

NITROGEN MANAGEMENT STUDIES IN MAIZE (*ZEA MAYS L.*) HYBRIDS

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ABSTRACT. A field experiment was conducted to study the effect of different nitrogen management methods on yield, yield components and quality attributes of maize hybrids (single cross-6142 and double cross-4444) under irrigated conditions. Nitrogen dose is met either by PM (poultry manure) or urea according to each treatment. PM was incorporated at the time of presowing irrigation whereas fertigation method at knee height stage and foliar spray at flowering were used for the application of urea. Results showed that plant height, cob diameter, number of grains per cob, grain yield and biological yield were significantly affected by the hybrids. Significantly, higher plant height, cob diameter, number of grains per cob, grain yield and biological yield were produced by single cross-6142. There was no significant difference occur between both hybrids on seed oil and protein contents. N management by the application of T₃ (60% N from PM + 38.5% N from urea through fertigation + 1.5% N from urea through foliar application) produced significantly more plant height, cob diameter, number of grains per cob, grain yield, biological yield,

seed protein and seed oil contents. The interaction of single cross-6142 and T₃ (60% N from PM + 38.5% N from urea through fertigation + 1.5% N from urea through foliar application) was found superior in production of more plant height, cob diameter and number of grains per cob. However, interaction between maize hybrids and N application methods for grain yield, biological yield, seed protein and oil contents was reported non-significant. It can be concluded that single cross hybrid-6142) and T₃ (60% N from PM, 38.5% N from urea through fertigation and 1.5% N from urea through foliar application) could be used successfully for improving maize yield under the irrigated conditions.

Key words: Maize; Poultry manure; Urea, Yield.

INTRODUCTION

Maize serves as staple food to large proportion in world (Tagne *et al.*, 2008). Its yield is severely

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affected by the nutrients especially nitrogen. Nitrogen (N) is the most critical element of plant growth and plays a key role in many metabolic and physiological functions (Balasubramaniyan and Palaniappan, 2001). Deficiency of N is usually the most limiting factor in maize production for early growth and grain filling (El-Douby *et al.*, 2001; Zeidan *et al.*, 2006). Many scientists had reported the increase in maize grain yield due to ample quantity of N (Iqbal *et al.*, 2010; Khan *et al.*, 2011).

It is obvious maize demand nutrients in quantity through an efficient source. Among the fertilizers, chemical fertilizer is an important, as it immediately supplies the nutrients after the application (Mlot, 1997). However, heavy wastage of N through leaching, volatilization and runoff is seemed in chemical fertilizers. Also fertilizers are expensive as well (Mlot, 1997). On the other hand, organic manures are the cheap and could substitute the chemical fertilizers (Delate and Camberdella, 2004). It has the potential to improve the soil fertility and quality (Zingore *et al.*, 2008). One of the excellent organic manure is poultry manure. It contains higher amount of nutrients i.e. NPK and other nutrients (Sims and Wolf, 1994). But, organic manure alone can't fulfill the crop requirement. In this situation integrated use of chemical and organic fertilizers seems to be a possible solution, as it supplies essential nutrients and also they have some positive interaction to enhance the

nutrient use efficiency (Ahmad *et al.*, 1996).

Time and method of N application plays an important role in its efficient utilization (Mohammad *et al.*, 1999). Split application of N at different plant growth stages increases grain yield and yield attributes of maize (Sangoi *et al.*, 2007). Among methods, fertigation is one of the best one (Feigin *et al.*, 1982) and it reduces the losses and increased the uptake of N by the plant (Cadahia, 1993). It enables users to supply nutrients in desired frequency, amount and concentration at proper time (Kumar *et al.*, 2000). Likewise, foliar application is also an important method and ensures the sufficient availability of nutrients to crops for obtaining high yield (Arif *et al.*, 2006). But integrated soil and foliar application of N through urea has been reported as a useful and economical (Mahajan *et al.*, 2004).

As far as the nitrogen use efficiency is concerned, crops are not efficient in the uptake of nutrients especially N. In addition, only 50% applied N is taken by the crop (maize and wheat) and rest amount of N is lost (Kronzucker *et al.*, 1998). Although the present varieties/hybrids of maize have good yield potential but still yield per hectares is much less to tackle the food security threat. So, this is the need of time to develop an N management strategy using the available high yielding varieties.

So, a study was planned to evaluate the effect of N management methods on the yield, yield

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components and quality attributes of maize hybrids under irrigated conditions.

