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Effect of Rate and Time of Nitrogen Application on Nutrient Content and Uptake in Summer Maize (*Zea mays* L.) and Soil Nutrient Status After Harvest

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Abstract

A field experiment was conducted at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari to study the effect of rate and time of nitrogen application on quality of summer maize. The treatments of the study included three rates (60, 90 and 120 kg N ha^{-1}) of nitrogen and three timings (two equal splits at sowing and 30 DAS, three equal splits at sowing, 30 and 45 DAS and four equal splits at sowing, 30, 45 and 60 DAS). Nitrogen, Phosphorus and Potassium content in grain and straw were determined by Modified Kjeldahl's method, Vanadomolybdo phosphoric acid colorimetric method and Flame photometric method, respectively. Nutrient content was multiplied by yield to calculate nutrient uptake (kg ha^{-1}). Available N, P_2O_5 and K_2O were determined by Alkaline permanganate method, Olsen's method and Flame photometric method, respectively. The rate and time of nitrogen had significant effect on nitrogen content in grain and straw. Phosphorus and Potassium content were non-significant. Nitrogen application at 120 kg ha^{-1} resulted in significantly higher nitrogen content and uptake. Nitrogen application in four equal splits at sowing, 30, 45 and 60 DAS resulted in higher N content and uptake. Similar results were observed in case of available N in soil after harvest. The available soil P_2O_5 and K_2O remained non-significant.

Keywords: Flame photometric method, maize, nutrient uptake, nitrogen

1. Introduction

Maize (*Zea mays* L.) also known as corn belongs to family Poaceae is one of the important cereal crops of the world due to its high value as staple food as well as straw demand for animal feed. It is one of the most versatile crops having wider adaptability and grown under varied agro-climatic conditions, diverse seasons and ecologies for various purposes (Niaz et al., 2014). Globally, maize is known as "queen of cereals" because of its highest genetic yield potential among the cereals. It is cultivated on nearly 183 m ha in the world with production of 1065 million tons with a productivity of 5820 kg ha^{-1} (USDA, 2016). It is grown in more than 160 countries having wider diversity of soil, climate, biodiversity and management practices that contributes 36% to the global grain production. USA is the largest producer of maize contributing nearly 35% of the total maize production in the world (Nemati and Sharifi, 2012). Maize is considered to be the driver of the US economy (Kumar et al., 2016). The USA has the highest productivity (≥ 10.96 t ha^{-1}) which is double of the global average (5.82 t ha^{-1}). Maize is the third most important food crop of India after rice and wheat. In India, it is cultivated in 9.63 m ha mainly during *Kharif* season which covers 80% area. Current maize production is 25.90 million tons, with an average productivity of 2689 kg ha^{-1} (MOAFW, 2016).

Nitrogen is the most unstable nutrient in the soil and is affected by several reactions such as volatilization, leaching, denitrification and immobilization (Karthika and Vageesh, 2014). The diversity of reactions that influence N dynamics makes timing of N application a crucial issue to balance N requirements for optimum maize growth and to minimize N losses to the environment (Jassal et al., 2016). The time of nitrogen application at appropriate crop growth stage when it is needed most and taken up at high rates by plants could enhance nitrogen use efficiency by reducing the immobilization, denitrification and leaching losses (Khalili et al., 2017). Optimum and efficient time of N application can increase the recovery of applied N upto 58-70% and hence, increase grain yield and quality of the crop (Rani et al., 2012).

Adequate nitrogen supply has the highest increasing effect on maize yield on most soils (Pal and Bhatnagar, 2015). However, the nitrogen recovery by the crops is very poor. It is reported that nitrogen use efficiency is variable with mean of only 33% of applied nitrogen being recovered by cereal crops (Adhikari et al., 2016). Lalita et al. (2017) also observed that maize N uptake improved and grain yield increased with split N fertilisation compared to single application at planting under irrigation system. There is little information available on nitrogen requirement and its time of application for summer maize. In view of the above, the present experiment was carried out.

