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RESPONSE OF *GOSSYPIUM HIRSUTUM* GENOTYPES TO VARIOUS NITROGEN LEVELS

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Abstract

Response of six different upland cotton genotypes to various nitrogen levels (0, 50, 100 and 150 kg N ha^{-1}) was studied during crop season 2010 at Khyber Pakhtunkhwa Agricultural University, Peshawar, Pakistan. Highly significant differences in yield and yield parameters were observed among cultivars, nitrogen levels and the interaction of cultivars vs. nitrogen levels for the given parameters. Application of N significantly increased plant height, sympodia per plant, bolls per plant, boll weight and seed cotton yield but various cultivars responded differently in term of percent increase over control. Maximum value of the given parameter for the given cultivar was observed at higher N level of 150 kg N ha^{-1}. However, when percent increases in the given parameter was considered, it was observed that those cultivars having lower growth and yield traits at control responded more to N application than those having initially higher growth traits which could be due to genetic variation and efficient use of N. Overall, the cultivar CIM-506 maintained higher plant height, sympodia per plant, boll per plant, boll weight and seed cotton yield at all nitrogen levels suggesting that it could be the promising cultivar under environmental conditions of Peshawar and could be grown by supplying 150 kg ha^{-1} N. Since a linear increase in all growth parameters was observed up to 150 kg N ha^{-1} for all cultivars, studies with further higher doses (levels beyond 150 kg ha^{-1}) are recommended for the confirmation of the findings of present study.

Introduction

Cotton crop, the white gold, serves as a backbone of Pakistan economy by occupying a prominent position in local textile and edible oil industry (Khan *et al*., 2009). Consequently, not only sustainable production of cotton is imperative but efforts must be made to further increase its yield per unit area since we are not in a position to allocate more land for cotton production at the expense of other crops. Cotton occupy 12% of the total cultivated area and during 2008-09 it was grown on 2.82 m ha which produced 11.82 million bales of seed cotton with an average of 713 kg ha^{-1} (Anon., 2009).

In Pakistan, cotton yield is comparatively lower than other countries which can be attributed to lack of advanced agronomical practices, cropping husbandry, market constraints and poor socio-economic conditions of the farming community. Poor soil fertility management resulting from imbalanced and non-judicial fertilizer application is another reason for lower seed cotton yields.

Among plant nutrients, nitrogen plays an important role in crop productivity and is regarded as growth and yield determinant in irrigated cotton (Ahmad, 2000). Management of nitrogen and irrigation is of prime importance for high cotton yield and quality. Being the primary constituent of chlorophyll molecule, protein and nucleic acids (Marschner, 1986), it determines plant growth, fruiting and seed cotton yield (Boquet *et al*., 1994; Khan, 1996). Nitrogen has been reported to increase plant height, monopodial/sympodial branches, boll weight and bolls per plant and eventually seed cotton yield (Soomro & Waring, 1987; Mukand *et al*., 1989; Prakash & Prasad, 2000; Karthikeyan & Jayakumar, 2002; Dar & Anwar, 2005; Swan *et al*., 2006; Nadeem *et al*., 2010). Seed cotton weight per boll and seed cotton yield ha^{-1} have also been found affected by nitrogen application at various doses (Nehra *et al*., 1986; Touchton, 1987; Khan *et al.,* 1993; Hussain *et al.*, 2000; Rochester *et al.,* 2001; Anjum *et al*., 2007; Kumbhar *et al*., 2008; Saleem *et al*., 2010).

With continuous cropping systems, the N supplied from the decomposition of organic matter must be supplemented from other sources (Strong *et al*., 1986; Herridge & Doyle, 1988; McDonald, 1992). In developed countries, adequate N is supplied as chemical fertilizer; however, in developing countries including Pakistan, it is not possible due to high cost of fertilizers, low per capita income and limited credit facilities (Shah *et al*., 1995). As a result, the crop receives less fertilizer or even remains unfertilized (Herridge *et al*., 1995) that significantly reduces genotypes yield than its genetic potential. Like lower N, excess of N also reduced the crop yield by promoting vegetative growth and delaying maturity (McConnell *et al*., 1996; Howard *et al*., 2001). In both cases i.e. excess and deficiency of N reduces the crop productivity which necessitates applying N in appropriate doses to get maximum economical potential yield.

