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# OPTIMIZING NITROGEN INPUT AND HARVEST TIME TO MAXIMIZE THE MAIZE FODDER YIELD IN PUNJAB, PAKISTAN

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Appropriate nutrient management and harvesting date are the main and quickest means for increasing maize production. A field experiment with three nitrogen fertilization rates ($N_1$= 50; $N_2$= 100; $N_3$= 150 (kg ha$^{-1}$) and three harvest dates ($H_1$= 50, $H_2$= 60 and $H_3$= 70 DAS) was carried out at the Agronomic Research Area, University of Agriculture, Faisalabad to predict the response of maize (*Zea mays* L.) fodder yield and its quality attributes to optimal nitrogen input rates and harvest dates. The results showed that increase in nitrogen fertilizer input resulted in significant ($P \leq 0.05$) increase in yield and quality traits. Yield attributes as plant height (179.40 cm), stem diameter (3.59 cm), leaf area plant$^{-1}$ (3755 cm$^2$), dry matter (33.44%), dry matter yield (17.68 t ha$^{-1}$) and green fodder yield (71.32 t ha$^{-1}$) were significantly increased with nitrogen input of 150 kg N ha$^{-1}$. Among nitrogen input rates, 150 kg N ha$^{-1}$ level was also responsible for highest crude fat (3.09%), crude protein (11.48%) and crude fiber (34.21%) except ash contents (10.17%) compared to other nitrogen treatments. Twenty days delayed for harvest proved to be best for increasing growth and quality characters of maize plants. The interaction between nitrogen rates and harvest dates was found to be highly significant except for plant height, dry matter percentage and crude protein. Nitrogen input of 150 kg N ha$^{-1}$ with 70 DAS harvest date ($N_3 \times H_3$) significantly improved the stem diameter (5.11 cm), leaf area plant$^{-1}$ (4108 cm$^2$), dry matter yield (21.35 t ha$^{-1}$), green fodder yield (83.87 t ha$^{-1}$) and crude fiber (37.21%) while crude fat (2.47%) and ash (9.17%) contents were decreased. In conclusion, on the basis of growth and quality parameters, the nitrogen application at 150 kg N ha$^{-1}$ and harvesting time (70 DAS) was the suitable option to attain highest maize fodder yield.

**Keywords:** Dry matter percentage, nitrogen rates, quality attributes, maize fodder yield, harvest date

## INTRODUCTION

In Pakistan, maize crop is an important cereal crop belonging to family poaceae thrives best in tropical regions with mild summers. Its importance arises both because of its higher biological efficiency and because it can be grown over an extremely wide environmental range. It is very important as food for human beings, animals and also provides raw material for many agro-based industries (Abuzar *et al.*, 2011; Memon *et al.*, 2011; Maqsood *et al.*, 2012). It was grown on an area of 1083 thousands hectares and annual production of 4271 thousands tones with 15.20 percent increase in production compared to preceding year (GOP, 2012).

The importance of fodder crops in agriculture needs no emphasis because of the fact that a regular, an adequate and nutritious fodder is the basic requirement for livestock production to meet the demand of milk, butter and other by-products for the human consumption. About two third of the total world production of maize is used for livestock feed or for commercial starch and oil production and also has a great nutritional value as 66.7 percent starch, 10 percent protein, 4.8 percent oil, 8.5 percent fiber, 3 percent sugar and 7 percent ash (Noor *et al.*, 2010). Regarding cash crop for growers, it is widely grown for sale as green fodder. Significant variations exist for nutritional quality attributes of its stover and whole plant forage in maize. Differences in the rate of dry matter accumulation in different parts of the plant are related to changes in morphological structure as peak yield of green herbage occurs at the beginning of the milky ripeness (Mehdi and Ahsan, 2000).

