Impact of fixed dose variable nitrogen management on growth and yield of quality protein maize (*Zea mays* L.)

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ABSTRACT

A field experiment has been conducted during *rabi* (November-April)season of 2021-22 and 2022-23 in the instructional farm of Uttar Banga Krishi Viswavidyalaya, West Bengal to study the impact of fixed dose variable nitrogen management on growth and yield of quality protein maize (*Zea mays* L.). The experiment was laid out in randomized block design with four replications. The experiment comprised of five nitrogen management option namelyN_1 - 40% as basal, 30% at knee height stage and 30 % at VT, N_2- 25% as basal, 25% at V_8, 25% at VT and 25% at R_1, N_3- 20% as basal, 30% at V_8, 30% at VT, 20% at R_1, N_4- 20% as basal, 30 % at V_8, 25 % at VT, 25% at R_1 and N_5- 10% as basal, 25 % at V_8, 40% at VT, 25 % at R_1. Results revealed that whenever nitrogen was applied in four split *i.e.*10% as basal +25 % at V_8+ 40% at VT +25 % at R_1 recorded significantly longest (17.71 & 18.21 cm), widest (16.03 & 16.57 cm) cob having maximum number of seed rows kernel^{-1} (15.90 &14.85), seeds row^{-1} (37 & 37.75) which ultimately helped in producing 18.28 & 34.32 % and 5.43 & 19.80 % higher grain yield respectively during 2021-22 and 2022-23 over N_1 and N_4. Whereas N_3 and N_5 was statistically at par with each other in terms of yield attributes and yield. Higher protein (8.92 & 8.88%) and starch (71.86 & 72.08%) was also observed under treatment N_5.

Key words : Fixed dose, Nitrogen, Maize, Protein & Starch

Introduction

Cereals cater the key sustenance in most of the diets and comprise over 73% of the total world harvested area supporting 60% of the global food production (Das *et al.*, 2012). Maize (*Zea mays* L.) is a one of the important staple food crops of the world and ranks next only to wheat and rice as the third most important crop in the world. Maize is considered a promising option for diversifying agriculture in areas of India. It now ranks as the third most important food grain crop in India. Its production is growing at double the annual rate of that of rice and thrice that of wheat (Fischer *et al.,* 2014). Among cereals, maize being a C4 plant has the capacity of harvesting as well utilizing solar radiation more efficiently thus resulting into higher genetic yield potentiality which makes maize as 'queen

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of cereal'.Unfortunately, maize lacks the full range of amino acids, namely lysine and tryptophan, needed to produce proteins leading to poor net protein utilization, malnutrition and low biological value.

Quality Protein Maize, is exactly similar to normal maize in grain texture, taste, colour but possesses double the level of lysine (4%) and tryptophan (0.8%), produces high yields and tolerates biotic and abiotic stresses. Such balanced condition of amino acids in the endosperm resulted to its higher biological value ensuring more availability of protein to human and animals than normal maize (Jena *et al.,* 2013). Hence, for better dissemination and adoption of QPM hybrids there is a need to understand the performance of QPM with various agronomic management practices among which nutrient management is a major one. QPM is a cheap source of protein, given that farmers can grow, manage, harvest and consume it in the same way they do Conventional Maize varieties (Vasal, 2008).

Nitrogen is a major yield-determining factor required for maize production (Yan *et al.,* 2016). Its availability in sufficient quantity throughout the growing season is essential for optimum maize growth. Applications of nitrogen enhance the source capacity, namely leaf area, Leaf area index (LAI), early canopy closure and the rate of photosynthesis (Dawadi, 2009; Gul *et al.,* 2021and Shah *et al.,* 2021a). Lack of sufficient soil nitrogen leads to reduced leaf area, lessening the rate of photosynthesis and delayed growth and development which resulted into lower yield. On the other hand, disproportionate use of nitrogen results in escalation of production costs and adds to environmental pollution by contaminating ground water and contributes to the global warming due to release of nitrous oxide through nitrogen volatilization (Sandhu *et al.,* 2021). Therefore, to obtain good yield and improve the use efficiency of applied nitrogenous fertilizer real time application of nitrogen is utmost necessary.

Considering the above-mentioned facts in mind, afield experiment entitled"Impact of fixed dose variable nitrogen management on growth and yield of quality protein maize (*Zea mays* L.)"was undertaken to study the effect of varying nitrogen management on productivity and economics of Quality Protein Maize.