2. Materials and Methods

A field experiment was conducted during summer 2018 at college farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari to assess the nutrient content and uptake by summer maize and the soil nutrient status after harvest of the crop. The soil of the experimental site was clayey in texture (62.17 %), medium in organic carbon (0.56 %), low in available nitrogen (192.86 kg ha^{-1}), medium in available phosphorus (49.58 kg ha^{-1}) and available potassium (501.42 kg ha^{-1}). The soil reaction was slightly alkaline (pH 8.15) with normal electrical conductivity.

Nine treatment combinations consisting of three nitrogen rates (N_1-60 kg N ha^{-1}, N_2-90 kg N ha^{-1} and N_3-120 kg N ha^{-1}) and three N timings (T_1-two equal splits at sowing and 30 DAS, T_2- three equal splits at sowing, 30 DAS and 45 DAS and T_3- four equal splits at sowing, 30 DAS, 45 DAS and 60 DAS) were evaluated in factorial randomized block design with four replications.

Before the experiment, pigeon pea was grown in the field and harvested in January and kept fallow prior to maize sowing. The maize variety GM-6 was sown on February 19, 2018. A seed rate of 25 kg ha^{-1} was used by keeping row-to-row distance of 60 cm and plant-to-plant distance of 20 cm. Sowing was done manually by maintaining plant-to-plant spacing with the help of marked stick (20 cm) as per the treatments. Seeds were covered with soil and irrigation was given immediately after sowing.

Bio-compost at 5 t ha^{-1} was applied on the experimental field before sowing and mixed well. Nitrogen was applied as per the treatments. Common application of 40 kg P_2O_5 ha^{-1} was made as basal. The sources of nitrogen and phosphorus were urea and single super phosphate, respectively. Total seven irrigations were given during the crop period. During the study the following chemical studies were conducted.

2.1. Nutrient content (%)

Representative samples of grain and straw were taken separately from each plot for the estimation of N, P and K content. The samples were oven died at 70ºC for 24-48 hours and powdered by mechanical grinder. The N, P and K content were determined by using the following methods (Table 1).

Table 1: Nutrient analysis methods of plant sample

Nutrients	Method	Reference
Nitrogen (%)	Modified Kjeldahl's method	Jackson (1973)
Phosphorus (%)	Vanadomolybdo phosphoric acid colorimetric method	Jackson (1973)
Potassium (%)	Flame photometric method	Jackson (1973)

2.2. Nutrient uptake (kg ha^{-1})

The nutrient uptake values of nitrogen (N), phosphorus (P) and potassium (K) by maize grins worked out using the following formula.

Nutrient uptake (kg ha^{-1})=(Nutrient content (%)×(Yield (kg ha^{-1}))/100

2.3. Nutrient status of soil (kg ha^{-1})

Representative soil samples from each plot were collected for chemical analysis. The samples were dried and powdered by mechanical grinder and passed through 2 mm sieve. The samples were analysed in respect of available nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) of soil before sowing and after harvest of the crop by following standard methods (Table 2).

Table 2: Nutrient analysis methods of soil sample

Nutrients	Method	Reference
Available nitrogen	Alkaline permanganate method	Subbiah and Asija (1956)
Available phosphorus	Olsen's method	Olsen et al. (1954)
Available potassium	Flame photometric method	Jackson (1973)

3. Results and Discussion

The results of the present study as well as relevant discussion have been summarized under following heads:

3.1. Nutrient content (%)

Nitrogen content of the grain and straw exhibited significant influence of the different levels of nitrogen. While, the different levels of nitrogen could not significantly influence the phosphorus and potassium content (Table 3). Application of 120 kg N ha^{-1} (N_3) recorded the significantly higher nitrogen content (1.593%) in grain which remained at par with 90 kg N ha^{-1}. Aulakh et al. (2012) also reported higher nitrogen content in grain with higher nitrogen dose. The phosphorus and potassium content in maize were not affected significantly.

