Research Article

Effects of Nitrogen Fertilization Rates on Growth, Quality and Economic Return of Fodder Maize (*Zea mays* L.)

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Abstract | A field trial was conducted to determine the effect of nitrogen fertilizer on forage production and quality and economic return of fodder maize cultivar Kissan. The experiment was conducted on silt loam soil at Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan during 2011. Six nitrogen treatments (80, 120, 160, 200, 240 and 280 kg ha^{-1}) and a control one were studied in this trial. Growth and yield traits and quality such as plant height, stem diameter, leaf area plant^{-1}, leaf area index, chlorophyll content, green fodder yield, dry matter yield, crude protein, crude fiber and ash percentage were significantly increased with increase nitrogen levels (200, 240, and 280 kg N ha^{-1}). However, highest benefit-cost ratio was estimated when 240 kg N ha^{-1} was applied which was found best compromise between forage yield and quality for maize cultivar Kissan under the agro-climatic conditions of Dera Ismail Khan, Pakistan. The study also indicates that crude protein and mineral content in fodder maize can be improved through N application and complete reliance on protein and mineral supplements for farm livestock can be reduced.

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Introduction

Most farm animals (cattle, cow, buffalo, lamb, sheep, goat) feed is from plants which can be taken as fodder/silage (refers particularly to food given to the animals, including plants cut and carried to them) or which they forage for themselves (mainly plant leaves and stems eaten by grazing livestock). Fodder feed also includes fodder maize, hay, straw, silage, compressed and pelleted feeds, oils and mixed rations, sprouted grains and legumes. Fodder maize used for silage is harvested while the plant is green and the fruit (cob) immature (Boller et al., 2010; Meehan and Gilliland, 2013). Fodder maize is extensively grown in temperate, subtropical and tropical regions of Pakistan (10.85 M ha) to fulfil forage and silage need of farm animals with an annual production of 46.31 M tonnes (FAOSTAT, 2012). However, a declined trend of total global production of fodder maize is noticed between year 2000 to 2010 (9494800 and 9188130 metric tonnes, respectively) (GeoHive, 2013). Today the bulk of fodder maize production occurs in the USA, China and Brazil. In the more northerly climates like that of the northern regions of Pakistan including Azad Jammu Kashmir where there is insufficient summer warmth to ripen the crop, maize is grown largely for forage. It has, therefore, become an important crop being the most important forage after grass. It is hence directly feed to farm animals as fresh or is ensiled to produce a quality, high-energy silage that complements grass silage for the winter feeding of livestock (Rasheed and Mehmood, 2004).

Fodder maize is relatively easy to grow and being drought tolerant is a consistent provider of high yields with minimum input from the farmer. From a practical point of view, forage maize also enhanced the silage making season as it is ensiled in September or October, long after most grass silage making has finished. Forage maize produces palatable silage that livestock like but which also produces much less effluent than grass. For farmers near watercourses this significantly reduces the environmental risks of effluent pollution (Yeates and Simpson, 2010). High quality maize silage is rich in starch for finishing cattle has no equal as a forage source. Typical analysis of good quality maize silage is 28-32% dry matter, 11-11.5 MJ ME kg^{-1} DM, 28-32% starch and 7-9% crude protein (Giggins, 2013). As all energy feeds are projected to remain high in price for the foreseeable future, growing a crop that produces forage of this quality and at high yields continues to make a lot of sense. This type of maize silage is replacing up to 30% of the concentrate requirement of a typical finishing animal. One hectare of maize that achieves the yield of 50t/ha can supply the forage component in the diet of 25 finish animals (Eltelib et al., 2006).

