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To Evaluate Efficient Use of Nitrogen and Sulphuric Acid Application Towards Increase in Seed Cotton Yield and Soil Health

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Abstract
Present study was study at Agronomic Research area BahauddinZakariya University, Multan to evaluate efficient use of nitrogen and sulphuric acid application towards increase in seed cotton yield and soil health during Kharif 2013. Experiment was laid out in split plot arrangement having three replications. Nitrogen levels (N_1= 50 kg ha^{-1}, N_2=100 kg ha^{-1}, N_3=150 kg ha^{-1}) were kept in main plots while sulphuric acid (S_1= 0 kg ha^{-1}, S_2= 125 kg ha^{-1}, S_3= 250 kg ha^{-1} and S_4= 375 kg ha^{-1}) was randomized in sub plots respectively.Statistical analysis of the data also revealed that maximumLAI, CGR, NAR, plant height (127.22 cm), matured bolls per plant (47.68), mean boll weight (2.94 g), seed cotton yield (3.11 t ha^{-1}), biological yield (26.81 t ha^{-1}) and soil organic matter (5.58%) was noted from the plots fertilized with 150 kg N ha^{-1}. Analysis of the data recorded from the sulfuric acid treatments showed that maximum LAI, CGR, NAR, average boll weight (3.02 g), seed cotton yield (3.13 t ha^{-1}), biological yield (27.16 t ha^{-1}) and changes in soil pH (5.26%) was noted from the plots which were supplied of 375 Kg ha^{-1} sulfuric acid. From the above results, it is concluded the nitrogen rate N_3 (150 kg ha^{-1}) with 375 kg ha^{-1} H_2SO_4 is recommended for achieving higher yield of cotton under the agro-ecological conditions of Multan.
Keywords: Nitrogen, Cotton, Yields, sulfuric acid

INTRODUCTION

Cotton (*Gossypiumhirsutum* L.)is one of the most important cash crops, playing a key role in the economic and social affairs of the world. The cotton crop significantly contributes to the national economy at 7.1% of value added products in the agriculture and about 1.5% of GDP (GOP, 2015). In Pakistan it is grown on an area of 2.96 million hectares with total production of 13.98million bales, which is tremendously lower than the yields obtained in other countries of the world(GOP, 2015). Out of various factors responsible for its low yield, poor quality seed (Rezapour*et al*., 2013), low organic matter (Jackson*et al*., 2004), injudicious use of irrigation water (Onder*et al*., 2009), flare up insect pressure (Gressel*et al*., 2004), excessive vegetative growth (Çopur*et al*., 2010), inappropriate planting method (Nawaz *et al*., 2015), imbalance and inefficient use of essential nutrients (Maitlo*et al*., 2006) are the major ones.

In cotton production, chemical fertilizers, particularly nitrogen (N), is one of the greatest production inputs. Nitrogen is an essential nutrient in creating the plant dry matter, as well as many energy-rich compounds that regulate photosynthesis and plant production (Sanjuan*et al*., 2003).It plays a dominant role in growth processes as it is an integral part of chlorophyll molecule, a constituent of enzyme molecule, protein and nucleic acids (Marschner, 1986; Jasso-Chaverria*et al*., 2005). Synthesis of fat requires both N and carbon skeletons during the course of seed development (Patil*et al*., 1996).Nitrogen transportation in plants, especially during growth and development stages, where N absorption from the soil is limited, is one of the questionable phenomena in fundamental of crop physiology (Barbottin*et al*., 2005). This translocation depends on environment conditions under genetic control (Charmet*et al*., 2005) and also can be affected by fertilizer N application.

Itis important for farmers to choose the optimal level of N application in cotton. Too much nitrogen causes excessive plant growth, slows fruiting, delays maturity, and makes defoliation more difficult, and disease, and insect problems (Gerik*et al*., 1994). Increasing the rate of N fertilizer application above the optimal rate increases the total nitrogen uptake but decrease the lint yield and fertilizer efficiency (Boquet and Breitenbeck, 2000). Too little nitrogen results in reduced plant growth, shortens fruiting branches, increases boll shed and cause premature cutout, resulting in low yields (Hodges *et al*., 1993).