Significantly higher nitrogen content in grain (1.591 %) and straw (0.578 %) were recorded under nitrogen application in four equal splits at sowing, 30 DAS, 45 DAS and 60 DAS (T_3), which remained statistically at par with nitrogen application in three equal splits at sowing, 30 DAS and 45 DAS (T_2). This might be due to timely supply of nitrogen and steady nitrogen intake by the crop.

3.2. Nutrient uptake (kg ha^{-1})

Nitrogen levels also increased the uptake of nitrogen, phosphorous and potassium by grain, straw and total uptake significantly (Table 4). Considerable improvement in N content and uptake was probably due to application of higher dose of nitrogen which increased its content in soil solution which increased the uptake and content of nitrogen by the maize.

Table 3: Effect of rate and time of nitrogen application on N, P_2O_5 and K_2O content in grain and straw of summer maize

Treatments	N content (%)		P_2O_5 content (%)		K_2O content (%)	
	Grain	Straw	Grain	Straw	Grain	Straw
Rate of N application (N)						
N_1 : 60 kg N ha^{-1}	1.445	0.511	0.456	0.310	0.379	0.860
N2 : 90 kg N ha^{-1}	1.560	0.546	0.467	0.319	0.386	0.868
N3 : 120 kg N ha^{-1}	1.593	0.578	0.484	0.327	0.406	0.881
SEm±	0.040	0.016	0.014	0.010	0.011	0.027
CD (*p*=0.05)	0.116	0.046	NS	NS	NS	NS
Time of N application (T)						
T_1 : Two equal splits (at sowing and 30 DAS)	1.448	0.509	0.462	0.311	0.387	0.868
T_2 : Three equal splits (at sowing, 30 DAS and 45 DAS)	1.558	0.548	0.466	0.320	0.389	0.872
T_3 : Four equal splits (at sowing, 30 DAS, 45 DAS and 60 DAS)	1.591	0.578	0.479	0.325	0.395	0.873
SEm±	0.040	0.016	0.014	0.010	0.011	0.027
CD (*p*=0.05)	0.116	0.046	NS	NS	NS	NS
Interaction (N×T)						
SEm±	0.069	0.028	0.024	0.017	0.019	0.046
CD (*p*=0.05)	NS	NS	NS	NS	NS	NS
CV %	8.96	10.13	10.11	10.71	9.91	10.57

Table 4: Effect of rate and time of nitrogen application on nitrogen, phosphorous and potassium uptake by summer maize

Treatments	N uptake (kg ha^{-1})			P_2O_5 uptake (kg ha^{-1})			K_2O uptake (kg ha^{-1})		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Rate of N application (N)									
N_1 : 60 kg N ha^{-1}	36.16	29.08	65.23	11.43	17.58	29.01	9.50	49.06	58.56
N2 : 90 kg N ha^{-1}	48.26	36.70	84.96	14.51	21.52	36.02	11.93	58.41	70.34
N3 : 120 kg N ha^{-1}	55.55	43.53	99.08	16.82	24.34	41.17	14.05	65.74	79.79
SEm±	2.04	2.07	3.65	0.60	1.12	1.59	0.49	3.32	3.63
CD (*p*=0.05)	5.96	6.04	10.65	1.75	3.27	4.64	1.44	9.68	10.59
Time of N application (T)									
T_1 : Two equal splits (at sowing and 30 DAS)	39.83	31.58	71.40	12.69	19.18	31.88	10.60	53.28	63.88
T_2 : Three equal splits (at sowing, 30 DAS and 45 DAS)	46.78	36.02	82.80	13.97	20.94	34.91	11.66	57.10	68.76
T_3 : Four equal splits (at sowing, 30 DAS, 45 DAS and 60 DAS)	53.35	41.70	95.06	16.10	23.32	39.41	13.22	62.82	76.04
SEm±	2.04	2.07	3.65	0.60	1.12	1.59	0.49	3.32	3.63
CD (*p*=0.05)	5.96	6.04	10.65	1.75	3.27	4.64	1.44	NS	NS
Interaction (N×T)									
SEm±	3.53	3.58	6.32	1.04	1.94	2.75	0.86	5.74	6.28
CD (*p*=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV %	15.15	19.67	15.22	14.59	18.37	15.55	14.48	19.89	18.06

The improvement in phosphorus and potassium uptake could be attributed to increase in grain and straw yield of maize under higher levels of nitrogen application. These findings are in agreement with those reported by Sharma et al. (2017) for nitrogen and phosphorus uptake.