Optimum supply of plant nutrients is always imperative for better growth and development of a crop. However, yield and quality parameters are greatly affected by inadequate availability of plant nutrients. Low yield of fodder maize is due to many constraints but NPK fertilizer application is one of the major factors (Witt et al., 2008). Nitrogen is a component of protoplasm, proteins, nucleic acids, chlorophyll and plays a vital role in vegetative and reproductive phases of crop growth. Higher nitrogen levels are reported to increase plant height, stem thickness, leaf area, leaf area index, dry matter accumulation; net assimilates ratio and yield per hectares (Cheema et al., 2010). Similarly, fodder maize cultivar Akbar received high nitrogen through fertigation produced maximum stem diameter, leaf area index, green fodder yield and total dry matter (Hassan et al., 2010; Iqbal et al., 2006). Reddy and Bhanumurty (2010) reported that applying 240 kg N ha^{-1} gave significantly higher green fodder yield, dry matter yield and crude protein. Similar findings were obtained by Almodares et al. (2009) who reported that fodder maize biomass and crude protein increased with increase in N content. High forage and dry matter yield of maize cultivars LG 2687, PR34N43 and H 2547 was obtained by the application of 300 kg ha^{-1} N (Karasu et al., 2009). Similarly, Amanullah et al. (2009) concluded that growing maize cultivar Azam at higher N rate in four to five splits can increase leaf area and plant height which consequently maximized biomass yield. In a similar study, Nadeem et al. (2009) observed that the growth characteristics of maize cultivar Afgooi (plant height, number of leaves per plant, stem diameter and leaf area) and crude protein were influenced significantly by increasing nitrogen levels. Similarly, Ayub et al. (2003) reported that higher nitrogen application significantly increased plant height, leaf area $plant^{-1}$, leaf number, stem diameter, green fodder yield, dry matter, crude protein, crude fiber and total ash percent. Keeping in view the importance of nitrogen for economical return, an experiment was designed to determine the effect of different levels of nitrogen on fodder maize yield and quality under the agro-climatic conditions of Dera Ismail Khan, Pakistan.

Materials and Methods

Field experiment was conducted at Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan during spring 2011 on silt loam soil (Alfisols, USDA soil classification) to evaluate the impact of nitrogen doses on growth, yield, quality and optimum economic return of fodder maize. The experiment was laid out on randomized complete block design having three replications with a net plot size of 3 m × 5 m (15 m^2). The detail of treatments is given below:

Treatments	**N (kg ha^{-1})**
T_1	Control (no fertilizer)
T_2	80
T_3	120
T_4	160
T_5	200
T_6	240
T_7	280

Recommended dose of phosphorus (80 kg ha^{-1}) was applied at the time of sowing while nitrogen was applied in three equal splits such as first dose was applied sowing time, second dose was applied 20 days after sowing (DAS) and third dose 40 DAS. All cultural and agronomic practices (hoeing, weeding, irrigation and insect management) were followed accordingly. As soon as the land came in *watter* (workable) condition, it was given 3-4 ploughings (disc plough, cultivator and rotavator). After seed bed preparation, seeds (100 kg ha^{-1}) of approved fodder maize cultivar

Kissan were sown manually with hand driven drill on 12 February and 30 cm distance was kept between rows while plant to plant distance was maintained at 5 cm to obtain a vigorous maize fodder crop. Plants received six irrigations throughout the growing season by canal water up to 30 cm root zone depth. The environmental detail is as under (Table 1).

Table 1: *Environmental detail of the experiment*

Growing Season	Mean Diurnal Temperature (°C)			Relative Humidity	Rainfall
	Min	Max	Average	(%)	mm
February	6.03	21.10	13.57	67	29.0
March	11.12	28.19	19.66	66	5.5
April	16.47	34.15	25.31	52	11.5

Min=Minimum; Max= Maximum

Data collection procedure for the following parameters is as under:

Plant Height

On 29 April 2011 (75 DAS), 10 plants were selected randomly from each plot at harvest and their height was measured from the soil surface to the tip of panicle with the help of a measuring tape and average height was calculated in cm.

Leaf Area Plant^{-1}

At harvest (75 DAS), 10 plants were selected randomly from each plot and their average leaf area was calculated in cm by measuring the length and breadth of each leaf and multiplied by the factor 0.75 to adjust the error.

$$Leaf\ area = (leaf\ length \times leaf\ breath) \times 0.75$$

Leaf Area Index

Leaf area per square meter was estimated as mentioned above at harvest (75 DAS) and was divided over one meter ground area to calculate leaf area index (LAI):

$$LAI = Leaf\ area / Ground\ area$$

Chlorophyll Content

The chlorophyll meter Minolta SPAD-502 (Konica Minolta Inc., Japan) was calibrated using calibration filter to produce a meter reading of 87.1 before estimating chlorophyll content. At harvest (75 DAS), representative samples of 10 plants were selected randomly from each plot and the chlorophyll content was estimated from the upper most leaf which covered 2 × 3 mm leaf area and the average was calculated.