MATERIALS AND METHODS

The present nitrogen management study was conducted at Agronomic Research Area, University of Agriculture Faisalabad, Pakistan. Chemical analysis of experimental soil and poultry manure (PM) was performed before conducting the experiment (*Tables 1 and 2*). The study comprised of two factors i.e nitrogen management methods (T₁: 20% N from PM + 79.5% N from urea through fertigation + 0.5% N from urea through foliar application, T₂: 40% N from PM + 59% N from urea through fertigation + 1% N from urea through foliar application, T₃: 60% N from PM + 38.5% N from urea through fertigation + 1.5% N from urea through foliar application, T₄: 80% N from PM + 18% N from urea through fertigation + 2% N from urea through foliar application, T₅: 100% N from PM) and two maize hybrids (H₁: Single cross hybrid-6142, H₂: Double cross hybrid-4444). The statistical design used was randomized complete block design (RCBD) with split plot arrangement and treatments were replicated four times. Maize hybrids were randomized in main plot while the N management methods were randomized in sub-plot. Seed of hybrids was sown on well-prepared seedbed on 75 cm spaced ridges, using a seed rate of 28 kg ha⁻¹ and maintaining plant to plant distance of 25 cm. Recommended dose of NPK 250-125-125 kg ha⁻¹ was followed. Nitrogen dose is met either by poultry manure (PM) or urea or both of them according to each treatment. PM was incorporated in soil at pre-sowing irrigation whereas urea was fertigated (at knee height stage of

crop) and foliar applied according to each treatment. Beside the poultry manure and soil also provides the phosphorus (P) and potassium (K) as their original quantity and for meeting the additional quantities of these elements, SSP (single super phosphate) and SOP (sulphate of potash) were used. Whole dose of P and K were applied at the time of sowing.

Standard procedures were adopted to record the data on yield, yield components and quality attributes of maize hybrids. The plant height at maturity was measured by taking 10 plants per plot and than mean value was calculated. Cobs from randomly selected 10 plants were removed and their diameter (with the help of Vernier Caliper) were measured in cm and then averaged. Grains from 10 randomly selected ears of each treatment were shelled, counted and converted into average number of grains per cob. For biological yield plants from each subplot were harvested manually, sun dried and weighed to determine the biological yield in kg per plot and then converted to t ha⁻¹. Similarly, for grain yield, cobs were separated from each harvested plot, shelled and their grains were weighed and finally converted into t ha⁻¹.

Oil content of the representative seed sample was determined by Soxhlet method described by Low (1990), while protein content of seed samples were determined by analyzing the nitrogen content of samples using the micro-Kjeldhal method (Anonymous, 1990) and then N value was multiplied with factor 6.25 according to following formula, Crude protein = Nitrogen x 6.25.

Data recorded were statistically analyzed using the Fisher's analysis of variance technique and treatments' means were compared by using the least

significant difference (LSD) test at 5 % level of probability (Steel *et al.*, 1997).

Table 1 - Chemical analysis of experimental soil

Chemical attributes	Results
Organic matter	0.74%
Nitrogen	0.05%
Phosphorous	5.34 ppm
Potassium	175 ppm
pH	8.1

Table 2 - Chemical analysis of poultry manure (PM)

Chemical attributes	Results
Nitrogen	2.04%
Phosphorous	1.08%
Potassium	0.93%

RESULTS AND DISCUSSION

In this study, the efforts were made to study the effect of N management methods on yield, yield components and quality attributes of maize hybrids under irrigated conditions.

Results regarding plant height (*Table 3*) revealed that both hybrids differ significantly between themselves for plant height and maximum height of plants were found in H₁ (Single cross hybrid-6142) over the H₂ (Double cross hybrid-4444). These results showed the genetic variation of both hybrids due to which difference in plant height has been obtained. Paponov and Engels (2003) also reported that maize hybrids respond different to applied nitrogen. In case of N management methods (*Table 3*), treatments T₃ (60% N from PM + 38.5% N by urea through

fertigation + 1.5% N from urea through foliar application) gave taller plants compare to the other treatments. The lowest plant height was obtained in treatment T₅ (100% N from PM). Such results in T₃ were obtained might be better supply and uptake of N at proper stage of crop development. Similarly, Ayoola and Makinde (2008) and Iqbal *et al.* (2010) reported that combine application of urea and PM increased the plant height in maize. Abd EL-Fattah *et al.* (2012) also resulted better growth of maize by foliar application of nitrogen. However, smaller plant height by the application of N from PM (T₅) might be attained because organic manure first needs to decompose for supplying the nutrient. In case of interaction (*Table 4*), all the interactions of maize hybrids and N management methods had non-significant effects on the plant height. These findings supported the findings of Khan *et al.* (2011).

