15.40	17.20	53.91ab	71.60b	0.56a	0.42b
CIM-1100	18.20	27.53	105.38	241.33a	16.33	17.26	63.57a	82.10b	0.57a	0.60a
S-12	17.07	27.07	100.17	238.11ab	15.87	17.27	47.48a	74.19b	0.58a	0.59a
Mean	18.32B	27.84	103.04B	219.97A	16.1B	18.43A	53.67B	86.23A	0.53	0.55^{NS}

Mean followed by same letter (s) are statistically similar at 5% probability. NS = Non-significant

(Matin, 1997). Sattelmacher *et al.* (1994) also reported that varieties having higher nutrient use efficiency can adopt better to nutrient deficient conditions. It can be concluded from this study that wide differences in growth and nitrogen use existed among cotton varieties grown at the same nitrogen level and varieties showing better utilization efficiency may be selected for low nitrogen conditions. FH-634, CIM-443, CIM-1100 and S-12 showed nitrogen use efficiency >50 g^2 mg^{-1} N absorbed.

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