Its fodder yield per unit area is alarmingly low when compared to the biological potential of the existing maize varieties. The fodder yield potential of Pakistani varieties is fairly high but it is not being completely exploited from farmers due to some management constraints as well as many agronomic, edaphic and environmental factors. The climatic conditions and existing varieties in Pakistan are highly favorable for increasing fodder maize production, but poor nutrient management and harvesting time are fundamentals to reach the highest potential (Ayub *et al.*, 2002; Mohamed, 2010). Hence, to improve yield and quality of maize fodder, it is indispensable to decide its nitrogen requirement as the application of nitrogen not only affects the forage yield of maize but also improve its quality especially its protein contents. Application of nitrogen to maize increases the fodder nutrition value by increasing the crude protein and by reducing the ash and fiber contents. Nitrogen has a dominant role in plant physiology as it is an integral part of protoplasm, chlorophyll, proteins, enzymes, amino acids and nucleic acids. Leaf emergence, thickness, branching, tillering, flowering, fruit setting, root development and extension are triggered by nitrogen application. Increasing nitrogen fertilization rates led to a significant increase in ear length, number of kernel per rows, ear weight and grain yield (Abbas *et al*., 2005; Patel *et al*., 2006). Increase in fodder yield was mainly due to increased crop growth rate, leaf area index, net assimilation rate, plant height, leaves per plant and stem diameter. Harvesting time is another important factor, which greatly influences the yield and quality of fodder crops. The optimum harvesting time increased the yield and the crude protein contents with increasing nitrogen rates while delayed harvesting decreased the protein contents. Harvesting date affects whole maize plant and its leaf and stem fractions, digestibility, neutral detergent fiber, acid detergent fiber cellulose, hemi cellulose and lignin (Shehzad *et al.*, 2012). Therefore, the present study was planned to optimize the nitrogen nutrition levels and harvsting time for maximizing the fodder yield and nutritive value of maize under semi arid environment.

## MATERIALS AND METHODS

The planned study to compare the fodder yield and quality of maize at different nitrogen input rates and harvesting times was carried out at the Agronomic Research Area, University of Agriculture, Faisalabad, Pakistan during the year 2011. The experimental site was situated by 73° 06′ E, $31^0$ 26′ N and at altitude of 184.4m above sea level with semi-arid climate. Prior to sowing, the experimental soil was analyzed for their physico-chemical characteristics (Homer and Pratt, 1961). A composite and representative soil sample to a depth of 30 cm was obtained with soil auger prior to sowing of maize crop. Analysis revealed that soil was sandy clay loam (sand 48.95%, silt 30.56% and clay 25.65%) with pH 7.6, 0.85% organic matter, 9.1 cmolc $kg^{-1}$ cation exchange capacity (CEC), 1.79 dS $m^{-1}$ electrical conductivity (EC), 7.86 $(mmol\ L^{-1})^{1/2}$ SAR, 30% saturation percentage, 0.062% totals nitrogen, 13.1 ppm phosphorus and 179 ppm potassium. Seasonal rainfall, relative humidity, prevailing air temperature (min. and max.), sunshine and wind speed were recorded from meteorological observatory in the immediate vicinity of the field during the crop phase of crop growth and development (Table 1).

The experiment was planned in a randomized complete block design (RCBD) with factorial arrangement with three replicates having a net plot size 3.0m × 5.0m comprising of 10 rows per plot. The treatments comprised of Nitrogen levels [$N_1$= 50; $N_2$= 100; $N_3$= 150 (kg $ha^{-1}$)] and Harvesting dates [$H_1$= 50; $H_2$= 60; $H_3$= 70 days after sowing (DAS)]. Maize crop (Neelum) was sown with single row hand drill in 30 cm spaced rows using a seed rate 120 kg $ha^{-1}$, on August, 2011. Whole of the phosphorus was applied at the time of sowing in the form of DAP at the rate of 60 kg $ha^{-1}$. The half of the nitrogen was applied at the time of sowing and the remaining half of the nitrogen was applied at knee height. The crop was thinned out at 3-4 leaf stage in order to maintain the optimum plant population. All other agronomic practices were kept normal and uniform for all treatments except harvesting times. The crop was harvested first time on September 28, 2010 and kept in the respective plots for sun drying. The cobs were removed from the dry stalks, unsheathed and threshed mechanically with the help of corn sheller.

