Precision Nitrogen Management for Enhancing Yield and Quality of Fodder Maize

Zahida Rashid[1], N. S. Khuroo[1], Tanveer Ahmad Ahngar[2*], Shabeena Majid[1], Sabiya Bashir[1], Sabina Nasseer[1], Faisul-Ur-Rasool[1], H. Shafeeq[1] and Z. A. Dar[1]

[1]*Dry land Agricultural Research Station, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Rangreth, India.*
[2]*Division of Agronomy, Faculty of Agriculture, Sher-e- Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura, Sopore–193201, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

A field experiment was conducted during *Kharif* 2020 at Dry land Agriculture Research Station, Rangreth, Srinagar, Kashmir on Precision Nitrogen Management for enhancing fodder yield and nitrogen use efficiency in forage maize variety SFM-1 (KDFM-1) planted in a spacing of 30 x10 cm. The treatments consisted of T_1 (No N), T_2 50 kg N/ha (40% N basal) + remaining based on SPAD meter critical value of 40, T_3 50 kg N/ha (40% N basal) + remaining based on SPAD meter critical value of 50, T_4 50 kg N/ha (40% N basal) + remaining based on LCC 4, T_5 50 kg N/ha (40% N basal) + remaining based on LCC 5, T_6 100 kg N/ha (40% N basal) + remaining based on SPAD meter critical value of 40, T_7 100 kg N/ha (40% N basal) + remaining based on SPAD meter critical value of 50, T_8 100 kg N/ha (40% N basal) + remaining based on LCC 4, T_9 100 kg N/ha (40% N basal) + remaining based on LCC 5, T_{10} 150 kg N/ha (40% N basal) + remaining based on SPAD meter critical value of 40, T_{11} 150 kg N/ha (40% N basal) + remaining based on SPAD meter critical value of 50, T_{12} 150 kg N/ha (40% N basal) + remaining based on LCC 4, T_{13}150 kg N/ha (40% N basal) + remaining based on LCC 5, T_{14} As per recommended package of practices (50% N as basal, remaining 50% at 30 days after sowing).The treatments were replicated thrice in a

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*Corresponding author: E-mail: tanveeragron@gmail.com;

randomized block design. The results recorded during the year indicated that production of fodder maize was better with the treatment T_{13} (150 kg N/ha (40% N basal) + remaining based on LCC 5. It recorded 470.01 q green and 135.02 q dry matter yield per hectare. The growth parameters namely; plant height; number of leaves per plant and quality were also improved with this treatment as compared to other treatments.

1. INTRODUCTION

Maize (*Zea mays* L.) is the third major cereal crop of the world and in India it ranks third after wheat and rice. Maize is considered as extensive cereal crop primarily due to highest productivity among cereals and acquires wider adaptability in varied agroclimatic conditions hence, it is known as "Queen of Cereals" [1]. Globally around 190 million hectares of area with production of about 1438 million tonnes is under maize cultivation [2]. In India about 9.50 million hectares with annual production of 27.23 million tonnes and productivity of 2870 kg hectare^{-1} is under maize cultivation [3]. In India the area under fodder production is around 9.85 million hectares and accounts only 4 per cent of cultivated area and production of about 462 million tonnes for green fodder and 394 million tonnes for dry fodder respectively [4]. In the union territory of Jammu and Kashmir maize is the second most important cereal crop after rice and is grown on an area of 0.31 million hectare with production of 0.51 million tonnes with an average productivity of 1650 kg ha^{-1} [3].

