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THE IMPACTS OF NITROGEN FERTILIZATION ON THE YIELD AND NUTRITIONAL QUALITY OF THREE *GOSSYPIUM HIRSUTUM L.* CULTIVARS

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ABSTRACT

Nitrogen fertilization is considered crucial for plants' growth and yield. Termed as "white gold" *gossypium hirsutum L.* or upland cotton is the backbone of Pakistan's economy. Under the existing agro-climatic conditions the need for N fertilization intensifies. The current study aimed at analyzing the effects of two levels of N (69kg/Acre and 140 kg/Acre) under normal irrigation (75cm 8 times) on the total yield, seed quality parameters and nutritional composition of three cotton cultivars (FH-942 (Bt), FH-142 (NBt), and MNH-886(Bt)) during the growing season. Significant increase in crop yield were observed in all the three genotrypes, the highest being in FH-142 and FH-942. Under the double dose N percent G.0.T (ginning out turn) increased significantly in FH-942. Seed index (as weight of 100 seeds) showed an increase in all the varieties though these increases were non significant. Seed volume increased in FH-142 while it remained stable in the other two genotypes. Nutritional composition revealed varied responses mostly being non significant for the macronutrients. A non significant increase in the protein (1.79%, 0.39%, and 4.78%) and a non significant decline in the percent oil (3.46%, 3.70%,

2.56%) were observed in the seeds. Crude fiber increased in FH-942 (7.86%) and MNH-886 (10.38%) while it declined in FH-142 (10.39%). The contents of percent ash were non significantly increased (0.95%, 1.29%, and 1.58% respectively). Under the doubling of N genotypic responses in terme of elemental composition were found to be quite varied. The concentrations of calcium (mg Kg^{-1}) increased in MNH-886 (27.73%) and FH-142 (3.22%) and decreased in FH-942 (40.52%). Iron contents increased in FH-142 (80. 36%) and MNH-886 (22.46%). The effects of additional N on Zn and Cu were modest. Responses of manganese were quite varied. FH-142 and MNH-886 showed positive responses (56.14% and 36.40% respectively) while it declined in FH-942 (14.53%). Cd was not detected at increased N while 30% increase was observed in MNH-886. It is concluded from the present study that doubling of N improve total yield, seed index, seed protein and some minerals but its impacts on environmental degradartion shall never be overlooked.

Keywords: Nitrogen fertiliztin, total yield, seed index, proximate composition, mineral composition

1. INTRODUCTION

Belonging to the *Malvaceae* family and tribe of *gossypieae, Gossypium* (Cotton) grow naturally as a perennial shrub or tree. However for commercial purposes it is grown as an annual crop. *Gossypium Hirsutum L*. (Upland Cotton) is a major cash crop known to be the source of world's most important textile fiber, the second best source of plant protein after soybean, and the fifth oil producing plant. Cotton fiber is used to make a number of textile products. In addition to textile industry cottonseed is used to produce oil which after refining can be used like any other vegetable oil. Traditionally four major species of cotton are being grown: *hirsutum, barbadense, arboretum*, and *herbaceum* around the world [1].

Agriculture is an important sector of pakistan's economy. This sector directly support the country's population and accounts for 26 percent of gross domestic product (GDP). The irrigation system of Pakistan belongs to one of the world's largets system to support agricultural production. Pakistan is world's largest producer of raw cotton. In the year 2011-2012 it ranked fourth as the largest producer of cotton with 9.8 pecent share in the global cotton [2, 3]. It is widely grown in hot and humid areas where there are higher pest hazarads. There are many requirements for the higher yield of

cotton such as high input, fertilizer, chemicals for pest control, highly drained soil and water [4]. Among the plant nutrients, nitrogen play a very important role in crop productivity and is an important determinant of the growth and yield of irrigated cotton [4]. Application of N fertilization between 100 and 215 Nha^{-1} are typically being considered to be required for optimize lint yield of irrigated cotton in Australia, USA, China, and Egypt [6-9]. Cotton production regions in Punjab consume over one third of all the fertilizer used in the country. Cotton belt of Sindh also consume significantly higher levels.

