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Growth Parameters and Protein Content of Maize as Influenced by Sowing Methods and Different Levels of Nitrogen

Bhanu Singh [a++*], Saba Siddiqui [a#], Dhruvendra Singh Sachan [b++], Sushil Kumar Yadav [a++] and Shabbeer Ahmad [a++]

[a] Department of Agriculture, Integral Institute of Agricultural Science and Technology, Integral University, Lucknow, U.P. – 226 026, India.
[b] Department of Agronomy, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, U.P. - 208 002, India.

Authors' contributions

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

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ABSTRACT

The field experiment was carried out at Research Farm, Integral University, Lucknow, Uttar Pradesh, India during Kharif season, 2021. The experiment envisages to study the effect of Sowing methods and different Nitrogen levels on yield and attributes of maize crop. The experiment was

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[++] Research Scholar;
[#] Head;
**Corresponding author: E-mail: bhanu6201@gmail.com;*

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laid down in the Split Plot Design and the treatments were replicated three times. The maximum plant height of 56.92 cm, 235.17 cm and 237.16 cm was observed in the ridge method of sowing at knee height stage, tasselling stage and at harvest stage, respectively. Among nitrogen levels, the maximum plant height of 57.61 cm, 235.29 cm and 238.38 cm was observed at knee height stage, tasselling stage and at harvest stage, respectively in the treatment (N5) 25% N through granular urea + 75% N through Nano-urea. Among nitrogen levels, the maximum DMA of 86.30, 425.36 and 1287.73 g sqm^{-1} day^{-1} was observed at knee height stage, tasselling stage and at harvest stage, respectively in the treatment (N5) 25% N through granular urea + 75% N through Nano-urea. At harvest stage number of leaves per plant were highest in the S1 (14.33) and N5 (16.13) treatment. Among nitrogen levels, the maximum leaf area index (LAI) of 1.55, 2.49 and 1.9 was observed at knee height stage, tasselling stage and at harvest stage, respectively in the treatment N5. Among sowing methods, highest protein content was found in the ridge method (10.14%) followed by flat method (9.81%) and broadcast method (9.42%) of sowing. The protein yielded maximum of 586.15 kg ha^{-1} in the N5 treatment. All parameters showed better in granular urea application rather than nano-urea, when used solely.

Keywords: Tasselling; nano-urea; granular; protein.

1. INTRODUCTION

Maize (*Zea mays* L.) is a highly significant fodder and cereal crop renowned for its extensive availability and it belongs to the Poaceae family and is regarded as a “Queen of cereals” [1]. Maize has become a major industrial crop worldwide, with 83% of its production going into feed, starch, and biofuel industries. Globally, maize consumption is divided as follows: 61% for feed, 17% for food, and 22% for industrial uses. This distribution highlights maize's significant role in driving the global agricultural economy [2]. It is predominantly cultivated during the kharif season, often in rainfed conditions and in marginal areas such as the hilly terrains of the Kashmir Valley, where it is frequently intercropped with pulses. Maize requires ample moisture and specific temperature conditions for optimal growth: 21°C for germination and 32°C for overall growth. However, maize is highly sensitive to stagnant water, particularly during its early growth stages [3].

Fertilizer application is crucial for optimizing both the yield and quality of fodder maize. Providing an adequate supply of nutrients at each growth stage is essential for improving maize fodder's yield and quality. Nitrogen, in particular, is a key nutrient required in relatively large quantities. It is a fundamental component of chlorophyll, protoplasm, amino acids, and nucleic acids. Nitrogen promotes growth and development of all plant tissues, enhancing fodder quality and increase the protein content of grains. It is a critical yield-limiting factor in agricultural systems [4]. Nitrogen is primarily supplied through mineral fertilizers, farm manure, symbiotic nitrogen fixation, and atmospheric deposition (both wet and dry). Essential for plant growth, nitrogen constitutes 1 to 4% of plant dry matter and facilitates the utilization of phosphorus, potassium, and other nutrients [5].

Sowing methods or land management system plays a major role in improving water and nutrient use efficiency of field crops. Land configuration increases water use efficiency and also increases availability of nutrients to crops [6]. The superiority of ridges and furrow system could be ascribed to proper drainage of excess water coupled with adequate aeration at the time of irrigation or heavy rainfall. Among the plant nutrients, nitrogen (N) management is one of the most important factors required for improving crop productivity [7].

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was carried out at Research Farm, Integral University, Lucknow, Uttar Pradesh, India during Kharif, 2021. Lucknow has a humid subtropical climate with hot, sunny summers from March to May. The city receives an average of 835 millimetres of rainfall from the southwest monsoon winds between June to October. Summers are very hot with temperatures rising to 40-45°C (104-113°F) range.