High evapotranspiration and shallow water tables in the Punjab result in salinity and sodicity which are important threats to soil fertility. Accumulation of excess Na^+ in soil causes numerous adverse phenomena on soil physical and chemical properties, such as destabilization of soil structure, deterioration of soil hydraulic properties, increased susceptibility to crusting and specific ion effects on plants (Qadir and Schubert, 2002).According to the United States Salinity Laboratory these soils have an exchangeable sodium percentage ESP more than 15, pH of saturated soil paste (pHs) more than 8.5 and electrical conductivity of saturation extracts (ECe) less than 4 dS m^{-1} (Richards, 1954). Economics of agriculture, especially our small farmers have been getting worse year after year due to loss of productivity of soils. Sodicand saline sodic soils account for more than 50 % of world's salt affected area (Beltran and Manzure, 2005). In Pakistan, about 6.68 m ha land is salt affected (Khan, 1998).

Sulfuric acid is potentially effective amendments in preventing soil crusting and reclaiming calcareous sodic soils (Amezketa*et al*., 2005). A decrease in pH may increase the availability of trace metals like Iron, copper, manganese and zinc (Halvin*et al*., 2005). Similarly, Miyamoto (1998) described the much-publicized effects of lowering pH of irrigation water, and resulting increase in crop performance was probably associated with better availability of some nutrients like Iron, copper, manganese and zinc.

The present study was, therefore, be conducted with the following objectives.

1. To evaluate the differences in yield components of cotton with different nitrogen levels.
2. To analyze the differences in yield and yield components among various treatments using the different rate of sulphuric acid.

MATERIALS AND METHODS

Experimental site

A field experiment was conducted at the agronomic research area, BahauddinZakariya University, Multan to evaluate efficient use of nitrogen and sulphuric acid application towards increase in seed cotton yield and soil health during Kharif2013.

Soil analysis

Soil samples were collected from 0 to 30 cm depth before sowing and analyzed for physicochemical characteristics. The experimental soil was silty clay loam with 0.65% organic matter, 0.17 dSm^{-1} EC, 8.2 pH, 15.45 ppm available phosphorus, 335 ppm available potassium and 36% saturation percentage. Soil samples were re-collected to record organic matter and pH.

Experimental details

Experiment was laid out in split plot arrangement having three replications.Nitrogen levels (N_1= 50 kg ha^{-1}, N_2=100 kg ha^{-1}, N_3=150 kg ha^{-1}) were kept in main plots whilesulphuric acid (S_1= 0 kg ha^{-1}, S_2= 125 kg ha^{-1}, S_3= 250 kg ha^{-1} and S_4= 375 kg ha^{-1}) was randomized in sub plots respectively. The net sub plot size was 3 m × 6 m.Seeds of cotton cultivar CIM 598 was collected from central Cotton research Institute, Multan.

Crop Husbandry

Prior to seedbed preparation, pre-soaking irrigation of 10 cm was applied. When the soil reached a workable moisture level, the seedbed was prepared by cultivating the field 3 times with tractor-mounted cultivator, followed by planking for each. Cotton cultivar CIM 598 was sown during first week of April 2013. Sowing was done via hand dibbling by keeping plant to plant distance of 25 cm on 75 cm spaced irrigated bed-furrows. Pre-emergence herbicide Stomp 33 EC (Pendimethaline) was applied at the rate of 2.5 L ha^{-1} for weed control in the experimental area. The crop was irrigated 72 hours after dibbling the seeds to have successful seed germination and emergence. After one week, the crop was again irrigated to create conditions that were favorable to fill the gaps where seeds were not germinated. Subsequent irrigations were given at 07 days interval up till crop maturity. Phosphorus and potassiumwere applied at the rate of56:62 kg ha^{-1}, respectively by using di-ammonium phosphate (DAP) and murate of potash as a source.Urea was used as nitrogen source and commercial H_2SO_4 for sulphuric acid source. The sulphuric acid was fertigated at the time of 1st irrigation. Full dose of phosphorus, potassium and one third dose of nitrogen were applied at the time of sowing. The second and third dose of nitrogen was top dressed at the time of flowering and boll formation, respectively. The crop was kept free from insect pest attack through regularsprays of recommended and required pesticides available in the market.