The single most important factor that affect the demand for fertilizer is the crop response to different levels of input. The use of fertilization is justified only if it makes an economic sense besides contributing to the physical out put of a crop. Despite relatively higher prices, fertilizer use in Pakistan is still profitable [10]. There is an incontrovertible evidence from farmer's own yield results that crop yield can be considerably increased above present levels through improved crop nutrition [11]. For this purpose integrated plant nutrient management (IPNM) is an important component for sustainable agricultural intensification [12].

Crop responses to the effects of fertilzation have been studied previously but the focus always remained on the percent yield and plants' growth. The consequent effects of fertilization on the nutritional composition of cottonseed has always been a neglected area. The current study is one of unique in its, nature that it aimed to analyze the effects of two levels of nitrogen fertilization on the nutritent (both macro and micro nutrient) contents of cotton cultivars commonly grown in Pakistan.

2. MATERIALS & METHODS

The study was carried out in the Cotton Research Center, Ayub Agriculture Research Institute, Faisalabad, Pakistan during the growing cotton season.

2.1 Experimental Design

About three varieties of upland cotton (FH-142 (Bt), FH-142 (non-Bt), MNH-886 (Bt) were sown manually with single row hand drill with 22cm plant and 2.5 (0.762m) line spacing and 34% soil moisture in three capacity replications each. A three factor factorial design in RCBD (Randomized Complete Block Design) arrangement was followed with two simultaneous treatments

T_1: Double dose of recommended nitrogen @ 140kg/Acre + normal irrigation (8 irrigations, 75cm)

T_2: Normal dose of recommended nitrogen @ 69kg/Acre + normal irrigation (8 irrigations, 75cm).

Whole of the phosphorus in the form of DAP @ 46kg/Acre^{-1} was applied at the time of sowing while nitrogen in the form of urea @ 69kg/Acre^{-1} as normal dose and $\pm$140kg/Acre^{-1} as double dose was applied in 1/3 splits i.e. first at the time of sowing, secondly with first irrigation and last 1/3rd with second irrigation. Hand weeding method was employed four times. The records of soil data, mean precipitations and relative humidity during experimental setup, and temperature are given in Tables-1 and 2.

2.2 Harvest and sampling

Cotton bolls were hand-picked at maturity. After the final boll picking total yield was measured by digital electronic balance. Before weighing, samples were hand cleaned by removing dried leaves, soil particles and other dried plant materials. Seeds and fibers were separated in local ginning machine and were stored first in brown paper envelops and then plastic bags

2.3 Seed Analyses

Seed index

After ginning about 100 healthy seeds were randomly selected. They were weight for linted seed index. Each sample was treated with concentrated sulfuric acid to remove the inherent lint on the seeds. Later seeds were neutralized with an alkali buffer and dried in oven till constant weight. These acid delinted samples both linted or fuzzy seeds samples and acid delinted samples were weighed on a digital electronic balance in grams. The weights of 100 seeds served as seed index per 100 seeds.

Seed volume

Volume of all the seeds was determined by putting 100 delinted seeds in a 50cc graduated cylinder and from a 100cc burette ethanol was poured slowly to cover the seeds until the volume of 40 was achieved in the cylinder. The amount of displaced ethanol was subtracted from the 40ml volume in the cylinder. These volumetric displacements served as volumes of the respective cotton seed samples.

Ginning out turn

G.O.T or lint percent of each sample was determined by the formula.

$$\textbf{G.O.T (Lint \%)} = \frac{\text{Weight of lint in sample}}{\text{Weight of seed cotton sample}}$$

G.O.T = ginning out turn

2.5 Chemical Analyses of Seed

Proximate Composition

Cotton seeds were grinded by means of electric lab grinding machine and were stored in opaque plastic bottles for its proximate

composition by standard procedures and protocols of Association of Official Analytical Chemists (AOAC) [13].

Elemental Analysis

Elements/minerals in the seed samples were determined by wet digestion and atomic absorption spectrophotometer (AAS – Perkin Elmer – Aanalyst 700 (equipped with standard burner, air acetylene flame and solid state detector). Two macro minerals calcium (Ca) and phosphorus (P) four micro minerals Zn, Cu, Fe, Mn, and one heavy metal (Cd) were determined.