Observations on plant height (cm), stem diameter (cm), leaf area $plant^{-1}$ ($cm^2$), dry matter (%), dry matter yield (t $ha^{-1}$), green fodder yield (t $ha^{-1}$), crude fat (%), crude protein (%), crude fiber (%) and ash contents (%) were recorded at each harvesting by using standard methods during the course of study.

**Procedures for recording quality parameters**

***Ether extractable fat (%):*** Took 1.0 g of oven dried plant sample in extraction thimble and plug it with cotton. Placed the thimble in souxhleth (extraction apparatus) consisting of three major parts (condenser, jacket containing the sample and flask). Put ether in flask (250ml or 500 ml flask) and connected condenser in inlet and outlet water tube. Place flask on heater hot plate to avoid direct heating. Ether in the flask evaporated at 40-60 °C and vapors moved to condenser and condensed there to form ether that felon the sample in the jacket. Ether after extracting fat from the sample fell in the flask through siphon tube. This process continued for 6-8 hours until whole of the fat was extracted then detached the flask put the mixture (ether fat) in reweighed beaker ($W_1$) and placed in oven. Ether evaporated and fat was left over.

$W_1$= weight of empty beaker

$W_2$= weight of beaker + fat

$W_3$= $W_2$ - $W_1$= weight of pure fat

From 1.0 g sample of dried plant material fat % age was calculated as

**Table 1. Weather data of the experimental site during the year 2011**

| Month | Rainfall (mm) | R.H (%) | Temp mini. (°C) | Temp maxi. (°C) | Sunshine (hours) | Wind speed (Km/h) |
|---|---|---|---|---|---|---|
| July | 24 | 13 | 26 | 35 | 12.50 | 05.0 |
| August | 18 | 14 | 25 | 34 | 13.50 | 09.0 |
| September | 31 | 15 | 23 | 32 | 14.00 | 07.0 |
| October | 12 | 9 | 21 | 29 | 12.00 | 04.0 |

Ether extractable fat (%) = $W_3$/ Sample weight (1.0g) × 100

***Crude protein (%):*** Took 1.0 g of oven dried plant material 30 ml of concentrated $H_2So_4$ and 5 g digestion mixture [$K_2So_4$; $CuSo_4$; $FeSo_4$ (100g; 10g; 5g)] was added and then digested the material on the gas heater in Kjeldhal digestion flask, cooled it and made up the volume to 100 ml. 10ml aliquot was taken form this for distillation. Nitrogen evolved as ammonia was collected in a receiver containing boric acid (2%) solution and mixed indicator (Bromocresol green and methyl red) and titrated against standard (0.1N) $H_2So_4$. The reading obtained after titration against $H_2SO_4$ was then multiplied by 6.25 to get crude protein percentage.

% N = Vol. of N/10 $H_2So_4$ used × 0.0014 × 250 × 100 / Weight of sample × 10

Crude protein (%) = % N × 6.25

***Crude fiber (%):*** The 1.0 g of oven dried plant material in 250 ml beaker added 1.25% $H_2SO_4$ and distilled water and made up the volume to 200 ml. then placed it on flame for 30 minutes. Filtered and washed. Then again added 1.25% Noah and distilled water and made up the volume to 200 ml. Heated again, filtered and washed put the sample in crucible and it was placed in oven at 10 $^oC$ for 24 hours. When well dried, weighed ($W_1$) and placed the crucible on flame and ignited. When smoke disappeared place it in muffle furnace at 600 $^oC$ till grey or white ash was obtained. Then cooled it and weighed ($W_2$) was recorded. The crude fiber percentage was calculated as;

Crude fibre (%) = $W_2$ - $W_1$/ Sample weight × 100

***Ash contents (%):*** Weighed the empty dry crucible $W_1$ and put 1.0 g of oven dried sample in crucible and then placed it in muffle furnace and heated at 600 $^oC$ for one hour, cooled and reweighed ($W_2$).

Ash (%) = $W_2$ - $W_1$/ Sample weight × 100

***Statistical analysis:*** The data collected were analyzed statistically by using the Fisher's analysis of variance techniques and Least Significant Difference (LSD) test at 5% probability level was employed to compare the significance of treatments' means (Steel *et al.*, 1997).