Measurements

15 plants were randomly selected from the central two rows in each plot and tagged to record the final plant height (cm), number of bolls per plant, unopened bolls per plant, mature bolls per plant, boll opening percentage, boll weight (g) and seed cotton yield (kg ha^{-1}). Seed cotton was handpicked twice in the middle two rows of each plot. The first picking started when the cotton bolls were about 60% open, and the second harvest was 22 days later and the last picking was done in the first week of December. The harvested seed cotton was weighed and then roller-ginned to measureginning out turn (%), seed index (g) and fiber characteristics.

Statistical analysis

Data recorded on yield and yield components were analyzed statistically by employing the Fisher's analysis of variance technique and significance of treatment means was tested using Duncan's Multiple Range (DNMR) test at 5% probability level (Steel *et al*., 1997).

RESULTS AND DISCUSSIONS

Leaf area index

Leaf area index gives a fairly good idea of assimilatory surface area of a crop.Data regarding leaf area index (LAI) recorded at different growth stages of crop asinfluenced by application of nitrogen and sulfuric acid (Figure 1). The leaf area index differed significantly between the treatments at all the stages of growth.Among different nitrogen levels, application of nitrogen at the rate of 150 kg ha^{-1} outperformed with higher LAI at all intervals of determinationwhile 50 kg N ha^{-1} remained poor in this regard. Application of sulfuric acid significantly improved LAI at all growth stages. Application of sulfuric acid at the rate of 375 kg ha^{-1} maintained higher LAI against the minimum was recorded from control plots.Nitrogen increases the leaf area expansion resulting in enhanced the efficiency of light interception and higher assimilation. LAI increased significantly by increasing nitrogen rates because of the fact that nitrogen increased leaf area of plants and canopies. Cotton canopy development is heavily reliant on N uptake (Wullschleger and Oosterhuis, 1990). Jackson and Gerik (1990) and Fritschi*et al*. (2003) also established greater LAI at higher nitrogen levels. Nitrogen deficiency at reproductive stage enhanced fruit abscission by decreasing leaf area and net photosynthetic rate (Zhao and Oosterhuis, 2000).

Crop growth rate (gm^{-2} day^{-1})

Crop growth rate is described as the gain in dry biomass of plant per unit area per unit of time. Data regarding crop growth rate (CGR) recorded at different growth stages of crop asinfluenced by application of nitrogen and sulfuric acid (Figure 2). Crop growth rate differed significantly between the treatments at all the stages of growth.Among different nitrogen levels, application of nitrogen at the rate of 150 kg ha^{-1} outperformed with higher CGR at all intervals of determinationwhile 50 kg N ha^{-1} remained poor in this regard. Application of sulfuric acid significantly improved CGR at all growth stages. Application of sulfuric acid at the rate of 375 kg ha^{-1} maintained higher CGR against the minimum was recorded from control plots.Increased nitrogen fertilizer rate increased leaf photosynthetic rate which might have resulted higher accumulation of metabolites (Cadena and Cothren, 1995; Reddy*et al*., 1996).

Net assimilation rate (gm^{-2} day^{-1})

Net assimilation rate is generally used as an indicator of mean photosynthetic efficiency. Data regarding net assimilation rate (NAR) recorded at different growth stages of crop asinfluenced by application of nitrogen and sulfuric acid (Figure 3). The net assimilation rate followed an increasing trend in the initial stages of crop growth and decreased thereafter. NAR differed significantly between the treatments at all the stages of growth.Among different nitrogen levels, application of nitrogen at the rate of 150 kg ha^{-1} outperformed with higher NAR at all intervals of determinationwhile 50 kg N ha^{-1} remained poor in this regard. Application of sulfuric acid significantly improved NAR at all growth stages. Application of sulfuric acid at the rate of 375 kg ha^{-1} maintained higher CGR against the minimum was recorded from control plots.The reduced photosynthetic efficiency at high leaf area indices may be the result of the shading of lower leaves.