Table 1: Soil Composition of the Test Area

Parameters	Concentrations
Electrical conductivity ds/m	2.2
pH	8.16
Organic matter %	0.67%
Total nitrogen %	0.023%
Available P mg/kg	7.83
Available K mg/kg	208
EDTA Zn mg/kg	1.8
EDTA Cu mg/kg	2.4
EDTA Fe mg/kg	53
EDTA Mn mg/kg	43
Textural class	loamy clay
Soil moisture %	34

Table 2: Mean Amount of Precipitation and Relative Humidity during Experimentation

Months	Rain mm/meter/Sq meter	Humidity (%)
April	19	74%
May	1.4	55.0
June	60.2	77.0
July	144.9	83.0
August	03	89.0
September	03	88.0
October	--	89.0
November	1.6	76.1
Total	233.11	

3. RESULTS & DISCUSSION

3.1 Effect On Yield, G.O.T and Seed Quality

The effects of two levels of N fertilizer on the total yield, percent GOT, seed index, seed volume are given in Figures 1-4 respectively. The effect on total yield was quite promising. Increased N fertilization imrpoved total yield significantly in FH-142 (43.6%) and FH-942 (54.8%). Increase in the total yield of MNH-886 was also obvious (21.4%). Results of GOT pecent showed highest percent increase

in FH-142 and MNH-886 while GOT of FH-942 remained stable. The effects of N were also positive on seed index. The highest percent increase occurred in FH-142 and MNH-886 while in FH-942 the increase was modest. The effect of double dose N on the seed volume was greater for FH-142 and MNH-886 while it exerted no effect on seeds from FH-942. As reported Nitrogen (N) is often the most limiting factor in crop production. Therefore, application of fertilizer nitrogen results in higher biomass yields and protein yield and concentration in plant tissue is commonly increased. The findings of the current study are in strong agreement with the findings of other researchers who reported similar significant increase in the total yield of cotton and other crops under increased N fertilization [13-16].

3.2 Effect on Proximate Composition

Results of the proximate composition under two levels of N showed varied results (Table 3). Percent increase in the crude protein content was nonsignificant in all the varieties though highest increase was observed in MNH-886. Responses of the cotton cultivars to two levels of N in terms of seed fiber contents of seed showed a non significant decline in crude percent fiber being 3.46%, 3.70%, 2.56% for FH-942, FH-142, and MNH-886 respectively. Variable responses of the cotton genotypes were observed in the percent seed oil. Percent oil in FH-942 increased non significantly and increased significantly in MNH-886 (7.86% and 10.38% respectively). Percent oil in FH-142 declined significantly (10.39%). Results of percent ash showed FH-942 remained unaffected while non significant increase in FH-142 and MHN-886 were observed (0.95% and 1.29% respectively). It has been well documented in earlier studies that additional nitrogen during the seed filling stage tends to improve the nutritional quality of seed crops [17-19]. The increase in the seed protein and decline in the percent oil of the current study are inline with the findings of other studies. These variations in the nutritional composition of the seeds were attributed to the dierect role of N in the formation of peptide bonds that are integral to the synthesis of all types of proteins [20].

3.3 Effect on Mineral Composition

The effects of N fertilization caused a 40.52% significant decline in the calcium contents of FH-942, a 3.22% non significant increase in FH-142 and 27.73% significant increase in MNH-886. Similarly a highly significant increase in the iron content of FH-942 and 22.46% in MNH-886 were observed. Decline in the iron content (mg Kg^{-1}) of FH-142 (31.11%) also occurred. The effects of

double dose N on zinc content (mg Kg^{-1})was non significant though a 9.36% increase in FH-942and a 8.16% decline MNH-886 were observed. Copper contents (mg Kg^{-1}) of the cultivars were also less affected in three varieties with 4.11 % and 7.05% decline in FH-942 and FH-142 respectively. The effects of N fertilization were quite obvious on manganese. The genotype FH-942 and MNH-886 gained significant manganese under double dose N concentrations (56.14% and 36.40%). The concentrations of cadmium were not detected under increased N while a 30% increase in Cd was observed in MNH-886. The effects N fertilzation on the increase in calcium, iron and zinc of the current study were found to be similar to a study on radicchio chicory [21]. Studies carried out on other crops showed less significant effects of N on the mineral composition of crops as compared to the our study [22-24].