Materials and methods

The experiment was conducted during *rabi*season of 2021-22 and 2022-23 at the research farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal. Cooch Behar is situated in the terai agro climatic zone at $26^{0}19'86"$ N latitude and $89^{0}23'53"$ E longitude and at an elevation of 43 meters above mean sea level. The soil of the experimental site was sandy loam having pH 5.63, organic carbon 0.79 %, available nitrogen 127.12 kg/ha, phosphorus 26.33 kg/ha and potassium 104.58 kg/ha. The experiment was laid out in randomized block design with four replications and individual plot size was 6m × 5 m. The experiment comprised of five nitrogen management option namelyN_1 - 40% as basal, 30% at knee height stage and 30 % at VT, N_2- 25% as basal, 25% at V_8, 25% at VT and 25% at $R_{1,}$ N_3- 20% as basal, 30% at V_8, 30% at VT, 20% at $R_{1,}$ N_4-

20% as basal, 30 % at V_8, 25 % at VT, 25% at R_1 and N_5- 10% as basal, 25 % at V_8, 40% at VT, 25 % at R_1.

Variety VL QPM Hybrid 59 was used in the trial and sown at a spacing of 60 cm x 30 cm. A recommended dose of 140:70:70 N: P_2O_5:K_2Oha^{-1}was used in the experiment. Full dose of phosphorus was applied at the time of final land preparation in the form of single super phosphate and half of potassium was applied as basal and remaining half was applied at V_8 stage. Standard agro-techniques were followed throughout the growth period. Starch content of maize was estimated by using Anthrone method (Sadsivam, 1996) and protein content was analyzed using Lowry method. The data on agronomic parameters namely plant height, number of leaves, cob length, cob diameter, kernel row/cob, number of seeds/row, test weight and grain yield were recorded during the course of investigation using standard procedures and statistical analysis was done by using SPSS software version 20.

Results and discussion

Plant height : Plant height was taken 30 days interval starting from 30 days after sowing to at harvest and presented in table 1. It was clearly noticed that plant height was increased continuously upto 120 days after sowing irrespective of treatment and thereafter sharply declined towards maturity. Tallest plant (332.35 &33.25, 169.36 &168.47, 280.31 &279.41, 301.50 &302.42 and 296.87 &295.27 cm at 30, 60, 90, 120 DAS and at harvest respectively during 2021-22 and 2022-23) was recorded in N_5 where nitrogen was applied in four split 10% as basal +25 % at V_8+ 40% at VT +25 % at R_1 which was statistically superior over N_1, N_2 and N_4 while N_3 showed statistically at par with N_5 probably due to supply of desired level of nitrogen for intermodal elongation through the growth stages. Better plant height was ascribed by the synchronized supply of nitrogen which heled in rapid cell division and enlargement and finally taller plant (Ganesaraja *et al.,* 2009; Singh *et al.,* 2013 and Choudhary *et al.,* 2013).

Number of leaves/Plant : Leaves number was also recorded 30 days interval starting from 30 days after sowing to at harvest and presented in table 2. In general number of leaves increases with the advancement of crop growth and found maximum at 90 days after sowing thereafter decline towards maturity due to senescence of older leaves irrespective of treatments. Treatment where nitrogen was applied in four split *i.e.*10% as basal +25 % at V_8+ 40% at VT +25 % at R_1 (N_5) produced significantly highest number of leaves (7.0 &6.89, 13.10 &12.85, 17.20 &16.85, 15.37 &15.59 and 10.33 &9.85 at 30, 60, 90, 120 DAS and at harvest respectively during 2021-22 and 2022-23) over N_1, N_2 and N_4. While application of nitrogen in four splits *i.e.*20% as basal, 30% at V_8, 30% at VT, 20% at R_1 (N_3) was found statistically equal with N_5 in terms of leave production at different growth stages. Leaf production of maize is directly correlated with the nitrogen fertilization as evidenced by Hassan *et al.* (2010), Syed *et al.*(2012) and Amanullah *et al.* (2009).

Yield attributes and grain yield :