Plant Height (cm)

Plant height indicated the imperious characteristic that divulges the growth performance of specific crop. Plant height significantly increased by increasing nitrogen application rate from 50 to 150 kg ha^{-1}. Plants fertilized with higher doses of nitrogen 150 Kg ha^{-1} attained maximum plant height (127.22 cm)against the minimum (121.17 cm) was observed from 50 Kg N ha^{-1} (Table 1).Higher nitrogenapplication increases cell division, cell elongation, nucleus formation as well as green foliage. It also encourages the shoot growth. Therefore higher doses of nitrogen increases the chlorophyll content which in turn increases the rate of photosynthesis and stem elongation resulting in increased plant height (Dawadi and Sah, 2012).This may also be due to provision of additional residual fertility left over by bacterial activity of the preceding crop. These results are in agreement with those of Rochester *et al*., (2001) that plant height in cotton is related to nitrogen application. Sulphuric acid treatments significantly affected the plant height. The maximum plant eight (125.83 cm)was observed from control plots. While the minimum plant height (121.16 cm) was achieved by the addition of 375 Kg ha^{-1} sulfuric acid.Interaction between sulphuric acid and nitrogen levels was statistically non-significant. These results are in agreements with those of Sawaji*et al*. (1994) who reported that N application increasedplant height.

Number of total bolls plant^{-1}

Number of bolls formed plant^{-1} is an important yield contributing components of cotton crop. Statistical analysis of the data showed significant differences among different levels of nitrogen (Table 1). Results showed that boll number significantly increased with an increase in nitrogen application rate. The highest boll number (55.28) was obtained in case of 150 kg ha^{-1}N treatment. Application of nitrogen fertilizer at the rate of 50 kg ha^{-1} produced minimum number of bolls plant^{-1} (33.97). The reason for increased number of bolls plant^{-1} with increased N fertilizer levels may be due to the active role of N in the growth and development of cotton plant. Sufficient amount of N when applied is utilized by the plants in photosynthesis process and the resultant photosynthates are diverted to different parts of the plant where they are needed as sink. Suitable amounts of photosynthates when provided at boll formation stage result into proliferation of bolls. Boquet*et al*. (1994) and Brar*et al*. (1993) also concluded that optimal N application benefited cotton yield by large bolls at a greater number of fruiting sites. Similar results were reported by Ram ParkashandMangal Prasad (2000) that boll production was significantly higher with the application of adequate nitrogen. Data regarding differentlevels of sulfuric acid showed non-significant results for number of bolls per plant. The interaction of sulphuric acid and nitrogen levels affecting number of bolls plant^{-1} was also non-significant..

Number of un-opened bolls plant^{-1}

Statistical analysis of the data showed that application of different nitrogen levels, sulfuric acid and their interaction had non-significant results regarding number of un-opened bolls plant^{-1}(Table 1).

Number of matured bolls plant^{-1}

Number of matured bolls plant^{-1} is a basic yield contributing components of cotton crop. Number of matured bolls per plant significantly increased by increasing nitrogen application rate from 50 to 150 kg ha^{-1}(Table 1).Plants fertilized with higher doses of nitrogen 150 Kg ha^{-1} produced maximum number of matured bolls per plant (47.68) against the minimum (26.73) was observed from 50 Kg N ha^{-1}.This clearly indicates that N enhances the photosynthetic activity and the partition of photosynthates effectively up to the level of 100 kg N ha-1, whereas, the increment in nitrogen levels above the optimum dose of 100 kg could not induce further partition of photosynthates towards the seed sink (Dawadi and Sah, 2012). Boquet*et al*. (1993) also presented the similar results that with N rates increased matured bolls plant^{-1} also increased. Application of sulfuric acidand interaction between sulphuric acid and nitrogen levels had non-significant impact on the number of matured boll plant^{-1}.

Boll opening (%)

Statistical results of study indicated non-significant differences for boll opening percentage due to application of nitrogen fertilizer, sulfuric acid and their interaction (Table 1). The boll opening (%) ranged from 79.17% to 86.29% with an average of 83.61%.