Stem Diameter

At harvest (75 DAS), stem diameter of 10 selected randomly plants from each plot was measured by Venire Calliper at three positions (bottom, middle, and upper portion of the stalk). The jaws of the Venire Calliper were positioned on both sides of the stem and were pushed firmly. The clamp screw of calliper was locked so that the jaws do not move and the reading on scale was noted. The average stem diameter was then calculated in cm.

Green fodder yield

Maize crop grown for fodder or forage purpose harvested before the cob maturity called as green maize and used as fresh fodder for animals. It is also called as green fodder yield or vegetative yield. To record this parameter, entire plot (15 m^2) of green maize plants harvested on 29 April 2011 (75 DAS) and the green fodder yield was estimated with the help of manual spring balance (Toolzone, Thornton, CO, USA) and then it was converted to tonnes ha^{-1} using following formula:

$$Green\ fodder\ yield\ (t\ ha^{-1}) = (Green\ plants\ yield\ per\ plot\ (kg) \times 10{,}000)/(Plot\ size\ (m^2) \times 1{,}000)$$

Dry Matter Yield

Maize crop grown for silage purpose dried under sun and used in autumn or winter when there is limited availability of plant-based food for animals, is called as dry matter yield. After recording green maize yield, plants of each plot were sun dried in the field for 15 days (from 29 April to 14 May 2011) and then the dried plants weighed with the help of manual spring balance (Toolzone, Thornton, CO, USA). The data were converted in to dry matter yield in tonnes ha^{-1} using following formula:

$$Dry\ matter\ yield\ (t\ ha^{-1}) = (Sun\ dried\ plants\ yield\ per\ plot\ (kg) \times 10{,}000) / (Plot\ size\ (m^2) \times 1{,}000)$$

Fodder quality parameters such as crude protein, crude fiber and ash percentage were determined at Nuclear Institute for Food and Agriculture, Peshawar, Pakistan on 15 May 2011.

Crude Protein

One gram of oven dried plant material, 30 ml of concentrated H_2SO_4 and 5 g digestion mixture [K_2SO_4 (100g); $CuSO_4$ (10g); $FeSO_4$ (5g)] were added and then digested the material on the gas heater in Kjeldhal digestion flask, cooled it and made up the volume

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to 100 ml. Ten millilitre aliquot was taken from digestion flask 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.

Percent N = (Volume of N/10 H_2SO_4 *used × 0.0014 × 250 × 100) / (Weight of sample × 10)*

$$Crude\ protein\ (\%) = \%\ N \times 6.25$$

Crude Fiber

H_2SO_4 (1.25%) and distilled water was added into a 250 ml beaker containing 1 g of oven dried plant material and made up the volume to 200 ml. It was then placed on flame for 30 minutes, which was then filtered and washed. NaOH (1.25%) and distilled water added to make up the volume to 200 ml. It was heated, filtered and washed. The sample was put into Gooch crucible and was placed in oven at 10°C for 24 hours. Well dried sample was weighed (W_1) and then the crucible was placed on flame and ignited. When smoke disappeared it was placed in muffle furnace at 600°C until grey or white ash was obtained. It was then cooled and weighed (W_2). The crude fiber percentage was calculated as:

$$Crude\ fiber\ (\%) = (W_2 - W_1 / Weight\ of\ sample) \times 100$$

Ash Contents

Empty dried Gooch crucible was weighed (W_1) and 1g of oven dried sample was put in crucible and then it was placed in muffle furnace and heated at 600°C for 1 hour. It was then cooled at room temperature and reweighed (W_2). Ash percentage was calculated as:

$$Ash\ (\%) = (W_2 - W_1 / Weight\ of\ sample) \times 100$$

Data regarding above-mentioned parameters were analysed through analysis of variance technique of MSTATC software, version 1 (Michigan State University, East Lansing, Michigan, USA) and subsequently least significance test (LSD) was applied for comparing and separation of treatment means (Freed, 1988).