## RESULTS AND DISCUSSION

***Growth and yield parameters:*** The statistical results about growth and yield traits are shown in Table 2-8 as significant increase in plant height was represented at each increased rate of nitrogen fertilizer ($P \leq 0.05$). The plots receiving nitrogen (150 kg $ha^{-1}$) produced significantly taller plants (179.40 cm) as compared to all other nitrogen rates. The minimum (167.59 cm) plant height was obtained when nitrogen was applied at 50 kg $ha^{-1}$. According to the results nitrogen application had marked effect in increasing vegetative growth of crop plants. Mahmood *et al*., (1994); Khan *et al*., (1999) also reported that increment in plant height of maize plants was observed with nitrogen supply. Harvesting dates also prominently affected the plant height as the plots harvested at 70 DAS produced significantly taller (203.90 cm) plants compared to other treated plots. The minimum plant height (153.65 cm) was observed in plots harvested at 50 DAS. The non significant difference between nitrogen rates and harvest date was recorded due to interaction effect. An increase in plant height with delayed harvesting has also been reported by (Musa *et al*., 1993).

A significant increase in stem thickness was observed at each increased rate of nitrogen fertilizer ($P \leq 0.05$). The plot receiving nitrogen at the rate of 150 kg $ha^{-1}$ produced significantly thicker stems (3.59 cm) than all other nitrogen levels. The minimum stem thickness (2.89 cm) was obtained when nitrogen was applied at the rate of 50 kg $ha^{-1}$. These results are also supported by Ahmad, (1999); Ali *et al*., (2000). Among the harvesting dates, plots harvested 70 DAS produced significantly thicker stem (4.30 cm) than other treatment. The minimum stem thickness (2.49 cm) was obtained in plots harvested at 50 DAS. These results are quite in agreement with the findings of Siddique *et al*., (1989). The interaction study reported that maximum stem diameter (5.11 cm) was attained with $N_3 \times H_3$ (150 kg N $ha^{-1}$ × harvesting 70 DAS) compared to all other treatments. Maximum (3755 $cm^2$) and minimum (3473 $cm^2$) leaf area $plant^{-1}$ was acquired with the application of 150 and 50 kg N

**Table 2. The mean squares of nitrogen nutrition and harvest time treatments on yield and quality parameters of maize**

| SOV | df | Mean squares | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **P.H** | **S.D** | **L.A/P** | **D.M** | **D.M.Y** | **G.F.Y** | **C.F** | **C.P** | **C.Fr** | **A.C** |
| **Replications (r)** | 2 | 44.97 | 0.15 | 510256.04 | 0.11 | 0.99 | 158.23 | 0.59 | 0.08 | 0.11 | 0.14 |
| **Nitrogen (N)** | 2 | $319.28^{**}$ | $0.56^{**}$ | $225014.11^{**}$ | $20.18^{**}$ | $33.45^{**}$ | $71.09^{**}$ | $3.32^{**}$ | $5.99^{**}$ | $35.89^{**}$ | $9.46^{**}$ |
| **Harvest date (H)** | 2 | $6826.50^{**}$ | $0.36^{**}$ | $668463.41^{**}$ | $131.24^{**}$ | $76.38^{**}$ | $927.58^{**}$ | $1.86^{**}$ | $32.76^{**}$ | $39.35^{**}$ | $12.99^{**}$ |
| **N × H** | 4 | $15.28^{NS}$ | 0.04 | 13578.25 | $0.19^{NS}$ | $1.87^{**}$ | $6.56^{**}$ | $0.29^{**}$ | $0.11^{NS}$ | $0.98^{**}$ | $0.49^{**}$ |
| **Error** | 16 | 14.63 | 0.02 | 5103.85 | 0.06 | 0.03 | 1.38 | 0.02 | 0.07 | 0.04 | 0.02 |
| **Total** | 26 | | | | | | | | | | |