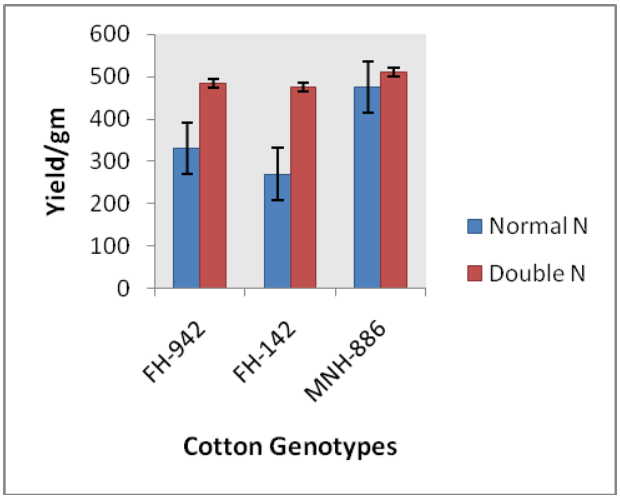

Figure 1: Yield/g of the Cotton Cultivars

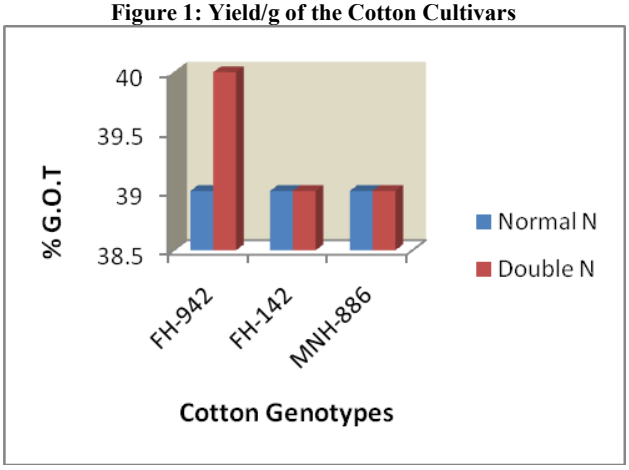

Figure 2: Ginning Out Turn of the Cultivars

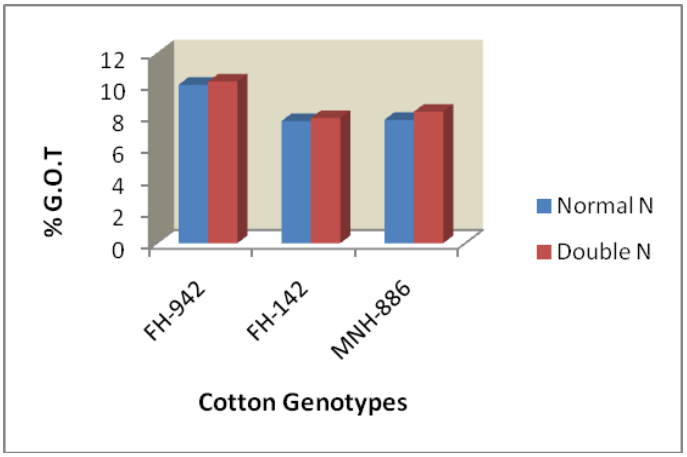

Figure 3: Seed Index Grown Under Two levels of Nitrogen

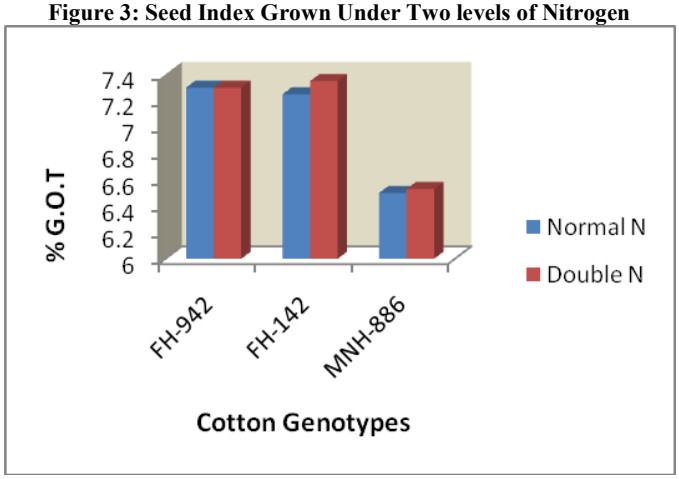

Figure 4: Seed Volume of the Cotton Cultivars at Two levels of N

Table 3: Proximate Composition of the Cotton Genotypes grown at two levels of N

Parameters	Normal Dose Nitrogen (69kg/Acre)	Double Dose Nitrogen (140kg/Acre)	% change	P-Level
Crude Protein				
FH-942	23.83±0.02	24.23±0.06	+1.79	ns
FH-142	23.65±0.87	23.56±0.02	+0.39	ns
MNH-886	23.61±0.22	24.74±0.71	+4.78	ns
Overall means	23.966±2.23	24.67±0.95	+2.09	ns
Crude Fiber				
FH-942	27.32±0.03	26.23±0.04	-3.46	ns
FH-142	21.82±0.61	20.91±0.01	-3.70	ns
MNH-886	27.00±1.45	27.09 ±0.43	-2.56	ns
Overall means	25.68±1.21	24.95±1.26	-2.84	ns
Crude Fat				
FH-942	18.81±0.04	20.29±0.045	+7.86	ns
FH-142	20.02±1.25	17.89±0.055	-10.39	0.067
MNH-886	19.74±1.12	21.82±0.072	+10.38	0.056
Overall means	19.523±1.48	20.76±2.38	+6.24	ns
Ash %				
FH-942	3.68±0.25	3.68±0.02	0.00	ns
FH-142	4.82±0.69	4.92±0.41	+0. 95	ns
MNH-886	3.53±1.59	3.93±0.56	+1. 29	ns
Overall means	4.11±1.35	4.62±2.28	+1.58	ns

*ns non significant **significance at P≤0.05

Table 3: Mineral Composition of the Cotton Genotypes grown at two levels of N

Minerals/ Varieties	Normal Dose Nitrogen (69kg/Acre)	Double Dose Nitrogen (140kg/Acre)	% change	P-Level
Calcium ($mgkg^{-1}$)				
FH-942	**1.741±0.031**	**0.862±0.231**	**-40.52**	**0.04**
FH-142	**0.936±0.06**	**0.968±0.04**	**+3.22**	**ns**