The data regarding hybrids and N management methods (*Table 3*) indicates that cob diameter was differed significantly while the effects of interaction between hybrids and N management methods (*Table 4*) were also found. Statistically, more cob diameter by the hybrid H₁ (Single cross hybrid-6142) and minimum was produced by H₂ (Double cross hybrid-4444). These results were likely to be obtained due to variation in genetic makeup of both hybrids. As far as different N management methods is concerned, higher cob diameter in the plots treated with T₃ (60% N from PM + 38.5% N by urea through fertigation

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+ 1.5% N from urea through foliar application) whereas lowest cob diameter was recorded in treatment T₅ (100% N from PM). It might be owing to more supply of N at different stages of crop due to combining the different N application methods and N sources. Mahajan *et al.* (2004) also reported that soil and foliar application of N proved more useful and economical. Furthermore, Khaliq *et al.* (2004) and Boateng *et al.* (2006) noted significant effect of organic and synthetic fertilizer on cob diameter. Minimum cob diameter in T₅ was obtained may be due to slow release of N from PM. In interactions, maximum cob diameter was found by the interaction of H₁T₃ while minimum was found in H₂T₅. Our results are supported by the findings of Khan *et al.* (2011).

It was revealed from the data (Table 3) that the number of grains per cob was significantly affected by maize hybrids. Maximum number of grains per cob was produced in the hybrid H₁ (Single cross hybrid-6142) which differed significantly from other hybrid (Table 2). The lowest number of grains per cob was produced in T₃ (60% N from PM + 38.5% N from urea through fertigation + 1.5% N from urea through foliar application) and it also differed significantly from the other N management methods. More number of grains per cob might be recorded owed to suitable supply of N at different stages by combining the foliar application (at flowering) method with soil application methods

(fertigation and soil incorporation of PM). Similarly, it was reported that foliar application at flowering stage increased harvest amount of crop (Stevens *et al.*, 2002). Our results are not supported by the Costa *et al.* (2002) who reported that the application of nitrogen did not affect the number of kernels per cobs. However, interactions between hybrids and N management methods (Table 4) were exhibited no significant effect on the parameter under discussion. Our findings are not inline with Alam *et al.* (2003).

Significant more weight of grain yield was produced by the H₁ than the H₂ (Table 3). These results were obtained due the fact that single cross hybrid are more productive than double cross (Khalil *et al.*, 2010). In case of N management methods, greater value of grain yield was recorded by the addition of T₃ (60% N from PM + 38.5% N from urea through fertigation + 1.5% N from urea through foliar application). Likely, results were obtained by Masauskas and Masauskiene (2002) and Mahajan *et al.* (2004). However, minimum grain yield was attained in the T₅. It might be owing to slow released of N from PM. The interaction between hybrids and N management methods (Table 4) was also found significant. H₁ + T₃ gave the highest grain yield while H₂ + T₅ remained shortened in the production of grain yield but it differed non-significantly with H₂ + T₄. These results supported the findings of Khan *et al.* (2011).

Table 3 - Effect of different nitrogen management methods on yield, yield components and quality attributes of maize hybrids

(Mean of four replicates)

Treats	Plant height (cm)	Cob diameter (cm)	Number of grains per cob	Grain yield (t ha ⁻¹)	Biological yield (t ha ⁻¹)	Seed oil content (%)	Seed protein content (%)
H ₁	210.69 a	4.14a	452.80 a	5.30 a	15.40 a	4.20	8.57
H ₂	162.84 b	3.42 b	343.33 b	3.48 b	12.69 b	4.35	8.07
LSD (0.05)	3.26	0.12	14.74	0.18	1.98	NS	NS
T ₁	184.90 c	3.77 c	401.67 c	4.46 c	14.58 a	4.37 b	8.23 b
T ₂	195.45 b	3.87 b	424.50 b	4.86 b	15.11 a	4.19 c	7.82 c
T ₃	207.13 a	4.08 a	440.50 a	5.33 a	15.56 a	4.06 d	8.56 a
T ₄	178.75 c	3.64 b	374.50 d	3.86 d	13.27 b	4.27 bc	8.54 a
T ₅	168.07 d	3.55 d	349.17 e	3.40 e	12.21 b	4.51 a	8.45 ab
LSD (0.05)	7.21	0.07	14.27	0.28	1.11	0.12	0.26

Treats : Treatments; H₁: Single cross hybrid-6142; H₂: Double cross hybrid-4444; T₁: 20% N from PM + 79.5% N from urea through fertigation + 0.5% N from urea through foliar application; T₂: 40% N from PM + 59% N from urea through fertigation + 1% N from urea through foliar application; T₃: 60% N from PM + 38.5% N from urea through fertigation + 1.5% N from urea through foliar application; T₄: 80% N from PM + 18% N from urea through fertigation + 2% N from urea through foliar application; T₅: 100% N from PM; NS: Non-significant