***Abbreviations:*** *P.H (plant height), S.D (Stem diameter), L.A/P (leaf area per plant), D.M (dry matter), D.M.Y (dry matter yield), G.F.Y (green fodder yield); Any two means not sharing a letter differ significantly at ($P \leq 0.05$); $^{**}$ Indicates the significance at ($P \leq 0.05$); $^{NS}$ Non-significant* ha$^{-1}$ respectively. These results are quite similar with the findings of (El-Hattab, *et al*., 1980). The plots harvested after 70 DAS produced significantly more leaf area (4231 cm$^2$) than other harvesting dates, minimum leaf area (3467 cm$^2$) was observed when crop was harvested 50 DAS. The highest leaf area plant$^{-1}$ (4108 cm$^2$) was recorded from the interaction of $N_3 \times H_3$ (150 kg N ha$^{-1}$ × harvesting 70 DAS) contrast to all other treated plots.

**Table 3. Effect of nitrogen fertilization rate and harvest time treatments on plant height of maize**

| Harvest date | Nitrogen | | | Means |
|---|---|---|---|---|
| | $N_1$ | $N_2$ | $N_3$ | |
| $H_1$ | 151.32 | 151.00 | 158.63 | 153.65 c |
| $H_2$ | 157.24 | 162.20 | 167.73 | 162.39 b |
| $H_3$ | 194.21 | 205.63 | 211.86 | 203.90 a |
| **Means** | 167.59 c | 172.94 b | 179.40 a | |

$LSD_{0.05}$ for nitrogen = 3.35
$LSD_{0.05}$ for harvest date = 4.58
$LSD_{0.05}$ for nitrogen × harvest date = NS
Any two means in their respective group sharing no common letter(s) are significant ($P \leq 0.05$)

**Table 4. Effect of nitrogen fertilization rate and harvest time treatments on stem diameter of maize**

| Harvest date | Nitrogen | | | Means |
|---|---|---|---|---|
| | $N_1$ | $N_2$ | $N_3$ | |
| $H_1$ | 2.43 g | 2.37 fg | 2.67 e | 2.49 c |
| $H_2$ | 2.48 g | 2.51 ef | 3.01 d | 2.66 b |
| $H_3$ | 3.78 c | 4.02 b | 5.11 a | 4.30 a |
| **Means** | 2.89 c | 2.96 b | 3.59 a | |

$LSD_{0.05}$ for nitrogen = 0.11
$LSD_{0.05}$ for harvest date = 0.13
$LSD_{0.05}$ for nitrogen × harvest date = 0.19
Any two means in their respective group sharing no common letter(s) are significant ($P \leq 0.05$)

**Table 5. Effect of nitrogen fertilization rate and harvest time treatments on leaf area/plant of maize**

| Harvest date | Nitrogen | | | Means |
|---|---|---|---|---|
| | $N_1$ | $N_2$ | $N_3$ | |
| $H_1$ | 3222 f | 3368 ef | 3245 de | 3278 c |
| $H_2$ | 3528 d | 3458 c | 3914 b | 3633 b |
| $H_3$ | 3671 c | 3774 b | 4108 a | 3851 a |
| **Means** | 3473 c | 3533 b | 3755 a | |

$LSD_{0.05}$ for nitrogen = 75.24
$LSD_{0.05}$ for harvest date = 69.95
$LSD_{0.05}$ for nitrogen × harvest date = 124.11
Any two means in their respective group sharing no common letter(s) are significant ($P \leq 0.05$)

**Table 6. Effect of nitrogen fertilization rate and harvest time treatments on dry matter of maize**

| Harvest date | Nitrogen | | | Means |
|---|---|---|---|---|
| | $N_1$ | $N_2$ | $N_3$ | |
| $H_1$ | 29.61 | 27.79 | 29.57 | 28.99 c |
| $H_2$ | 32.94 | 34.72 | 33.65 | 33.77 b |
| $H_3$ | 31.19 | 34.64 | 37.11 | 34.31 a |
| **Means** | 31.24 c | 32.38 b | 33.44 a | |

$LSD_{0.05}$ for nitrogen = 0.23
$LSD_{0.05}$ for harvest date = 0.34
$LSD_{0.05}$ for nitrogen × harvest date = NS
Any two means in their respective group sharing no common letter(s) are significant ($P \leq 0.05$)