Maize is a suitable fodder crop due to its high biomass and the fodder which we get from maize is of high nutritional quality amongst the non-leguminous fodder crops grown in our country. Among various production practices, nutrient management plays an important role in improving production, productivity and quality of farm produce. Nitrogen is a major and a dominant nutrient in crop production. Thakur et al., [5] reported that significant increase in plant height, number of leaves per plant and dry matter production with 200 kg ha^{-1} of nitrogen application than lower levels in early composite varieties of baby corn. Shivay and Singh, [6] divulged that increasing nitrogen dose up to 120 kg ha^{-1} gave significant increase in plant height, leaf area per plant, leaf number and dry matter with no application of nitrogen. Yield components of maize and yield were mainly determined by the nitrogen level application which is the key nutrient for all biochemical reaction enhancing source to sink capacity and quality [7]. Ayub et al., [8] reported that higher levels of nitrogen application gave significant increase in green fodder yield. Leary and Rehm, [9] disclosed that application of 225 kg ha^{-1} increases crude protein content in maize. Protein content in maize was found to be statistically higher with application of 200 kg ha^{-1} [10]. The inherent nitrogen supplying capacity of soil can't be accessed directly by any prevalent soil test. Thus, the organic carbon status of soils has been used as an indirect index for developing nitrogen fertilizer recommendations to the crops. The organic carbon based blanket recommendation for nitrogen fertilizer have well served the purpose to produce optimum yields, but these led to application of N fertilizer above than the requirement which led to increase in cost of cultivation and environmental and groundwater pollution. Various state of the art techniques in nitrogen nutrient recommendations are site specific nutrient management *viz.,* Leaf Colour Chart (LCC) and Soil Plant Analysis Development (SPAD) chlorophyll meter which aim to reduce fertilizer dose or tailor the supply of nutrient for the target yield besides enhancing the nutrient use efficiency of applied fertilizer to address cost of effectiveness and environmental concerns. Among the various precision nitrogen management tools, Leaf Colour Chart (LCC) is the one and it was developed for rice and it is also suitable for maize as indicated by spectral reflectance measurement performance on rice [11] and maize leaves [12]. LCC helps in promoting need based variable nitrogen application, based on soil nitrogen supply and crop demand. It is an ideal tool to optimize nitrogen use, irrespective of the source of nitrogen applied [13]. Thus, the researchers shifted their emphasis from soil test based N applications to establish the of need-based nitrogen fertilizer management technologies that can match crop N demand with fertilizer N supply. Leaf color chart (LCC) and SPAD offers substantial opportunities to estimate plant nitrogen (N) demand in real time for efficient fertilizer use and high yield.

Fodder grasses are highly responsive to nitrogen application in terms of growth, quality and yield. Fertilizer nitrogen is a common input used by

farmers in different agro-climatic conditions in India with varied use efficiency (30-50%). Nitrogen exhibits high synergistic effect in combination with water and other inputs. Application of inadequate dose of nitrogen results in yield reduction and application in excess leads to increased cost of cultivation and environmental pollution. In view of this, an experiment was carried out to study the effect of precision nutrient management in fodder maize.

2. MATERIALS AND METHODS

A field experiment was conducted during *kharif* 2020 at Dry Land Agricultural Research Station, Srinagar, Jammu and Kashmir situated at $34°05'$ N latitude and $74°50'$ E longitude at an altitude of 1640 meter above mean sea level with an annual precipitation of 730 mm most of which is received from December to April in the form of snowfall and rain. Climatically the experimental site falls in temperate zone of north western Himalaya characterized by hot summers and very cold winters. The total rainfall received during the experimentation period was 158.4 mm and the maximum and minimum temperatures were $33.6°C$ and $13°C$, respectively. The soil of the experimental field was silty clay loam in texture, neutral in reaction (pH 7.2), medium in organic carbon (0.63%), medium in available nitrogen (380 kg/ha), low in phosphorus and medium in potassium (202 kg/ha).