Among the yield attributes of maize significantly longest (17.71 & 18.21cm respectively during 2021-22 and 2022-23) and widest (16.03 &16.57 cmrespectively during 2021-22 and 2022-23) cob was found whenever nitrogen was applied in four split *i.e.*10% as basal +25 % at V_8+ 40% at VT +25 % at R_1 (N_5). Maximum number of seed rows/kernel (15.90 &14.85respectively during 2021-22 and 2022-23) and seeds/row (37.0 &37.75respectively during 2021-22 and 2022-23) were also found highest under N_5. All these yield attributes ultimately helped in producing 18.29 % &34.32 %, 7.80 &19.80 % and 5.43 &15.80 % higher grain yield in N_5 over N_1, N_4 and N_2 respectively during 2021-22 and 2022-23 might be due adequate supply of nitrogen particularly during post tasseling stage namely silking and grain filling. Grain yield of N_5 and N_4 failed to achieve level of significance. Lowest yield attributes and yield (6.89 & 6.44 t ha^{-1} respectively during 2021-22 and 2022-23 respectively) was found in N_1 where nitrogen was applied in three splits i.e.40% as basal, 30% at knee height stage and 30 % at VT simply due to non-synchronous supply of nitrogen particularly after tasseling stage. Higher doses of nitrogenous fertilizer upto 200 kg ha^{-1} was found advantageous in order to boost productivity as delineated bySrivastava*et al.* (2018), Nemati and Sharifi (2012), Verma *et al.* (2013), Kandil *et al.* (2017) and Singh *et al.* (2013).

Protein and Starch concentration : Protein content in cereals like rice, wheat and maize in now gaining attention because except wheat most of the traditional varieties of rice and maize contained less than 6 % protein which could not meet up our daily protein requirement. Protein and starch content of QPM was analyzed and presented in fig. 1 and fig. 2. It is clear from the data that protein content varied from 8.14 to 8.92 % and 8.09 to 8.88 % while starch content varied from 66.54 to 71.86 % and 65.12 to 72.03 % respectively during 2021-22 and 2022-23. Highest protein and starch content was found whenever nitrogen was applied in four splits i.e. 10% as basal +25 % at V_8+ 40% at VT +25 % at R_1 (N_5) followed by N_3, N_2 and N_4. Comparatively lowest protein and starch concentration was found under the treatments which received nitrogen in three splitsi.e. 40% as basal, 30% at knee height stage and 30 % at VT (N_1). Higher starch and protein content with the higher doses of nitrogen was witnessed earlier by Bindhani *et al.* (2008) and Choudhary *et al.* (2015).

Conclusion

Application ofnitrogen @ 140 kg ha^{-1} in four splits i.e. 10% as basal +25 % at V_8+ 40% at VT +25 % at R_1 are recommended for hybrid quality protein maize for better productivity and quality under light texture soil of terai region of West Bengal.

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Table 1: **Plant height (cm) of QPM as influenced by fixed dose variable nitrogen management at different growth stages**

Treatments	30 DAS		60 DAS		90 DAS		120 DAS		At Harvest	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
N_1	23.36	24.27	155.00	154.15	268.75	269.29	282.09	283.29	277.74	276.66
N_2	26.42	26.75	157.52	157.45	272.28	272.45	288.82	289.43	285.48	284.68
N_3	29.31	30.11	160.92	159.72	274.14	275.26	296.95	297.45	293.40	291.77
N_4	26.21	26.45	156.57	155.33	271.89	270.65	286.54	287.33	281.68	279.28
N_5	32.35	33.25	169.36	168.47	280.31	279.41	301.50	302.42	296.87	295.27
S Em.(±)	1.35	1.34	2.04	2.02	1.91	1.92	4.27	4.29	2.42	2.37
CD (P=0.05%)	4.12	4.02	6.21	6.06	5.78	5.76	12.86	12.78	7.34	7.12

Table 2 : **Number of leaves/plant of QPM as influenced by fixed dose variable nitrogen management at different growth stages**

Treatments	30 DAS		60 DAS		90 DAS		120 DAS		At Harvest	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
N_1	5.10	4.87	10.57	10.13	14.87	14.22	12.57	11.96	8.50	8.27
N_2	5.57	5.23	11.43	10.83	15.43	14.88	13.17	13.67	9.60	8.89
N_3	6.13	5.87	12.20	12.15	16.13	16.23	13.70	14.10	10.03	9.27
N_4	5.33	4.95	11.10	10.57	15.37	14.67	12.97	12.25	9.20	8.67
N_5	7.00	6.89	13.10	12.85	17.20	16.85	15.37	15.59	10.33	9.85
S Em.(±)	0.28	0.30	0.34	0.35	0.44	0.52	0.61	0.58	0.48	0.46
CD (P=0.05%)	0.86	0.91	1.02	1.06	1.36	1.56	1.84	1.74	1.41	1.39

Table 3 : Yield attributes and yields of QPM as influenced by fixed dose variable nitrogen management