Average weight boll^{-1}

Boll weight was also an important factor that decided the yield per plant and per hectare. Results of study also showed that different application rates of N significantly influenced boll weight (Table 2). Results indicated that boll weight significantly increased by increasing N application rate. Plants fertilized with higher doses of nitrogen 150 Kg ha^{-1} produced maximum boll weight (2.94 g) against the minimum (2.84 g) was observed from 50 Kg N ha^{-1}.Increased boll weight may be associated with more dry matter accumulation in the higher fertilization plot. This may be due to increased photosynthetic activity that increases accumulation of metabolites, with direct impact on seed weight (Sawan et al., 2007). Actually, application of nitrogen enhances the chlorophyll contents and hence possessing a vital role in photosynthesis that leads to yield maximization and heavier grains by means of more assimilate partitioning (Ezzat et al., 1999; Ehsanullah et al., 2012).Sulphuric acid treatments significantly affected the average boll weight. The maximum average boll weight (3.02 g) was recorded by the addition of 375 Kg ha^{-1} sulfuric acid. While the minimum boll weight (2.71 g) was achieved from control plots. The interaction of sulphuric acid and nitrogen levels was statistically non-significant.

Seed index (100-Cotton seed weight)

Statistical results of study indicated non-significant differences for seed index due to application of nitrogen fertilizer, sulfuric acid and their interaction (Table 2). The 100-cotton seed weight ranged from 7.57 g and 8.23 g in all the treatment combinations. Similar results were presented by Bhutta (1996) andElayan (1992) who reported no effect of increased nitrogen application on seed index.

Seed cotton yield kg ha^{-1}

Seed cotton yield is the combined effect of individual yield components under particular environmental conditions. Results indicated that seed cotton yield significantly increased by increasing N application rate (Table 2). Plants fertilized with higher doses of nitrogen 150 Kg ha^{-1} produced maximum seed cotton yield (3.11 t ha^{-1}) against the minimum (2.85 t ha^{-1}) was observed from 50 Kg N ha^{-1}. Nitrogen is the primary ingredient in the raw food of the plant, which is ultimately processed through photosynthesis and chemical reactions and finally converted in to 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 (Dawadi and Sah, 2012). Dilipkumar (2000); Ram Parkash and Mangal Prasad(2000); Yasar*et al*. (2004) also pleaded the role of nitrogen in enhancing seed cotton yield. Brar*et al*. (2000) reported that response to higher doses of nitrogen might be attributed to the vital role of N in cell division and cell elongation.While nitrogen deficiency is associated with elevated levels of ethylene (which increases boll shedding), suggesting ethylene production in response to N-deficiency stress (Legé*et al*., 1997).Sulphuric acid treatments significantly affected the seed cotton yield per unit area. The maximum seed cotton yield (3.13t ha^{-1}) was recorded by the addition of 375 Kg ha^{-1} sulfuric acid. While the minimum boll weight (2.81 t ha^{-1}) was achieved from control plots.The interaction between sulphuric acid and nitrogen levels affecting the yield of seed cotton yield was non-significant. The results are in line with those of Ravankar and Deshmukh (1994), they reported increased seed cotton yield at 100 Kg N ha^{-1}. While the results about H_2SO_4 are in contradiction with those of Griffen and Silverttoth (1999) and Christensen and Lyerly (1954) who reported more yield with control as compared to higher levels.

Ginning Out Turn (%)

Statistical results of study indicated non-significant differences for ginning out turn (GOT) due to application of nitrogen fertilizer, sulfuric acid and their interaction (Table 2). The GOT values ranged from 38.80% to 41.73%

in different treatment combinations with an average GOT of 40 60%. These results are in contradiction with those of Brar et al (1992) who indicated that lint %age also increases with increasing nitrogen rates. These results are in accordance with those of Elayan (1992) who reported that there was no effect on lint% with increase in nitrogen.