The experiment comprising of fourteen treatments including control and was laid down in Randomized Block Design with three replications. The fourteen treatments are (T1=Control, T_2 50 kg N/ha (40% N basal) + remaining based on SPAD meter critical value of 40, T_3 50 kg N/ha (40% N basal) + remaining based on SPAD meter critical value of 50, T_4 50 kg N/ha (40% N basal) + remaining based on LCC 4, T_5 50 kg N/ha (40% N basal) + remaining based on LCC 5, T_6 100 kg N/ha (40% N basal) + remaining based on SPAD meter critical value of 40, T_7 100 kg N/ha (40% N basal) + remaining based on SPAD meter critical value of 50, T_8 100 kg N/ha (40% N basal) + remaining based on LCC 4, T_9 100 kg N/ha (40% N basal) + remaining based on LCC 5, T_{10} 150 kg N/ha (40% N basal) + remaining based on SPAD meter critical value of 40, T_{11} 150 kg N/ha (40% N basal) + remaining based on SPAD meter critical value of 50, T_{12} 150 kg N/ha (40% N basal) + remaining based on LCC 4, T_{13} 150 kg N/ha (40% N basal) + remaining based on LCC 5, T_{14} As per recommended package of practices (50% N as basal, remaining 50% at 30 days after sowing). The field was prepared by giving two to three ploughings followed by harrowing and planking. After layout plan, full dose of Diammonium phosphate @ 60 kg P/ha and Muriate of Potash @ 40 kg K/ha was applied at the time of sowing and nitrogen was applied in the form of Urea as per LCC and SPAD readings. LCC is a useful tool to give nitrogen to the crop on the need basis. It evaluates the nitrogen status of a crop in a non-destructive way without taking leaf samples, laboratory analysis and delay in getting the results, hence saves both time and cost. Similarly SPAD chlorophyll meter is useful in determining the N status of the crop and real time nitrogen application. For the treatment of Leaf Colour Chart threshold 4 and 5, nitrogen was applied 40 % basal and remaining as guided by Leaf Colour Chart threshold level of 4 and 5. Furthermore, the remaining application of nitrogen was done by matching the color of youngest fully expanded leaf of 10 randomly selected plants from each plot starting from 21 days after sowing and then on an interval of 10 days till harvesting. If the greenness of 6 or more samples out of 10 showed more than 5 then no application of nitrogen was done. LCC reading was taken during morning hours of the day under the shade of the body. For SPAD, 40% of the nitrogen was applied as basal and further threshold based application of nitrogen was done on the basis of SPAD reading at critical value of 40 and 50. In treatments where recommended dose of fertilizer were applied, 50% nitrogen was applied as basal and remaining was applied at 30 days after sowing. The crop was sown in rows 60 cm apart with plant to plant spacing of 20 cm with seed rate of 30 kg/ha. All other agronomic practices were followed as per standard recommendations. Crop was harvested at green stage (80 days after sowing). The growth and yield parameters were recorded from three randomly selected and tagged plants from each plot using the standard procedures. In each plot of each replication randomly five plants were selected and tagged and plant height (cm) was measured from base of plant to the apex of the flag leaf before tasselling and after tasselling up to base of tassel up to harvest. Five randomly selected plants were selected for counting number of leaves plant[-1]. The fodder yield of each net plot (leaving border and penultimate rows) was harvested and the weight from each plot was recorded separately as kg plot[-1] and then converted into q ha^{-1}. The nitrogen (N) content was estimated by the modified micro-kjeldahl procedure and expressed in percentage. Protein content was calculated from the N

Table 1.Precision nitrogen management for enhancing fodder yield and quality in fodder maize