**Table 7. Effect of nitrogen fertilization rate and harvest time treatments on dry matter yield of maize**

| Harvest date | Nitrogen | | | Means |
|---|---|---|---|---|
| | $N_1$ | $N_2$ | $N_3$ | |
| $H_1$ | 8.57 g | 10.35 f | 14.24 e | 11.05 c |
| $H_2$ | 12.89 f | 15.44 d | 17.45 b | 15.26 b |
| $H_3$ | 14.78 c | 16.99 b | 21.35 a | 17.71 a |
| **Means** | 12.08 c | 14.26 b | 17.68 a | |

$LSD_{0.05}$ for nitrogen = 0.05
$LSD_{0.05}$ for harvest date = 0.13
$LSD_{0.05}$ for nitrogen × harvest date = 0.21
Any two means in their respective group sharing no common letter(s) are significant ($P \leq 0.05$)

**Table 8. Effect of nitrogen fertilization rate and harvest time treatments on green fodder yield of maize**

| Harvest date | Nitrogen | | | Means |
|---|---|---|---|---|
| | $N_1$ | $N_2$ | $N_3$ | |
| $H_1$ | 55.19 h | 59.27 g | 60.24 g | 58.23 c |
| $H_2$ | 61.83 f | 66.85 e | 69.84 d | 66.17 b |
| $H_3$ | 73.85 c | 77.82 b | 83.87 a | 78.51 a |
| **Means** | 63.62 c | 67.98 b | 71.32 a | |

$LSD_{0.05}$ for nitrogen = 1.04
$LSD_{0.05}$ for harvest date = 1.38
$LSD_{0.05}$ for nitrogen × harvest date = 2.01
Any two means in their respective group sharing no common letter(s) are significant ($P \leq 0.05$)

The dry matter percentage was affected significantly with the supply of nitrogen and harvest time as significantly was increased with increased nitrogen rates. The increase in dry matter percentage could reach a significant level ($P \leq 0.05$) from 50-100 kg N ha$^{-1}$. The highest dry matter percentage (33.44%) was attained when fertilized with 150 kg ha$^{-1}$ nitrogen rate. An increase in dry matter percentage with nitrogen application has also been reported by Jain and Goel, (1980). Dry matter percentage was also increased significantly with the advancement in maturity and all harvesting dates differed significantly from each other. The plots that were harvested after 70 DAS and 50 DAS showed minimum to maximum (28.99%; 34.31%) dry matter percentage, respectively. These results are similar with the previous findings of Hsu *et al*., (1987). The combined effect between nitrogen fertilization rate and harvest date did not reach the level of significant ($P \leq 0.05$).

The maximum dry matter yield (17.68 t $ha^{-1}$) was obtained from plots when feeding with 150 kg N $ha^{-1}$ and the plots receiving nitrogen at the rate of 50 kg N $ha^{-1}$ gave lowest dry matter yield (12.08 t $ha^{-1}$). The significant effect of nitrogen application on dry matter yield had also been reported by Khan *et al*., (1999). Dry matter yield was also affected significantly by harvesting date and all harvesting dates differed significantly from each other. The maximum dry matte yield (17.71 t $ha^{-1}$) was recorded in plots harvested after 70 DAS. The minimum dry matter yield (11.05 t $ha^{-1}$) was obtained from plots harvested 50 DAS. At first (50 DAS) and second (60 DAS), the application of 100 and 50 kg N $ha^{-1}$ have statistically similar dry matter yield. Maximum dry matter yield (21.35 t $ha^{-1}$) was observed at third harvest (70 DAS) with the supply of 150 kg N $ha^{-1}$ under interaction study. The plots receiving nitrogen (150 kg $ha^{-1}$) provided significantly highest yield (71.32 t $ha^{-1}$) following the application of 100 kg N $ha^{-1}$ in descending order which produced yield of 67.98 t $ha^{-1}$. The minimum green fodder yield (63.62 t $ha^{-1}$) was recorded in plots receiving nitrogen at the rate of 50 kg $ha^{-1}$. The increase in yield with nitrogen application was mainly due to higher number of leaves $plant^{-1}$, stem diameter and plant height (Bakht, *et al*., 1989). Among harvesting dates plots harvested at 70 DAS produced significantly ($P \leq 0.05$) higher green fodder yield (78.51 t $ha^{-1}$) than other harvesting times. Plots harvested 50 DAS gave minimum green fodder yield (58.23 t $ha^{-1}$) as increase in green fodder yield with delayed harvesting. Combined effect of nitrogen and harvesting also prominent as the maximum green fodder yield (83.87 t $ha^{-1}$) was acquired from $N_3 \times H_3$ (150 kg N $ha^{-1}$ × harvesting 70 DAS) treatments contrast to other combinations. These results are in strong agreement with the conclusions of Begna *et al*., (2000); Ahmed *et al*., (2001).