Biological Yield

Data regarding biological yield was significantly affected by nitrogen levels and sulphuric acid application. Results indicated that biological yield significantly increased by increasing N application rate (Table 2). Plants fertilized with higher doses of nitrogen 150 Kg ha^{-1} produced maximum biological yield (26.81 t ha^{-1}) against the minimum (23.95 t ha^{-1}) was observed from 50 Kg N ha^{-1}. The increase in biomass production such like that straw and biological yields, were more pronounced with nitrogen nutrition application. In fact, nitrogen supply enhances the vegetative growth, photosynthesis activity, informs green color to the plants and also a basic part of chlorophyll contents that contributes towards increase net assimilates. Indeed, about 75 percent of leaf nitrogen is allocated in chloroplast, most of which is used for synthesis of photosynthetic apparatus. Metabolic processes, based on protein leading to increase in vegetative and reproductive growth and yield are totally dependent upon the adequate supply of nitrogen fertilizer (Pandey*et al*., 2000; Naeem, 2001; Singh *et al*., 2002). Application of sulfuric acid significantly increased the biological yield per unit area. Maximum biological yield (27.16 t ha^{-1}) was recorded at 375 kg H_2SO_4 ha^{-1} against the minimum (24.83 t ha^{-1})was recorded from control plots. As regard of nitrogen levels, maximum biological yield (26.81 t ha^{-1}) was produced by 150 Kg ha^{-1} N followed by 100 Kg ha^{-1} (24.11 t ha^{-1}) and the lowest biological yield of 23.95 t ha^{-1} was recorded at minimum nitrogen level 50 Kg ha^{-1}. The interaction between sulphuric acid and nitrogen levels affecting the yield of biological yield was non-significant. Results are in accordance with those of Ryan *et al.* (1977) who reported soil applied H_2SO_4 significantly increased the dry matter yield of sorghum crop.

Harvest index

Statistical analysis of the datashowed non-significant differences in harvest index due to different sulphuric acid rates and nitrogen levels and their interaction (Table 3). The harvest index ranged from 11.28% to 12.19%. Over all mean of harvest index was 11.61%.

Staple length (mm)

Statistical analysis of the data showed non-significant differences in staple length (mm) due to different sulphuric acid rates and nitrogen levels and their interaction (Table 3). It was evident from the data that both the sulphuric acid and nitrogen levels showed non-significant effect on staple length. The average staple length ranged from 27.10 mm to 28.46 mm in all the treatment combinations. The interaction of nitrogen levels and sulphuric acid was also non-significant. The results were contradictory with those of Bhutta (1996) who observed increase in staple length with increase in nitrogen level over control.

Micronaire

Results indicated that micronaire value significantly affected nitrogen application rate. Plants fertilized with lower dose of nitrogen 150 Kg ha^{-1} produced maximum micronaire value (4.93) against the minimum (4.79) was observed from 100 Kg N ha^{-1}(Table 3). Application of sulfuric acid and interaction between nitrogen level and sulfuric acid showed non-significant effect on micronaire value. The results are in contradiction with those of Elayan (1992) who reported that there was no effect of nitrogen on fiber properties.

Change in pH

The statistical analysis of the data showed non-significant results for changes in soil pHdue to different nitrogen levels. While application of increasing levels of sulphuric acid significantly affected the soil pH.Application of sulfuric acid (375 kg ha^{-1}) reduced maximum soil pH (-5.26%) against the minimum change in pH (-2.70%) was recorded from control plots (Table 3). The interaction of nitrogen and sulphuric acid levels on soil pH change was also non-significant and the overall mean of pH change was -4.01%. These results are in accordance with those of Christensen and Lyerly (1954) who reported the decrease in pH with the continuous application of acidified water in the long run.

Change in organic matter (%)

Results indicated that soil organic matter significantly increased by increasing level of nitrogen (Table 3). Plants fertilized with higher doses of nitrogen 150 Kg ha^{-1} produced maximum changes in organic matter (+5.18%) against the minimum (5.17%) was observed from 50 Kg N ha^{-1}. While application of sulphuric acid and interaction between nitrogen level and sulfuric acid had no significant effecton soil organic matter percentage.Kemmitta*et al*. (2006) reported the similar results that sulphuric acid has no significant effect on total soil C and N.

Conclusion

The general conclusion for this study is that seed cotton yield was related to yield contributing traits. The data suggested that there is considerable scope to exploit the yield potential of cotton with variable nitrogen rates and to reclaim the soil by decreasing soil pH with the application of sulphuric acid. It may be concluded from this

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study that the nitrogen rate N_3 (150 kg ha^{-1}) with 375 kg ha^{-1} H_2SO_4 is recommended for achieving higher yield of cotton under the agro-ecological conditions of Multan.