The appropriate amount of N depends on factors like soil type, nitrogen concentrations in soil and its mineralization potential, crop specie and cultivar and other numerous environmental factors (Power & Schepers, 1989). Applications of N fertilizer between 100 and 215 kg N ha^{-1} are typically required to optimize lint yield of irrigated cotton in Australia (Constable & Rochester, 1988), USA (McConnell *et al*., 1995), China (Jin *et al*., 1997) and Egypt (Hussein *et al*., 1985). In Pakistan, 120-160 kg N ha^{-1} is recommended depending on soil, climate and crop types. The management of N will correct the future elevated CO_2 deleterious effects on fiber quality if nitrogen is optimum (Reddy *et al*., 2004).

Recognizing the importance of cotton crop and its role in the economy of the country, there is a dire need to get and improve the yield of cotton genotypes under prevailing environmental conditions. The research project was initiated with the objectives to evaluate the response of different upland cotton genotypes to various nitrogen levels and their effect on yield contributing traits and seed cotton yield under the agro-ecological conditions of Peshawar, Pakistan.

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Materials and Methods

Plant material and field procedure: The study on evaluating the response of cotton (*Gossypium hirsutum* L.) genotypes to various N levels was conducted during crop season 2010 at Khyber Pakhtunkhwa Agricultural University, Peshawar, Pakistan. Treatments included six genotypes (CIM-473, CIM-496, CIM-499, CIM-506, CIM-554 and CIM-707) and four levels of nitrogen (0, 50, 100 and 150 kg N ha^{-1}) in randomized complete block (RCB) design with split plot arrangement replicated three times. Cotton seeds of each cultivar were hand sown with plant to plant and row to row spacing of 30 and 75 cm respectively during May 2010. All the N levels were applied in three equal split doses to respective treatment plots at sowing, first irrigation and flowering stage, respectively. Thinning was performed after 15 to 20 days when plants gained height of 15 to 20 cm to ensure single plant per hill. Recommended cultural practices were adopted and crop was grown under uniform field conditions to minimize environmental variations to maximum possible extent. Pickings were made during mid to end of November on individual plant basis.

Traits measurement and statistical analysis: Data were recorded on 10 randomly selected plants in each treatment for plant height, sympodia per plant, bolls per plant, boll weight and seed cotton yield. After compilation and taking averages of per plant data, finally replicated data were subjected to analysis of variance (ANOVA) techniques through MSTATC computer programme to compare mean differences among cotton genotypes, N levels and their interactions for various morpho-yield traits as outlined by Steel & Torrie (1980). Least Significant Difference (LSD) test was used for means separation and comparison after significance.

Results and Discussion

Cultivars (C), nitrogen levels (N) and their interaction (C × N) exhibited highly significant ($p\leq0.01$) differences for plant height, sympodia per plant, bolls per plant, boll weight and seed cotton yield ha^{-1} (Table 1). The significant differences in means of cultivars, nitrogen levels and their interactions were further separated and compared using LSD test (Tables 2-6).

Table 1. Mean squares of cultivars, nitrogen levels and their interaction (C × N) for various traits in upland cotton.

Variables	Mean squares			Correlation (r) with yield
	Cultivars	Nitrogen levels	Interactions (C × N)	
Plant height	2810.114**	1316.718**	6.529**	0.451**
Sympodia plant^{-1}	67.567**	259.125**	1.022**	0.787**
Bolls plant^{-1}	90.1897**	467.944**	3.278**	0.940**
Boll weight	0.123**	0.520**	0.010**	0.706**
Seed cotton yield ha^{-1}	382841.389**	1999131.019**	5488.796**	-

** Significant at $p\leq0.01$

Table 2. Effect of nitrogen levels on plant height of various cotton cultivars.