***Quality traits:*** Plots receiving nitrogen at 150 kg $ha^{-1}$ gave significantly higher crude fat percentage (3.09%) than all other nitrogen levels and it was followed by 100 kg N $ha^{-1}$ in downward order which provided crude fat percentage of (2.57%). The minimum extractable fat percentage (2.29%) was recorded in plots fertilized with 50 kg N $ha^{-1}$. The extractable fat concentration was decreased significantly ($P \leq 0.05$) with the improvement in maturity and by differing all harvests form one ant another. The maximum (3.17%) and minimum (2.25%) extractable fat percentage were noted when crop was harvested 50 DAS and 70 DAS, correspondingly. A significant interaction has been found between nitrogen and harvest time as maximum crude fat (4.02%) was reported with $N_3 \times H_1$ (150 kg N $ha^{-1}$ × harvesting at 50 DAS) treatments (Table 9). Significant effects of nitrogen application on crude fat of maize fodder have also been reported by Vindis *et al.*, (2010).

**Table 9. Effect of nitrogen fertilization rate and harvest time treatments on crude fat of maize**

| Harvest date | Nitrogen | | | Means |
|---|---|---|---|---|
| | $N_1$ | $N_2$ | $N_3$ | |
| $H_1$ | 2.57 cd | 2.92 b | 4.02 a | 3.17 a |
| $H_2$ | 2.40 fg | 2.41 de | 2.79 bc | 2.53 b |
| $H_3$ | 1.91 h | 2.38 g | 2.47 ef | 2.25 c |
| **Means** | 2.29 c | 2.57 b | 3.09 a | |

$LSD_{0.05}$ for nitrogen = 0.11
$LSD_{0.05}$ for harvest date = 0.11
$LSD_{0.05}$ for nitrogen × harvest date = 0.14
Any two means in their respective group sharing no common letter(s) are significant ($P \leq 0.05$)

The application of nitrogen at 150 kg $ha^{-1}$ gave maximum crude protein content (11.48%) than nitrogen level of 50 kg $ha^{-1}$ (10.17%). The increased in crude protein content with increase in nitrogen rate might be due to the reason that nitrogen application has enhanced the amino acid formation. Crude protein content was decreased significantly with delayed harvesting date as maximum (12.36%) and minimum (9.14%) crude protein contents were noted when crop was harvested 50 DAS and 70 DAS, respectively. The combined effect between seeding density and cultivars was found to be not significant ($P \leq 0.05$) (Table 10).

**Table 10. Effect of nitrogen fertilization rate and harvest time treatments on crude protein of maize**

| Harvest date | Nitrogen | | | Means |
|---|---|---|---|---|
| | $N_1$ | $N_2$ | $N_3$ | |
| $H_1$ | 11.64 | 12.59 | 12.87 | 12.36 a |
| $H_2$ | 9.81 | 10.47 | 11.32 | 10.53 b |
| $H_3$ | 9.07 | 8.11 | 10.25 | 9.14 c |
| **Means** | 10.17 c | 10.39 b | 11.48 a | |

$LSD_{0.05}$ for nitrogen = 0.37
$LSD_{0.05}$ for harvest date = 0.36
$LSD_{0.05}$ for nitrogen × harvest date = NS
Any two means in their respective group sharing no common letter(s) are significant ($P \leq 0.05$)