Figure 1: Effect of nitrogen and sulfuric acid on leaf index

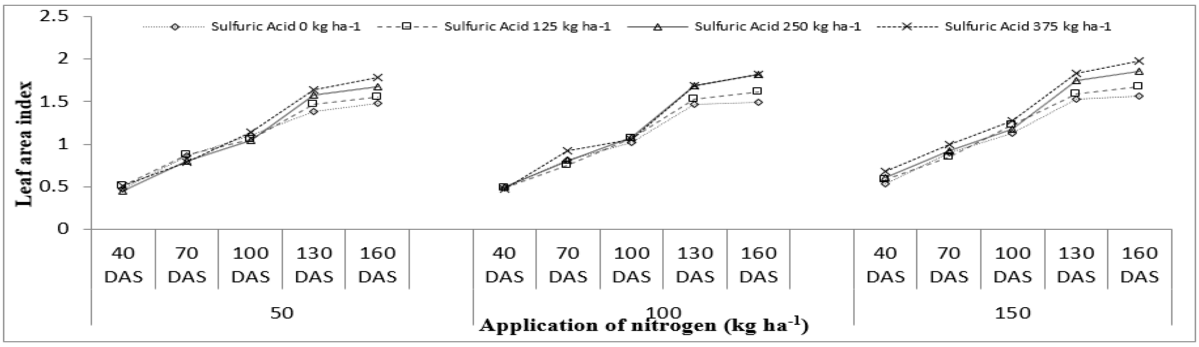

Figure 2: Effect of nitrogen and sulfuric acid on crop growth rate (gm^{-2} day^{-1})

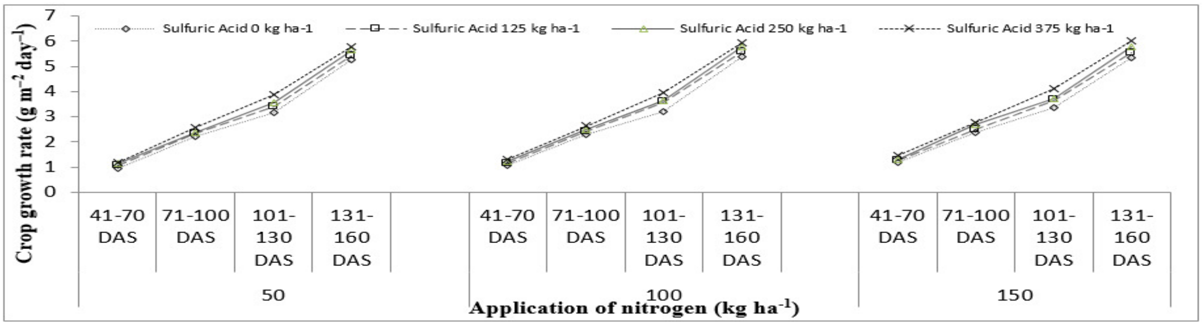

Figure 3: Effect of nitrogen and sulfuric acid on net assimilation rate (gm^{-2} day^{-1})

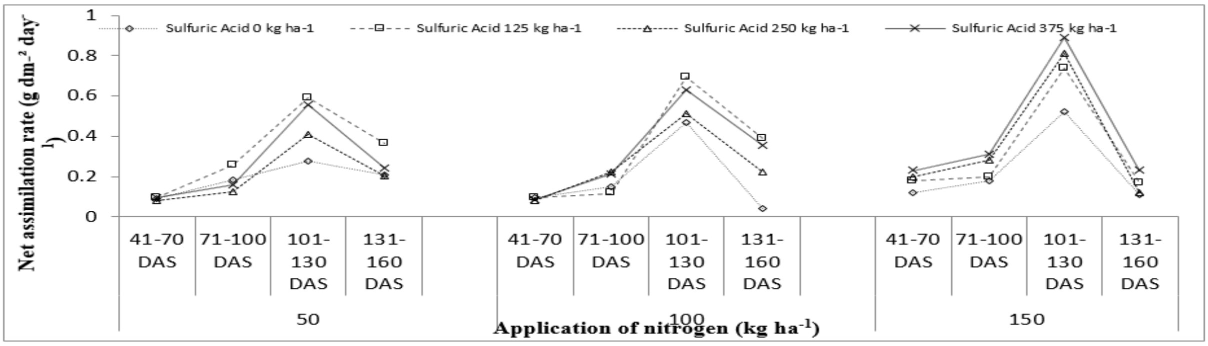

Table 1: Effect of nitrogen level and sulfuric acid on growth and yield contributing parameters of cotton