2.2 Edaphic Condition

The soil in the experimental field was clayey in texture and slightly alkaline with pH of 7.8. Organic carbon in the soil was 0.31% which was estimated by rapid titration method given by

Chart 1. Treatments details

Main plots (Method of sowing)	
S1	Ridge sowing
S2	Flat-bed sowing
S3	Broadcasting
Sub plot (Nitrogen Management)	
N1	100% N through granular urea
N2	100% N through Nano-urea
N3	75% N through granular urea + 25% N through Nano-urea
N4	50% N through granular urea + 50% N through Nano-urea
N5	25% N through granular urea + 75% N through Nano-urea

**RDF= 120 N: 60 P_2O_5 :60 K_2O*

Walkley and Black (1934). The available Nitrogen in soil was 138 kg ha^{-1}, which was estimated by the Alkaline permanganate method given by Subbiah and Asija [8]. The available Phosphorus was 17.7 kg ha^{-1} estimated by Olsen's method given by Olsen et al. [9]. The available K was 294.1 kg ha^{-1} which was estimated by the Flame photometer method given by Jackson [10].

2.3 Experimental Design and Treatment Details

The experiment was designed as Split Plot Design. The treatments were replicated thrice. The details of the treatments are shown in Chart 1.

2.4 Preparation of the Experimental Field and Application of Fertilizers

The seed bed was prepared by ploughing with a cultivator followed by rotavator. The field was then manually laid out according to the plan, and *TMMH 826* Hybrid seeds were sown at a rate of 25 kg ha^{-1} with a spacing of 45 cm × 20 cm. Granular Urea (46% N) and Nano urea (4% N) was applied as per the treatments, while DAP (46% P_2O_5) and MOP (60% K_2O) were uniformly applied as a basal application across all treatments.

3. RESULTS AND DISCUSSION

3.1 Plant Height

The data pertaining to plant height is given under Table 1. Among sowing methods, the maximum plant height of 56.92 cm, 235.17 cm and 237.16 cm was observed in the ridge method of sowing at knee height stage, tasselling stage and at harvest stage, respectively. Among nitrogen levels, the maximum plant height of 57.61 cm, 235.29 cm and 238.38 cm was observed at knee height stage, tasselling stage and at harvest stage, respectively in the treatment (N5) 25% N through granular urea + 75% N through Nano-urea. Sole application of granular urea was found to be better than nano-urea. Similar type of results was also obtained by Naik et al. [11]; Manwar and Mankar [12].

3.2 Dry Matter Accumulation

The data pertaining to Dry matter accumulation (DMA) is given under Table 2. Among sowing methods, the maximum DMA of 78.32, 365.9, 1279.96 g sqm^{-1} day^{-1} was observed in the ridge method of sowing at knee height stage, tasselling stage and at harvest stage, respectively. Among nitrogen levels, the maximum DMA of 86.30, 425.36 and 1287.73 g sqm^{-1} day^{-1} was observed at knee height stage, tasselling stage and at harvest stage, respectively in the treatment (N5) 25% N through granular urea + 75% N through Nano-urea. Sole application of granular urea was found to be better than nano-urea. Hence, higher DMA was found in granular urea compared to nano urea. Similar type of results was also obtained by Thakur et al. [13].

3.3 Number of Leaves per Plant

The data pertaining to number of leaves per plant is given under Table 3. Among sowing methods, the maximum number of leaves per plant of 7.82, 12.82 and 14.33 was observed in the ridge method of sowing at knee height stage, tasselling stage and at harvest stage, respectively. Among nitrogen levels, the maximum number of leaves per plant of 8.43, 13.81 and 16.14 was observed at knee height stage, tasselling stage and at harvest stage, respectively in the treatment (N5) 25% N through granular urea + 75% N through Nano-urea. Similar type of results was also obtained by Naik et al. [11]; Manwar and Mankar [12].