MNH-886	**0.778±0.02**	**0.989±0.06**	**+27.73**	**0.027**
Iron ($mgkg^{-1}$)				
FH-942	**161.7±0.004**	**292.8±0.02**	**+80.36**	**0.00**
FH-142	**218.2±0.02**	**150.8±0.001**	**-31.11**	**0.011**
MNH-886	**150.2±0.02**	**184.3±0.03**	**+22.46**	**0.049**
Zinc ($mgkg^{-1}$)				
FH-942	**75.0±0.003**	**82.3±0.02**	**+9.36**	**ns**
FH-142	**57.8±0.002**	**58.9±0.016**	**+1.75**	**ns**
MNH-886	**75.6±0.02**	**69.0±0.03**	**-8.16**	**ns**
Copper ($mgkg^{-1}$)				
FH-942	**12.9±0.02**	**12.3±0.02**	**-4.11**	**ns**
FH-142	**12.6±0.02**	**11.7±0.04**	**-7.05**	**ns**
MNH-886	**10.4±0.04**	**10.7±0.012**	**+2.48**	**ns**
Manganese ($mgkg^{-1}$)				
FH-942	**19.2±0.01**	**16.4±0.02**	**-14.53**	**0.045**
FH-142	**14.7±0.04**	**22.4±0.01**	**+56.14**	**0.006**
MNH-886	**22.7±0.015**	**30.3±0.012**	**+36.40**	**0.004**
Overall Mean	**19.66±1.899**	**23.33±1.02**	**+26.23**	**0.010**
Cadmium ($mgkg^{-1}$)				
FH-942	**0.6±0.02**	**ND**	**----**	**–**
FH-142	**0.2±0.04**	**ND**	**------**	**–**
MNH-886	**0.3±0.001**	**0.7±0.002**	**+30.0**	**0.047**

***ns non significant **significance at P≤0.05**

CONCLUSION

Nitrogen nutrition of plants significantly increased the total yield in all varieties. The 100 seed weight, seed volume was increased but the effects were modest. Intra-varietal variations were observed in the crops' nutritional responses. The increased nitrogen positively affected the total protein content and some minerals. It can be concluded from the current study that intensive nitrogen nutrition will be of benefits to cotton cultivation however similar effects on other genotypes needs to be explored.

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