The data regarding biological yield as affected by different maize hybrids and nitrogen management methods (*Table 3*) reflects that both hybrids significantly affected the biological yield. Maximum biological yield was produced by single cross hybrid-6142 (H₁). However, other hybrid (H₂) produced lowest biological yield. These results showed supported the fact that single cross hybrid are more productive than double cross hybrid (Khalil *et al.*, 2010). Among N management methods, statistically highest biological yield was given by T₃ (60% N from PM + 38.5% N from urea through fertigation + 1.5% N from urea through foliar application) which

was found at par with T₂ and T₁. Maximum biological yield with T₃ indicates the balanced and more availability of N to the plants throughout the growing period. These results are in line with the findings of Ibeawuchi *et al.* (2007) and Mohamed *et al.* (2009). Our results were also inline with Alston (1979), who concluded that better vegetative and reproductive growth of the maize was due to the foliar application of nitrogen. Nonetheless, interactions among hybrids and N management methods (*Table 4*) were reported non-significant.

Seed oil concentration (*Table 3*) was recorded non-significant among the hybrids whereas, N management

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methods significantly affected the parameter under discussion. More seed oil content was obtained by the application of N through T₅ (100% N from PM) while lowest seed oil content was recorded in T₃ (60% N from PM + 38.5% N from urea through fertigation + 1.5% N from urea through foliar application). The depression of seed oil content in T₅

was due to fact that N had negative correlation with oil contents. Our results regarding the oil content are in line with Khan (2008) and Iqbal *et al.* (2010). The interactions between hybrids and N management methods (Table 4) resulted non-significant effects on the seed oil content. Our outcomes are against the results of Khan *et al.* (2011).

Table 4 - Interactive effect of different nitrogen management methods and maize hybrids on yield, yield components and quality attributes

(Mean of four replicates)

Treats	Plant height (cm)	Cob diameter (cm)	Number of grains per cob	Grain yield (t ha ⁻¹)	Biological yield (t ha ⁻¹)	Seed oil content (%)	Seed protein content (%)
H ₁ T ₁	208.47	4.14 bc	454	5.41 c	15.67	4.23	8.42
H ₁ T ₂	218.70	4.18 b	478	5.84 b	16.20	4.19	8.61
H ₁ T ₃	231.83	4.33 a	491.33	6.51 a	17.08	4.11	8.88
H ₁ T ₄	205.67	4.04 cd	430.33	4.70 d	14.58	4.14	8.80
H ₁ T ₅	169.77	3.99 d	410.33	4.02 e	13.16	4.35	8.15
H ₂ T ₁	161.35	3.38 g	359.33	3.50 f	13.19	4.50	8.04
H ₂ T ₂	169.20	3.55 f	371	3.89 ef	14.02	4.19	8.30
H ₂ T ₃	182.43	3.82 e	389.67	4.16 e	14.03	4.01	8.24
H ₂ T ₄	151.84	3.24 h	318.67	3.02 g	11.96	4.39	8.28
H ₂ T ₅	146.38	3.12 i	288	2.79 g	11.26	4.67	7.48
LSD (0.05)	NS	0.10	NS	0.40	NS	NS	NS

Treats : Treatments; H₁: Single cross hybrid-6142; H₂: Double cross hybrid-4444; T₁: 20% N from PM + 79.5% N from urea through fertigation + 0.5% N from urea through foliar application; T₂: 40% N from PM + 59% N from urea through fertigation + 1% N from urea through foliar application; T₃: 60% N from PM + 38.5% N from urea through fertigation + 1.5% N from urea through foliar application; T₄: 80% N from PM + 18% N from urea through fertigation + 2% N from urea through foliar application; T₅: 100% N from PM; NS: Non-significant

The data revealed (Table 3) that non-significant results of seed protein were attained among hybrids. Dissimilar results were obtained by Khan *et al.* (2011). But the N management had significant effects on the seed protein. Highest seed protein content was achieved by the

fertilization of T₃ (60% N from PM + 38.5% N from urea through fertigation + 1.5% N from urea through foliar application) and it was not statistically differed from T₄ (80% N from PM + 18% N from urea through fertigation + 2% N from urea through foliar application) and T₅

(100% N from PM). Similar results of seed protein content by application of N had been reported by Khan (2008) and Iqbal *et al.* (2010). However, interactions between hybrids and N management methods (*Table 4*) were not significantly affected the seed protein concentration. These results are not inline with findings of Khan *et al.* (2011).

CONCLUSIONS

It is concluded from the results that single cross hybrid-6142 was remained superior in attaining the high yield compare to double cross hybrid-4444. Further, 60% N from PM + 38.5% N from urea through fertigation + 1.5% N from urea through foliar application proved the best N management method for maize. So, single cross hybrid-6142 could be grow with 60% N from PM + 38.5% N from urea through fertigation + 1.5% N from urea through foliar application in order to attain optimum yield.

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