Results and Discussion

Data presented in Table 2 indicated that different nitrogen levels have significant (P≤0.05) effects on plant height, stem diameter, leaf area plant^{-1}, leaf area index, chlorophyll content, green fodder yield, dry matter yield, crude protein, crude fiber and ash of fodder maize cultivar Kissan. Maximum plant height (176.60 cm) was obtained when highest N dose (280 kg ha^{-1}) was applied followed by 240 kg ha^{-1} (159.37 cm) and 200 kg ha^{-1} (154.21 cm). However, plant height was minimum (87.04 cm) when no fertilizer was applied followed by minimum (80 kg ha^{-1}) N dose (132.22 cm). The increment in plant height with the rise in N dose indicated that plants used N during active cell division to form building blocks (protein) for cell elongation. Leaf area determines the photosynthetic activity of a crop i.e. large leaf area more assimilates production. It is revealed from the mean data that fodder maize plants received 280 kg ha^{-1} N dose produced maximum leaf area plant^{-1} (332.13 cm^{-2}) followed by 240 kg ha^{-1} N dose (299.67 cm^{-2}) which was decreased to minimum (106.13 cm^{-2}) in control treatment. The enlarged leaf area with increase in N levels could be due to rapid and active cell multiplication within plant leaves resulting larger leaves blades. Like leaf area, LAI was also increased as N level increased. Maximum LAI (1.99) was observed when plants received highest N dose (280 kg ha^{-1}), followed by 240 kg N ha^{-1} (1.80). However, minimum LAI (0.63) was recorded in control treatment. Plants received 80 and 120 kg N ha^{-1} were at par statistically (1.08 and 1.19, respectively). Increase in LAI with increased N levels might be due to more number of leaves produced and maximum leaf area per plant.

Mean data of different treatments indicated that maximum chlorophyll content (42.80) was noted in plants received 200 kg N ha^{-1} followed by 280 kg N ha^{-1} (41.79) and 240 kg N ha^{-1} (41.10). However, minimum chlorophyll content (15.68) was recorded in control treatment followed by 80 kg N ha^{-1} treatments (26.23). While the remaining treatments 120 and 160 kg N ha^{-1} were statistically at par (39.39 and 39.44, respectively). The escalating trend of chlorophyll content with raising N dose indicated better nitrogen up take by the fodder maize plants, resulting more greenish leaves. Similarly, maximum stem diameter (3.8 cm) was recorded in plants received 240 kg N ha^{-1} followed by 280 (3.58 cm) and 200 kg N ha^{-1} (3.48 cm). However, minimum stem diameter (2.1 cm) was recorded in control plants followed by plants received lowest N dose, 80 kg ha^{-1} (2.76 cm). Plants received either 120 or 160 kg N ha^{-1} behaved alike (3.20 and 3.46 cm, respectively). An increased

Table 2: *Effects of different N-levels on growth, yield and quality characteristics of fodder maize*

Nitrogen Treatments (kg ha^{-1})	Plant Height (cm)	Leaf Area Plant^{-1} (cm^{-2})	Leaf Area Index	Chloro-phyll Content	Stem Diameter (cm)	Green fodder Yield (t ha^{-1})	Dry matter Yield (t ha^{-1})	Crude Protein (%)	Crude Fiber (%)	Ash (%)
Control	87.04 f	106.13 e	0.63 e	15.68 d	2.10 d	16.04 e	4.83 d	4.03 f	24.56 g	5.27 e
80	132.22 e	180.58 d	1.08 d	26.23 c	2.76 c	25.38 d	8.32 c	5.30 e	25.26 f	5.80 d
120	144.81 d	198.79 d	1.19 d	39.39 b	3.20 b	30.30 c	9.12 bc	7.16 d	26.90 e	6.61 c
160	147.69 cd	257.19 c	1.54 c	39.44 b	3.46 b	35.91 b	9.44 ab	8.10 c	27.70 d	6.90 c
200	154.21 bc	281.22 bc	1.68 bc	42.80 a	3.48 ab	41.99 a	9.99 a	9.60 b	28.66 c	8.15 b
240	159.37 b	299.67 ab	1.80 ab	41.10 ab	3.88 a	45.35 a	9.46 ab	12.20 a	32.36 b	8.97 a
280	176.6 a	332.13 a	1.99 a	41.79 ab	3.58 ab	45.23 a	9.59 ab	12.70 a	33.00 a	9.35 a
$LSD_{0.05}$	9.37	37.13	0.22	3.19	0.40	3.39	0.83	0.66	0.53	0.48

Means sharing similar letter(s) in respective column do not differ significantly at 5% level of probability.

supply of N concentration might trigger cell division which eventually attributed to steady expansion in stem diameter. Mahdi et al. (2011), Hassan et al. (2010), Nadeem et al. (2009), Ayub et al. (2007) and Iqbal et al. (2006) have also reported that plant height, leaf area index, chlorophyll content and stem diameter increased with increased N application.