Cultivars	Nitrogen levels (kg ha^{-1})				Mean (cm)
	Control	50	100	150	
CIM-473	70	78	88	94	83
CIM-496	71	77	84	88	80
CIM-499	62	67	76	83	72
CIM-506	75	82	88	94	85
CIM-554	105	110	120	123	115
CIM-707	89	96	103	105	98
Mean (cm)	79	85	93	98	

Table 3. Effect of nitrogen levels on sympodia plant^{-1} of various cotton cultivars.

Cultivars	Nitrogen levels (kg ha^{-1})				Mean
	Control	50	100	150	
CIM-473	11	13	15	20	15
CIM-496	9	12	14	17	13
CIM-499	7	9	11	16	11
CIM-506	12	15	17	20	16
CIM-554	12	16	19	23	17
CIM-707	12	14	16	21	16
Mean	10	13	15	19	

Table 4. Effect of nitrogen levels on bolls plant^{-1} of various cotton cultivars.

Cultivars	Nitrogen levels (kg ha^{-1})				Mean
	Control	50	100	150	
CIM-473	13.33	17.00	20.67	25.00	19.00
CIM-496	11.33	16.00	17.67	23.00	17.00
CIM-499	9.33	15.00	18.67	21.00	16.00
CIM-506	16.67	20.33	24.00	31.00	23.00
CIM-554	15.00	18.67	22.33	28.67	21.17
CIM-707	12.33	16.00	17.67	22.00	17.00
Mean	13.00	17.17	20.17	25.11	

Table 5. Effect of nitrogen levels on boll weight of various cotton cultivars.

Cultivars	Nitrogen levels (kg ha^{-1})				Mean (g)
	Control	50	100	150	
CIM-473	3.00	3.20	3.30	3.41	3.23
CIM-496	2.95	3.18	3.25	3.38	3.19
CIM-499	3.02	3.22	3.32	3.40	3.24
CIM-506	3.19	3.21	3.30	3.40	3.28
CIM-554	2.70	2.95	3.03	3.30	3.00
CIM-707	2.88	3.15	3.20	3.29	3.13
Mean (g)	2.96	3.15	3.23	3.36	

Table 6. Effect of nitrogen levels on seed cotton yield of various cotton cultivars.

Cultivars	Nitrogen levels (kg ha^{-1})				Mean (kg ha^{-1})
	Control	50	100	150	
CIM-473	1220	1420	1610	1960	1553
CIM-496	1100	1240	1613	1887	1460
CIM-499	1000	1140	1510	1800	1363
CIM-506	1560	1700	1950	2280	1873
CIM-554	1260	1453	1650	1953	1579
CIM-707	1100	1200	1590	1880	1443
Mean (kg ha^{-1})	1207	1359	1654	1960	

Plant height: The cotton plant height linearly increased with each increment of N from 0 to 150 whereby each higher dose was significantly higher the preceding level (Table 2). When values were averaged across cultivars, plant height increased by 8.19, 18.49 and 24.49% with 50, 100 and 150 kg N ha^{-1}, respectively as compared to control. The increases in plant height with each increment of the said levels as compared to preceding lower levels were 8.19, 9.53 and 5.06%, showing that percent increase in plant height was relatively lower at higher increment of 150 as compared to lower levels of N. The significant interaction of nitrogen levels x cultivars revealed that N levels exhibited variable increase in plant height of the cultivar. Cultivars CIM-473 and CIM-499 expressed 34.29 and 33.87% increases in plant height with 150 kg N ha^{-1} as compared to control whereby the same level of N increased plant height of CIM-554 and CIM-707 cultivars by only 17.14 and 18.31%, respectively. Those cultivars which had comparatively lower plant heights at control like CIM-473 and CIM-499 showed higher response to N as compared to those cultivars having comparatively maximum plants heights at control like CIM-554 and CIM-707. These results are in agreement with those of Rochester *et al*., (2001) and Kumbhar *et al*., (2008) who reported that plant height of cotton is related to nitrogen application. Similar effect of nitrogen on plant height and enhancement in the said trait has also been reported (Brar *et al*., 1993; Sawaji *et al.,* 1994; Soomro & Waring, 1987).