Treatment	Plantheight (cm)	No. of bolls per plant	No. of unopen bolls per plant	No. of matures boll per plant	Boll opening (%)
Nitrogen level					
N_1 = 50 Kg ha^{-1}	121.17 b	33.97 b	7.23	26.73 b	79.17
N_2 = 100 Kg ha^{-1}	125.80 a	45.97 ab	6.63	38.63 ab	85.37
N_3 = 150 Kg ha^{-1}	127.22 a	55.28 a	7.59	47.68 a	86.29
LSD	2.89	15.85	n.s	13.22	n.s
Sulfuric acid					
S_1 = 0 Kg ha^{-1}	125.83 a	47.71	6.27	37.44	85.63
S_2 = 125 Kg ha^{-1}	124.66 a	44.77	7.21	37.56	83.28
S_3 = 250 Kg ha^{-1}	122.43 b	46.15	8.20	37.96	81.66
S_4 = 375 Kg ha^{-1}	121.16 c	44.71	6.93	37.78	83.87
LSD	1.80	n.s	n.s	n.s	n.s
Interaction	n.s	n.s	n.s	n.s	n.s

Table 2: Effect of nitrogen level and sulfuric acid on yield and yield contributing parameters of cotton

Treatment	Mean boll weig (g)	Seed index (g)	Seed cotton yield ha^{-1})	Ginning out Tu (%)	Biological yield (t ha^{-1})
Nitrogen level					
N_1 = 50 Kg ha^{-1}	2.78 c	7.98	2.85 c	40.98	23.95 c
N_2 = 100 Kg ha^{-1}	2.85 b	8.08	2.94 b	40.72	24.11 b
N_3 = 150 Kg ha^{-1}	2.94 a	7.83	3.11 a	40.11	26.81 a
LSD	0.01	n.s	0.08	n.s	0.61
Sulfuric acid					
S_1 = 0 Kg ha^{-1}	2.71 d	7.90	2.81 b	40.84	24.83 b
S_2 = 125 Kg ha^{-1}	2.79 c	7.89	2.89 b	40.38	25.62 ab
S_3 = 250 Kg ha^{-1}	2.90 b	7.98	3.02 a	40.49	26.42 a
S_4 = 375 Kg ha^{-1}	3.02 a	8.09	3.13 a	40.70	27.16 a
LSD	0.03	n.s	0.11	n.s	0.87
Interaction	n.s	n.s	n.s	n.s	n.s

Table 3: Effect of nitrogen level and sulfuric acid on harvest index, staple length, micronaire value, change in pH and organic matter (%)

Treatment	Harvest index (%)	Staple length (mm)	Micronaire	Change in pH(%)	Change in O.M (%)
Nitrogen level					
N_1 = 50 Kg ha^{-1}	11.90	28.17	4.93 a	4.35	5.17 b
N_2 = 100 Kg ha^{-1}	12.19	27.93	4.79 b	3.49	5.40 a
N_3 = 150 Kg ha^{-1}	11.60	27.51	4.81 b	4.19	5.58 a
LSD	n.s	n.s	0.08	n.s	0.21
Sulfuric acid					
S_1 = 0 Kg ha^{-1}	11.32	27.92	4.81	2.70 d	5.35
S_2 = 125 Kg ha^{-1}	11.28	27.72	4.83	3.64 c	5.37
S_3 = 250 Kg ha^{-1}	11.43	27.98	4.83	4.44 b	5.39
S_4 = 375 Kg ha^{-1}	11.52	27.84	4.90	5.26 a	5.42
LSD	n.s	n.s	n.s	0.58	n.s
Interaction	n.s	n.s	n.s	n.s	n.s

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