Treatments	Plant height (cm)	No. of leaves / plant	Green fodder yield (q/ha)	Dry fodder yield (q/ha)	N Content (%)	N uptake (Kg/ha)	C P yield (Kg/ha)
No N Control	217.35	9.88	418.52	83.23	0.39	32.46	202.87
50 kg N/ha (40% basal) + remaining based on LCC 4	222.12	10.21	423.43	89.45	0.41	36.67	229.22
50 kg N/ha (40% basal) + remaining based on SPAD meter critical value of 40	226.41	10..66	438.16	97.55	0.44	42.92	268.26
50 kg N/ha (40% basal) + remaining based on LCC 5	230.22	10.92	440.02	101.78	0.51	51.91	324.42
50 kg N/ha (40% basal) + remaining based on SPAD meter critical value of 50	233.01	11.25	442.98	105.25	0.59	62.10	388.11
100 kg N/ha (40% basal) + remaining based on SPAD meter critical value of 40	235.45	11.67	444.25	107.85	0.65	70.10	438.14
100 kg N/ha (40% basal) + remaining based on LCC 4	236.03	12.11	449.54	111.23	0.68	75.64	472.73
100 kg N/ha (40% basal) + remaining based on SPAD meter critical value of 50	240.45	12.52	453.32	114.48	0.69	78.99	493.70
100 kg N/ha (40% basal) + remaining based on LCC 4	242.78	12.94	457.01	119.56	0.73	87.28	545.49
As per recommended package of practices (50 % N as basal, remaining 50 % at 30 days after sowing	243.36	13.31	462.18	121.13	0.76	92.06	575.37
150 kg N/ha (40% basal) + remaining based on SPAD meter critical value of 40	246.12	13.42	464.23	124.36	0.83	103.22	645.12
150 kg N/ha (40% basal) + remaining based on LCC 4	248.21	13.50	466.21	128.09	0.97	124.25	776.55
150 kg N/ha (40% basal) + remaining based on SPAD meter critical value of 50	252.56	14.17	467.12	130.07	1.02	132.67	829.20
150 kg N/ha (40% basal) + remaining based on LCC 5	260.01	16.42	470.01	135.02	1.06	143.12	894.51
SE(m) ±	2.99	0.31	3.60	2.23	0.23	2.68	9.09
C.D. (P=0.05)	8.98	0.94	10.80	6.70	0.70	8.04	27.29

content by multiplying with a factor 6.25. Based on the crude protein concentration and respective dry matter production, the crude protein yield (kg ha^{-1}) was calculated. The data was analyzed as per the standard procedure for Analysis of Variance using software 'OP STAT'. The difference in the treatment mean was tested by using critical difference (CD) at 5% level of significance.

3. RESULTS AND DISCUSSION

Plant height and number of leaves per plant as presented in Table 1 were significantly affected by different Sight Specific Nutrient Management (SSNM) techniques and doses. It was found that plant height (260.01 cm) and number of leaves per plant (16.42) were higher with treatments where nitrogen was applied at 150 kg/ha (40% as basal and remaining was applied at LCC 5) and lowest plant height (217.35 cm) and number of leaves per plant (9.88) was recorded in absolute control. The increase in plant height and number of leaves with higher doses of nitrogen could be attributed to the fact that nitrogen is responsible for promoting growth factors, increase in length of internodes which leads to increase in plant height and more production of internodes and leaves [14]. The growth parameters in absolute control may be low due to inadequate supply of plant nutrients. The results are in conformity with the findings of [15]. Highest Green fodder yield (470.01 q/ha) was found with the treatment which received 150 kg N/ha (50% basal and remaining at LCC 5 readings) which was statistically at par (467.12 q/ha) with treatment where N was applied at 150 kg/ha (50% basal and remaining at SPAD critical value of 50). However, the green fodder yield increased with increase in nitrogen levels up to 150kg/ha. The close relation between the biomass and nitrogen available in the soil has been found by [16] and [17].

The attained results showed that different doses of nitrogen based on LCC and SPAD readings significantly affected the dry fodder yield and increased progressively by increase in nitrogen levels up to LCC reading 5 and SPAD critical value 50 as compared to control where no fertilizer was applied. Forage yield is a function of growth parameters *viz.,* plant height and number of leaves. Highest dry fodder yield (135.02 q/ha) was recorded with T14 which was found statistically at par (130.07 q/ha) with T13 and lowest (83.23q/ha) was recorded with control. This could be attributed to the positive effect of

nitrogen on growth parameters investigated in this study.

Further, the results showed that the N content, N uptake and Crude protein yield was found more with T14 and lowest values were recorded with T1 (control). Increasing crude protein may definitely be due to the reason that nitrogen often plays an important role in the synthesis of protein. Higher N uptake with SSNM techniques over recommended dose of fertilizer and biomass may be probably due to the fact of better timing and splitting of nitrogen fertilization, similar findings were observed by [18].

4. CONCLUSION

The results of the investigation revealed that the treatment T_{13} (150 kg N/ha (40% N basal) + remaining based on LCC 5) recorded significantly higher values of all the growth parameters, yield parameters and yield and quality parameters as well. So it can be concluded that T_{13} treatment is suitable for enhancing fodder yield and quality in fodder maize.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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