Various cultivars had significantly different plant heights at each level of N. However, the cultivar having higher plant height at control maintained higher plant height at succeeding all N levels and *vice versa* (Table 2). For example the CIM-554 had a plant height of 105, 110, 120 and 123 cm at 0, 50, 100 and 150 kg N ha^{-1}, respectively which were the maximum for the cultivars at any given N level. When averaged across the N levels, the maximum plant height of 114.60 cm was recorded for CIM-554 whereas the lowest of 72.00 cm was recorded for CIM-499. Such differences could be attributed to the genetic variations in the genotypes. Dar & Anwar (2005) observed that growth was significantly influenced by different nitrogen levels and N applied @ 150 and 200 kg ha^{-1} showed maximum plant height, monopodial and sympodial branches, however, lowest values of these variables were observed at 50 kg N ha^{-1}. Khan *et al*., (1993; 1994) and Soomro *et al*., (1997) also observed significant increase in plant height due to optimum doses of nitrogen fertilizers. Plant height was found highly significant and positively correlated (r = 0.451) with seed cotton yield (Table 1) and same positive association of the said trait with seed cotton yield was also observed in previous findings if lodging didn't occur (Khan *et al*., 2009). Results revealed that increase in plant height resulted in increased number of sympodia and bolls, which in turn increased seed cotton yield. However, cotton breeders are mostly interested in short stature plants due to lodging threat and also suitable for mechanical picking.

Sympodia per plant: The fruiting branches were significantly increased with increase in N levels from 0 to 150 with values from 10.33 to 19.33 when averaged across cultivars (Table 3). When compared to control, application of 50, 100 and 150 kg N ha^{-1} increased sympodia per plant by 27.49, 48.40 and 87.12%, respectively. However, cultivars responded differently to increasing N levels. Those cultivars having initially lower sympodia at control exhibited relatively higher increases when compared to those cultivars having initially higher sympodia. For example, CIM-499 having 7.00 sympodia per plant at control (N0) showed 128.57% increases in sympodia by getting 16.00 sympodia at 150 kg N ha^{-1} while on the other hand CIM-544 and CIM-707 which had initially 12.33 and 11.67 sympodia per plant exhibited 82.48 and 75.66% increases with same level of N. Dar & Anwar (2005) reported that growth was significantly influenced by different nitrogen levels and N applied @ 200 and 150 kg N ha^{-1} enunciated maximum plant height, fruiting and vegetative branches per plant as compared to the other nitrogen levels and control. Boquet *et al*., (1993) also observed that sympodial branches enhanced with increased nitrogen rates.

It was observed that sympodia per plant were closely associated with plant height. Those genotypes which were comparatively of short stature had lower sympodia per plant as compared to taller cultivars. Cultivar CIM-544 which was the tallest cultivar at all N levels also produced the maximum number of sympodia per plant at the given N levels. When averaged across N levels, CIM-499 which had the lowest plant height (72.00 cm) and also produced the minimum sympodia per plant with value of 10.75 as compared to 17.38 produced by tallest cultivar CIM-544 which had a plant height of 114.60 cm. Karthikeyan & Jayakumar (2002) observed that increased N rates had produced more sympodia and bolls per plant and eventually increased seed cotton yield as compared to control. Kumbhar *et al*., (2008) reported that nitrogen played its part in the accelerated vegetative growth of the plants and sympodial and monopodial branches showed better response to increased nitrogen levels. The increase in fruiting branches with increasing N application rate has also been reported by Mukand *et al*., (1989). Highly significant and positive relationship (r = 0.787) was observed for fruiting branches with yield (Table 1). Sympodium is very important yield contributing trait and has greater share in managing seed cotton yield after bolls per plant and boll weight.