An increase in crude protein content of maize fodder with nitrogen application and decrease with delayed harvesting has also been reported by Shanghoon and Dongam, (1996); Ali *et al*., (1999). Nitrogen input at 150 kg $ha^{-1}$ gave significantly higher crude fiber percentage (34.21%) than all other nitrogen levels and it was followed by 100 kg N $ha^{-1}$ which gave a crude fiber percentage of (31.87%). The minimum crude fiber percentage (28.27%) was recorded in plots fertilized at the rate of 50 kg N $ha^{-1}$. The crude fiber contents were increased significantly with delayed harvesting time as minimum and maximum (29.06%; (33.97%) fiber content were noted when crop was harvested 50 DAS and 70 DAS, respectively (Table 11). The interactive study was also significant as maximum crude fibre contents were achieved in response to $N_3 \times H_1$ (150 kg N ha$^{-1}$ × harvesting 50 DAS) treatments parallel to other treatment combinations. These results are in agreement with Agath *et al*., (1997).

**Table 11. Effect of nitrogen fertilization rate and harvest time treatments on crude fiber of maize**

| Harvest date | Nitrogen | | | Means |
|---|---|---|---|---|
| | $N_1$ | $N_2$ | $N_3$ | |
| $H_1$ | 25.48 h | 29.91 f | 31.81 e | 29.06 c |
| $H_2$ | 28.51 g | 31.84 d | 33.61 c | 31.32 b |
| $H_3$ | 30.84 e | 33.87 b | 37.21 a | 33.97 a |
| **Means** | 28.27 c | 31.87 b | 34.21 a | |

$LSD_{0.05}$ for nitrogen = 0.29
$LSD_{0.05}$ for harvest date = 0.27
$LSD_{0.05}$ for nitrogen × harvest date = 0.37
Any two means in their respective group sharing no common letter(s) are significant ($P \leq 0.05$)

**Table 12. Effect of nitrogen fertilization rate and harvest time treatments on ash content of maize**

| Harvest date | Nitrogen | | | Means |
|---|---|---|---|---|
| | $N_1$ | $N_2$ | $N_3$ | |
| $H_1$ | 9.57 e | 12.76 b | 10.07 a | 10.80 a |
| $H_2$ | 7.76 f | 10.24 d | 11.28 c | 9.76 b |
| $H_3$ | 8.95 g | 9.01 f | 9.17 e | 9.04 c |
| **Means** | 8.76 c | 10.67 a | 10.17 b | |

$LSD_{0.05}$ for nitrogen = 0.22
$LSD_{0.05}$ for harvest date = 0.17
$LSD_{0.05}$ for nitrogen × harvest date = 0.23
Any two means in their respective group sharing no common letter(s) are significant ($P \leq 0.05$)

Nitrogen supply at 100 kg ha$^{-1}$ gave significantly higher ether ash content (10.67%) than all other nitrogen levels which were followed by 150 kg N ha$^{-1}$ that gave ash content of (10.17%). The minimum ash percentage (8.76%) was recorded in plots fertilized with 50 kg N ha$^{-1}$. Significant effect of nitrogen application on ash percentage has also been described by Safdar, (1997). Ash contents were also influenced significantly by the harvesting times as the ash contents were decreased significantly with the progress in maturity and all harvests differed significantly from one another. The higher (10.80%) and lower (9.04%) ash contents were noted when crop was harvested 50 DAS and 70 DAS. In combined study, the maximum ash percentage (10.07%) was observed when nitrogen was fertilized at 150 kg N ha$^{-1}$ and harvested 50 DAS. The minimum ash percentage (7.76%) was noted from plots receiving nitrogen at the rate of 50 kg ha$^{-1}$ and harvested 70 DAS (Table 12). These results are in parallel with Gonent and Stadejek, (1992).

***Conclusions:*** In conclusion, the yield and quality constraints were improved with increased nitrogen rates and by delayed harvesting time but quality attributes except crude fiber was decreased with late harvesting. However, the maize can perform best when fertilized with 150 kg N ha$^{-1}$ and harvesting at 70 DAS.

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