Plants received the 240 kg N ha^{-1} produced maximum green fodder yield (45.35 t ha^{-1}) followed 280 and 200 kg N ha^{-1} (45.23 and 41.66 t ha^{-1}, respectively). However, minimum green fodder yield (16.04 t ha^{-1}) was recorded in control treatment followed by 80 (25.38 t ha^{-1}) and 120 kg N ha^{-1} (30.30 t ha^{-1}). The reason for higher green fodder yield in plants received higher N may be attributed to the most lucrative consumption of applied nitrogen and other allied environmental resources by the maize crop which resulted in maximum biomass yield. Increase in green fodder yield with increased nitrogen was mainly associated with greater plant height, number of leaves plant^{-1} and stem diameter. Similarly, Aslam et al. (2011) obtained maximum green fodder maize yield with highest N application (150 kg ha^{-1}). In another study, two maize hybrids (YH-1898 and YH-1921) produced highest yield when received 150:125 kg NP ha^{-1} (Mukhtar et al., 2011). Similarly, maize cultivar Azam produced highest yield when 160 kg N ha^{-1} was applied (Arif et al., 2010). Results of an integrated application of NPK to maize cultivars Golden and Sultan showed that 175:80:60 kg NPK ha^{-1} is the most appropriate fertilizer dose to obtain maximum yield (Asif et al. 2010). Dry fodder yield is function of photosynthetic efficiency of a plant to convert its photosynthates into dry matter production by integrated effects of genetic makeup of cultivars and growing condition of a crop. Fodder maize plants received N-doses of 200 (9.99 t ha^{-1}), 280 (9.59 t ha^{-1}), 240 (9.46 t ha^{-1}) and 160 kg ha^{-1} (9.44 t ha^{-1}) produced maximum and statistically equal dry fodder yield. Similar trend was observed in green fodder yield which indicated that nitrogen played an important role in the production of assimilates. Increase in nitrogen might have resulted in more active plants growth, which consecutively resulted in more dry matter partitioning. Cerny et al. (2012) observed that dry matter yield of fodder maize was linearly increased (14.8 t ha^{-1}) with increased in mineral fertilizer N up to120 kg ha^{-1}. Similar results were reported by Ayub et al. (2002).

Highest crude protein (12.70 and 12.20%) of fodder maize cultivar Kissan was observed when highest N-doses (280 and 240 kg ha^{-1}) were applied. However, minimum crude protein (4.03%) was estimated in control treatment followed by 80 kg N ha^{-1} treatment (5.30%). Plants received 120, 160 and 200 kg N ha^{-1} gave 7.16, 8.10 and 9.60% crude protein. It is an estimate of the level of protein in the feed based on the amount of nitrogen present. Crude protein is a critical nutrient in all animal diets. Signs of crude protein deficiency include lowered appetite, weight loss, poor growth, depressed reproductive performance, and reduced milk production. Young, growing and lactating animals are most likely to require crude protein supplementation. Providing adequate crude protein in animal diets is important for animal health and productivity as well as ranch profitability (Firdous et al., 1996; Kebede et al., 2012). A linear increase in crude protein percentage with increased N concentration might be due to nitrogen being an active ingredient of protein molecule and a building block of amino acid. Similar trend was observed by Aslam et al. (2011) at highest N application (150 kg ha^{-1}).