Treatments	Cob length (cm)		Cob diameter (cm)		No. of seed rows/ kernel		No of seeds/ row		Test weight (g)		Grain yield (t/ha)	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
N_1	16.96	16.22	15.14	14.95	14.80	14.37	35.20	34.85	26.92	27.17	6.89	6.44
N_2	17.08	17.12	15.79	15.85	15.73	15.22	35.87	35.91	28.51	29.66	7.73	7.47
N_3	17.12	17.65	15.90	16.13	15.87	15.98	35.93	36.10	29.56	30.44	8.02	8.11
N_4	17.08	16.84	15.62	15.33	15.20	15.20	35.53	35.22	28.47	28.65	7.56	7.22
N_5	17.71	18.21	16.03	16.57	15.90	14.85	37.00	37.75	30.13	31.10	8.15	8.65
S Em.(±)	0.13	0.13	0.13	0.16	0.18	0.17	0.42	0.42	0.77	0.71	0.14	0.19
CD (P=0.05%)	0.42	0.40	0.37	0.48	0.56	0.52	1.25	1.26	2.34	2.13	0.42	0.56

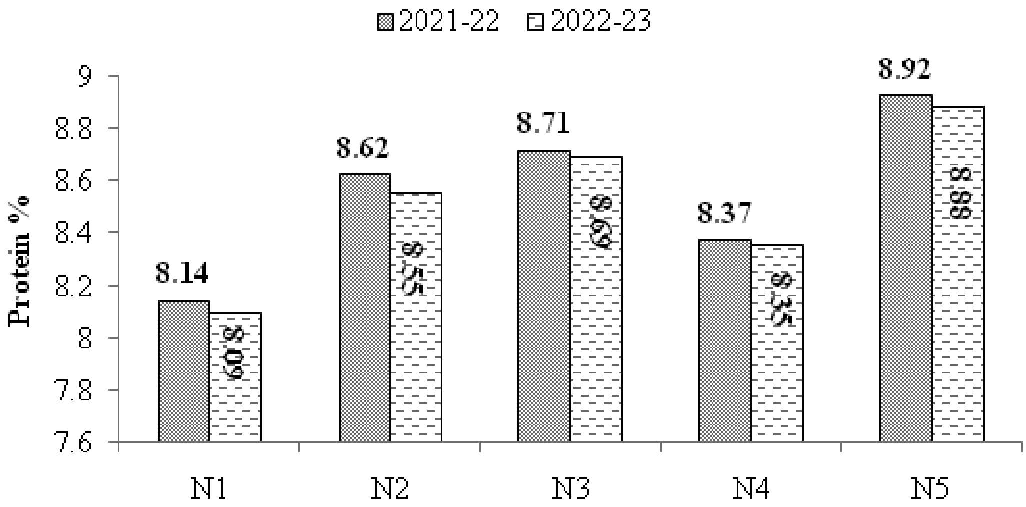

Fig.1: Protein % of QPM as influenced by fixed dose variable nitrogen management

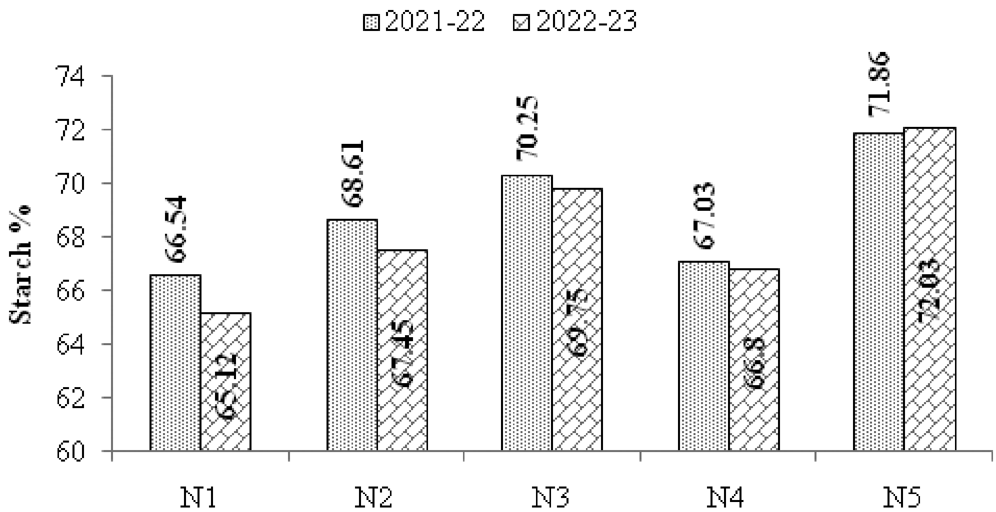

Fig. 2: Starch % of QPM as influenced by fixed dose variable nitrogen management