Bolls per plant: Application of N also significantly increased the bolls per plant of each cultivar. When averaged across cultivars, application of 50, 100 and 150 kg N ha^{-1} increased bolls per plant from 13.00 at control to 17.17, 20.17 and 25.11, respectively. However, the response was different for various cultivars. CIM-499 showed higher response and its bolls per plant increased from 9.3 at control to 21 at 150 kg N ha^{-1} while CIM-707 showed the least net increase of 78.43% with the same higher N level. This variable response could be attributed to genetic variations among genotypes which could not be avoided. However, in interactions of genotypes and N levels, maximum bolls per plant (31.00) were exhibited by cultivar CIM-506 with 150 kg N ha^{-1} and here the genetic potential played important role in boosting the bolls per plant. Certainly, all the cultivars except CIM-506 and CIM-554 in control plots showed minimum bolls per plant which ranged from 9.33 to 13.33. However, the cultivars CIM-506 (16.67) and 554 (15.00) were better in performance than other cultivars even at zero N kg ha^{-1} which may be due to their genetic potential. Hooger & Gidnavar (1997) mentioned that excessive vegetative growth of plant was due to high rate of nitrogen which also enhanced yield components like bolls per plant and boll weight and eventually seed cotton yield. Bolls per plant observed in present study were also agreement with those obtained by Ali & El-Sayed (2001) where N was applied @ 95 to 190 kg ha^{-1}, and Ram *et al*., (2001) the N was applied up to 100 kg ha^{-1} and Swan *et al*., (2006) when N applied @143 kg ha^{-1}.

When values were averaged across N levels, maximum bolls per plant were observed in cultivar CIM-506 (23.00) and CIM-554 (21.17) (Table 4). The said cultivars were also having more fruiting branches and plant height and that may be the reason of having more bolls per plant. Cultivar CIM-473 with 19.00 bolls per plant followed the above promising genotypes. Cultivars CIM-496 and CIM-707 manifested medium and at par (17.00) bolls per plant. Least number of bolls per plant (16.00) was noted in cultivar CIM-499 and same genotype was also at the bottom for sympodia per plant and plant height. Brar *et al*., (1993) results also revealed that nitrogen increased the plant height and bolls per plant. Khan *et al*., (2001) mentioned that nitrogen levels significantly affected sympodial branches, bolls per plant and seed cotton yield, and nitrogen @ 187 kg ha^{-1} provided significant increase in yield components and yield. Boll production was significantly higher with adequate application of nitrogen and when cotton crop was grown in the field after legume crop (Prakash & Prasad, 2000). However, the over increase application of nitrogen also enhanced the plant height, flowers and bolls but didn't increase the seed cotton yield because of increased shedding of lower bolls (Nehra *et al*., 1986; Howard *et al*., (2001); Khan *et al*., (1993 & 2001); Hassan *et al*., 2003). Therefore, care should be made in managing optimum requirement of N for cotton crop because nitrogen impacts the crop productivity through either excess or deficiencies. Bolls per plant have direct influence and major role in managing seed cotton yield and the said trait was also found significantly positively correlated (r = 0.940) with seed cotton yield (Table 1).

Boll weight: Like plant height, sympodia and bolls per plant, the boll weight was also significantly increased with increase in N levels from 0 to 150 kg ha^{-1}. Application of N @ 50, 100 and 150 kg ha^{-1} increased the boll weight by