Table 3: *Benefit-Cost Ratio (BCR) of fodder maize as affected by different N-levels*

Nitrogen Treatments (kg ha^{-1})	Fixed Cost ha^{-1} (Rs.)	Variable Cost (Nitrogen) ha^{-1} (Rs.)	Total Expenditure ha^{-1} (Rs.)	Green Fodder Yield (t ha^{-1})	Fodder Income ha^{-1} (Rs.)	Net Income ha^{-1} (Rs.)	BCR
Control	32000	0	32000	16.043	40107.50	8107.50	1.25
80	32000	4500	36500	25.387	63467.50	26967.50	1.74
120	32000	6750	38750	30.303	75757.50	37007.50	1.96
160	32000	9000	41000	35.913	89782.50	48782.50	2.19
200	32000	11250	43250	41.993	104982.50	61732.50	2.43
240	32000	13500	45500	45.35	113375.00	67875.00	2.49
280	32000	15750	47750	45.23	113075.00	65325.00	2.37

Note: Market price of fodder maize was taken as Rs. 2500 per tonne; Rs. Pakistani Rupees, 1 USD = Rs. 101.76 (dated: 8 March, 2015)

Similarly, maximum crude fiber percentage (33%) was observed when fodder maize plants received highest N-dose (280 kg ha^{-1}) followed by plants received 240 kg N ha^{-1} (32.36%). However, minimum crude fibre (24.56%) was recorded in control treatment. Plants received 80, 120, 160 and 200 kg N ha^{-1} produced 25.26, 26.90, 27.70 and 28.66% crude fibre respectively. It is the insoluble carbohydrate remaining in the feed analysis process after the sample is boiled in weak acid and alkali. Crude fiber is required for normal rumen function and metabolism and is a positive dietary factor. The physical characteristics of fiber (particularly particle size) are also important in regulating rate of passage, rumination, insalivation and the pH of the rumen (Johnston et al., 2003; Kebede et al., 2012). The rise in crude fiber percentage with increase in N-levels may be attributed to higher stem diameter and plant height. Similar results were reported by Aslam et al. (2011).

Plants received higher N content (280 and 240 kg ha^{-1}) produced maximum ash percentage i.e. 9.35 and 8.97%, respectively followed by plants received 200 kg N ha^{-1} (8.15%). However, minimum total ash (5.27%) was recorded in control treatment followed by plants received 80 kg N ha^{-1} (5.80%). Ash is simply the total mineral content of forage. Minerals in feeds can be broken down into two general categories, endogenous and exogenous. Endogenous minerals can be loosely defined as minerals plants normally contain such as calcium, phosphorus, potassium, and magnesium etc. Many endogenous minerals are of nutritional value for lactating animals and we often want the value, such as in the case of calcium to be high to reduce supplementation cost. Exogenous minerals can be defined as minerals that are exterior to normal plant minerals which are primarily the minerals associated with soil such as silica and forages should contain as little soil contamination as possible (Kebede et al., 2012). Present study indicated an increase in total ash percentage with the increase in N-levels which could be due to higher dry matter production in plants that contributed directly or indirectly in biosynthesis of minerals. Safdar (1997) had also reported a raise in ash contents with augment in nitrogen rate in fodder maize. Similarly, Ayub et al. (2003) also reported that ash percentage was significantly increased with increase in nitrogen.

The cost-effective viability of adapting suitable nitrogen management strategies for fodder maize production was determined by economics of different nitrogen application doses and calculating benefit-cost analysis. Table 3 revealed that maximum (2.49) benefit-cost ratio (BCR) was recorded from the application of 240 kg N ha^{-1} followed by 200 (2.43), 280 (2.37) and 160 (2.19) kg N ha^{-1}. All these four treatments proved economical with reasonable BCR as compared to control, 80 and 120 kg N ha^{-1} treatments having BCR 1.25, 1.74 and 1.96, respectively. Estimates in Table 3 showed an economically workable choice at existing expenses of nitrogenous fertilizer (urea) and production prices of green fodder maize. Hence, it appeared that the most economical and reasonable fertilizer application approach is 240 kg N ha^{-1}, with premier BCR as compared to other treatments.

Conclusions

It is concluded from the findings of present research that the maize can efficiently serve as forage crop to farm animals as throughout the growth period the increased nitrogen level was beneficial for maintaining and improving the green and dry matter fodder maize yield. The maize plants having sufficient supply of nitrogen were also higher in forage quality. Therefore, it is recommended that 240 kg ha^{-1} nitrogen applications is most economical strategy for obtaining best quality green and dry matter fodder maize yield under the agro-climatic conditions of Dera Ismail Khan, Pakistan. This dose seems to be good when taken green and dry fodder yields along with high crude protein, crude fiber and minerals as standard quality attributes. This shows that crude protein and mineral values in maize can be improved and complete reliance on protein and mineral supplements can be reduced at farm level.

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