Table 1. Effect of sowing methods and nitrogen levels on plant height (cm)

Treatments	Plant height(cm)		
	Knee height stage	Tasseling stage	At harvest
Method of sowing			
S1	56.92	235.17	237.16
S2	54.23	229.31	235.32
S3	51.20	228.16	229.12
SEm±	1.01	0.91	1.35
CD (P=0.5)	4.07	3.68	5.49
Nitrogen levels			
N1	52.22	228.93	232.91
N2	50.37	227.34	228.53
N3	54.57	230.44	233.87
N4	55.79	232.42	235.66
N5	57.61	235.29	238.38
SEm±	0.83	1.15	1.39
CD (P=0.5)	2.45	3.39	4.08

Table 2. Effect of sowing methods and nitrogen levels on dry matter accumulation (g/m^2/day)

Treatments	Dry matter accumulation (g/m^2/day)		
	Knee height stage	Tasseling stage	At harvest
Method of sowing			
S1	78.32	365.90	1279.96
S2	70.27	353.24	1264.56
S3	62.35	333.21	1243.44
SEm±	2.96	4.85	1.68
CD (P=0.5)	11.95	19.56	6.77
Nitrogen levels			
N1	69.40	309.22	1250.33
N2	42.61	290.22	1236.40
N3	75.16	350.02	1265.73
N4	78.10	379.31	1273.06
N5	86.30	425.36	1287.73
SEm±	2.30	5.40	3.41
CD (P=0.5)	06.76	15.85	10.03

Table 3. Effect of Sowing Methods and Nitrogen Levels on Number of leaves per plant

Treatments	Number of leaves per plant		
	Knee height stage	Tasseling stage	At harvest
Method of sowing			
S1	7.82	12.82	14.33
S2	6.88	11.19	13.98
S3	6.05	9.86	13.32
SEm±	0.12	0.23	0.14
CD (P=0.5)	0.49	0.90	0.56
Nitrogen levels			
N1	6.12	9.94	12.73
N2	5.18	8.72	11.61
N3	6.96	10.98	13.98
N4	7.90	13	14.90
N5	8.43	13.81	16.14
SEm±	0.18	0.36	0.43
CD (P=0.5)	0.54	1.10	1.27

Table 4. Effect of sowing methods and nitrogen levels on leaf area index

Treatments	Leaf area index		
	Knee height stage	Tasseling stage	At harvest
Method of sowing			
S1	1.54	2.45	1.83
S2	1.46	2.42	1.69
S3	1.39	2.38	1.60
SEm±	0.014	0.012	0.008
CD (P=0.5)	0.055	0.047	0.032
Nitrogen levels			
N1	1.43	2.38	1.61
N2	1.38	2.35	1.54
N3	1.46	2.40	1.70
N4	1.51	2.45	1.77
N5	1.55	2.49	1.90
SEm±	0.015	0.011	0.009
CD (P=0.5)	0.045	0.031	0.026

Table 5. Effect of sowing methods and nitrogen levels on protein in grain (%) and Protein yield (kg ha^{-1})

Treatments	Protein (%) in grain	Protein Yield (kg per hectare)
Sowing methods		
S1	10.14	522.24
S2	9.81	474.52
S3	9.42	424.14
SEm±	0.026	6.58
CD (P=0.5)	0.105	26.56
Nitrogen levels		
N1	9.5	420.09
N2	9.3	373.90
N3	9.8	466.01
N4	10.06	522.01
N5	10.28	586.15
SEm±	0.032	16.72
CD (P=0.5)	0.095	49.11

3.4 Leaf Area Index (LAI)

The data pertaining to Leaf area index is given under Table 4. Sole application of granular urea was found to be better than nano-urea. Hence, higher LAI was found in granular urea compared to nano urea. Among sowing methods, the maximum LAI of 1.54, 2.45 and 1.83 was observed in the ridge method of sowing at knee height stage, tasselling stage and at harvest stage, respectively. Among nitrogen levels, the maximum LAI of 1.55, 2.49 and 1.9 was observed at knee height stage, tasselling stage and at harvest stage, respectively in the treatment (N5) 25% N through granular urea + 75% N through Nano-urea. Similar type of results was also obtained by Naik et al. [11]; Manwar and Mankar [12].

3.5 Protein in Grain (%) and Protein Yield (kg ha^{-1})

The data pertaining to protein content in grain is given under Table 5. Among sowing methods,

highest protein content was found in the ridge method (10.14%) followed by flat method (9.81%) and broadcast method (9.42%) of sowing. Among nitrogen levels highest protein content was found in the N5 treatment followed by N4. The protein percent was comparatively higher in sole application of granular urea as compared to nano-urea. Similarly, protein yield was higher in (S1) ridge method of sowing and 25% N through granular urea + 75% N through Nano-urea(N5). Similar type of results was also obtained by Thakur et al. [13]; Khan et al. [14]; Ali and Anjum [15].

4. CONCLUSION

Research data indicated that using only urea was more effective than using nano-urea alone. However, combining urea with nano-urea yielded the best results for maize in the plains of Uttar Pradesh. Nano-urea applied by itself did not produce satisfactory outcomes. Therefore, it is recommended to cultivate maize using ridge sowing and apply 25% of the nitrogen as granular urea and 75% as nano-urea.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc have not been used during writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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