6.42, 9.12 and 13.51% as compared to control. However, the cultivars responded differently to increasing N levels in terms of boll weight which can also be observed in interaction of N levels and cultivars. Maximum percent increase in boll weight was observed in CIM-554 (22.22%) followed by CIM-496 (14.58%) and CIM 707 (14.24%) with 150 kg N ha^{-1} as compared to control (Table 5). Maximum and at par boll weight were noticed in cultivars CIM-473 (3.41 g), CIM-506 (3.40 g), CIM-499 (3.40 g) and CIM-496 (3.38 g) with 150 kg N ha^{-1}. Cultivars CIM-499, CIM-506 and CIM-473 with 100 N kg ha^{-1} (ranged from 3.30 to 3.32 g) also followed the above promising interactions for boll weight. The least and at par boll weight of 2.70 and 2.88 g was governed by cultivars CIM-554 and CIM-707 with zero nitrogen level. Other interaction of various cultivars and nitrogen levels showed medium boll weight. Increase in boll weight was also noticed with optimum nitrogen doses (Karthikeyan & Jayakumar, 2001; Ram *et al*., 2001). Hassan *et al*., (2003) noted that N @168 kg ha^{-1} applied in three equal split doses produced significant increase in boll weight, plant height, bolls per plant and seed cotton yield. Boll weight increased as N rate increased from 95 to 143 kg ha^{-1}. Khan *et al*., (1993), Arain *et al*., (2001), Memon *et al*., (2001) and Soomro *et al*., (2001) also reported significant increase in boll weight and seed cotton yield with split application of nitrogen. However, Anjum *et al*., (2007) reported that seed cotton yield, ginning outturn and lint yield were not influenced by split nitrogen application.

When values were averaged across the N levels, cultivar CIM-506 showed the highest boll weight (3.28 g) followed by CIM-499 and CIM-473 with at par boll weight of 3.24 and 3.23 g, respectively (Table 5). Cultivars CIM-496 and CIM-707 exhibited medium boll weight of 3.19 and 3.13 g, respectively, while lowest boll weight of 3.00 g was recorded in cultivar CIM-554. Increased nitrogen fertilizer also increased leaf photosynthetic rate which might have resulted higher accumulation of metabolites thus impacted boll weight (Cadena & Cothren, 1995). Increase in boll weight may be due to increase in N rate and increases in mineral uptake, photosynthetic assimilation and accumulation (Sawan *et al.,* 2006). Significant effect of various nitrogen rates on boll weight and seed cotton yield has also been reported by Nehra *et al*., (1986) and Khan *et al*., (1993). However, Hussain *et al*., (2000) and Saleem *et al*., (2010) reported that nitrogen fertilizer @ 120 kg ha^{-1} proved to be best for obtaining highest boll weight and seed cotton yield but no effect on fiber quality traits. Boll weight has highly significant positive correlation (r = 0.706) with yield (Table 1). Boll weight is 2nd major yield contributor after bolls per plant in creation of variation and managing seed cotton yield.

Seed cotton yield: Seed cotton yield was significantly influenced by N levels, cultivars and N levels x cultivars interaction (Table 1). Seed cotton yield enhanced with each increment of N from 50 to 150 kg ha^{-1} in each cultivar. When values were averaged across the cultivars, the application of 50, 100 and 150 kg N ha^{-1} increased seed cotton yield from 1207 kg ha^{-1} to 1359, 1654 and 1960 kg ha^{-1}, respectively. In other words, when compared with control, application of 50, 100 and 150 kg N ha^{-1} increased cotton yield by 12.59, 37.03 and 62.39%, respectively. Perusal of the data further revealed that increase in seed cotton yield with each increment was not the same. First increment of 50 kg N ha^{-1} increased the yield by 12.59% while the second and third increment increased the yield by 21.70 and 18.50%, respectively suggesting that further increases in N may increase the seed cotton yield under the prevailing agro-climatic conditions.

Though, the seed cotton yield of all cultivars increased with increase in N levels, however, the response in term of percent increase in yield varied for various cultivars. CIM-499 showed the maximum increase of 80.00% with 150 kg N ha^{-1} as compared to control while CIM-506 showed an increase of 46.15% with the same level of N. The percent increases in CIM-499 and CIM-506 with 150 kg N ha^{-1}, revealed that those cultivars having initially lower seed cotton yield responded more to N as compared to those cultivars having higher seed cotton yields at control (Table 6). However, the highest seed cotton yield (2280 kg ha^{-1}) was noted in cultivar CIM-506 with 150 kg N ha^{-1}. It was followed by at par yield of three cultivars CIM-473 and CIM-707 at 150 kg N ha^{-1} and CIM-506 with 100 kg N ha^{-1} ranged from 1950 to 1960 kg ha^{-1}, and that may be due to there genetic potential which even excelled other genotypes. Certainly, the lowest seed cotton yield of 1000 to 1100 kg ha^{-1} was observed in cultivars CIM-496, CIM-499 and CIM-707 with zero nitrogen intensity. Other associations of various cultivars and nitrogen levels showed medium seed cotton yield. Results also revealed that seed cotton yield increased due to positive role of major yield contributors i.e., bolls per plant and boll weight. The yield response of each cultivar to N increments was best expressed by a quadratic response model (Ibrahim *et al*., 2010). Increasing N rate from 0 to 84 kg ha^{-1} increased average boll weight by 0.16 g and average yield per fruiting site by 0.29 g (Boquet *et al*., 1994). Nitrogen fertilizers level of 150 kg ha^{-1} was found sufficient for satisfactory seed cotton yield and recorded maximum values for yield contributing traits, yield and N-uptake (Kumbhar *et al*., 2008).

When cultivars values averaged over N levels, cultivar CIM-506 presumed maximum seed cotton yield with a mean of 1873 kg ha^{-1} (Table 6). The said promising cultivar was followed by two cultivars i.e., CIM-554 and CIM-473 having at par seed cotton yield of 1579 and 1553 kg ha^{-1}, respectively. Cultivars CIM-496 (1460 kg ha^{-1}) and CIM-707 (1443 kg ha^{-1}) exhibited at par and medium seed cotton yields, while lowest yield was observed in cultivar CIM-499 (1363 kg ha^{-1}). Previous studies revealed that nitrogen levels had created significant differences in yield contributing traits and seed cotton yield, and nitrogen level of 100 kg ha^{-1} revealed significant increase in seed cotton yield due to more sympodial branches, bolls per plant and boll weight (Nadeem *et al*., 2010). Highest seed cotton yield of 3120 kg ha^{-1} was observed with increased application of N (187.5 kg ha^{-1}) followed by 150 and 112.5 kg N ha^{-1} (Singh & Sigh, 2009). Correlation of seed cotton yield was highly significant positive with all morpho-yield traits (Table 1). It is concluded that a unit increase in yield contributing traits will increase seed cotton yield and a little accomplishment will have a great positive impact on yield.

Nitrogen is the basic component in raw food of the plant, which ultimately processed through photosynthesis and other chemical reactions and finally converted into the photosynthates which are the primary prerequisites in all the physiological processes undergoing in the plant body. Thus, more the available nitrogen more will be the partition of photosynthetic outcomes towards final seed cotton yield. Khan & Ahmed (1996) also declared the role of nitrogen in enhancing seed cotton yield, and nitrogen is an essential component of photosynthetic activity (Bondada & Oosterhuis, 2000). In fact, the N is an important nutrient in controlling new growth (Perumai, 1999; Borowski, 2001) and nutrient uptake, and in preventing abscission of squares and bolls. Integration of growth and development mediated by N led to a favorable canopy environment for productivity (square formation and seed cotton yield) (Perumai, 1999). Zhao & Oosterhuis (2000) indicated that low N supply at the reproductive stage decreased cotton leaf area, leaf net photosynthetic rate, and chlorophyll content. They also observed that fruit abscission increased and lint yield decreased in N deficient plants. Yield decrease also reported as a result of N application above an optimum level (Howard *et al*., 2001).

Conclusion

From the results it can be concluded that significant variations were observed among cultivars, nitrogen levels and cultivars × nitrogen levels for all the traits. Application of N significantly increased plant height, sympodia per plant, bolls plant^{-1}, boll weight and consequently the seed cotton yield of all cultivars. However, the percent increases in these parameters with increasing level of N were different for various cultivars that could be associated with genetic variations of genotypes. When percent increase in the given parameter was considered, it was observed that those cultivars having lower growth and yield traits at control responded more to N application than those having initially higher growth traits. Overall, the cultivar CIM-506 showed best performance and increased seed cotton yield at all levels of N suggesting that it could be the promising cultivar if grown with maximum N level of 150 kg ha^{-1} under environmental conditions of Peshawar, Pakistan.

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