Significantly higher uptake of nitrogen and phosphorus as well as remarkably higher potassium uptake by grain, straw and total uptake were recorded under T_3 as compared to two equal splits at sowing and 30 DAS (T_1). It was due to more production of biological yield in the former than later. Whereas potassium content of straw and total potassium content showed non-significant result under the various nitrogen timings. Results are more or less in accordance with those reported by Sunitha and Reddy (2012) in case of nitrogen and phosphorus uptake.

3.3. *Nutrient status of soil after harvest (kg ha^{-1})*

Data on (Table 5) available nitrogen status in soil was significant due to different nitrogen levels and it was increased with the increase in nitrogen level from 60 to 120 kg ha^{-1}. Treatment 120 kg N ha^{-1} (N_3) recorded significantly highest available nitrogen in soil (166.39 kg ha^{-1}). While, nitrogen at 60 kg ha^{-1} (N_1), recorded significantly lowest (141.29 kg ha^{-1}) available soil nitrogen. The increase in available nitrogen status in soil might be attributed to the increased application of nitrogen in soil and plants cannot utilize the excessive nitrogen content from soil solution. Niaz et al. (2014) reported higher available soil N after harvest of maize under higher nitrogen doses. Nitrogen levels did not manifest any significant effect on available phosphorus and potassium in soil after harvest of the crop.

Table 5: Effect of rate and time of nitrogen application on available N, P_2O_5 and K_2O status of soil after harvest of summer maize

Treatments	Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})
Rate of N application (N)			
N_1 : 60 kg N ha^{-1}	141.29	33.42	427.79
N2 : 90 kg N ha^{-1}	153.56	32.18	420.81
N3 : 120 kg N ha^{-1}	166.39	30.35	413.79
SEm±	4.08	0.96	12.06
CD (*p*=0.05)	11.91	NS	NS
Time of N application (T)			
T_1 : Two equal splits (at sowing and 30 DAS)	141.37	33.59	431.09
T_2 : Three equal splits (at sowing, 30 DAS and 45 DAS)	157.05	32.14	419.09
T_3 : Four equal splits (at sowing, 30 DAS, 45 DAS and 60 DAS)	162.82	30.21	412.20
SEm±	4.08	0.96	12.06
CD (*p*=0.05)	11.91	NS	NS
Interaction (N×T)			
SEm±	7.07	1.66	20.89
CD (*p*=0.05)	NS	NS	NS
CV %	9.19	10.36	9.93

The effect of split application of nitrogen had a significant effect on available nitrogen, while it did not significantly influence the available phosphorus and potassium content in soil after harvest. This might be due to timely adequate supply of nitrogen through fertilizer application and continuous transformation of nutrient in soil reserve. Pal and Bhatnagar (2015) also observed higher available soil N after harvest under higher number of split applications.

4. Conclusion

Remarkable increase in nitrogen content of grain and straw and nitrogen, phosphorous and potassium uptake by grain and straw as well as total uptake were noted with application of 120 kg N ha^{-1}. The available nitrogen status of soil after harvest of crop showed significant improvement up to 120 kg N ha^{-1} (166.39 kg ha^{-1}). Nitrogen application in four equal splits splits at sowing, 30 DAS, 45 DAS and 60 DAS recorded significantly higher nitrogen content, uptake and available N after harvest.

5. References

Adhikari, P., Baral, B. R., Shrestha, J., 2016. Maize response to time of nitrogen application and planting seasons. Journal of Maize Research and Development 2(1), 83-93.

Aulakh, G.S., Vashist, K.K., Sharma, S., Mahal, S.S., 2012. Productivity, quality and water expense efficiency of late *kharif* sown hybrid maize (*Zea mays* L.). Journal of Crop and Weed 8(2), 139-142.

Jackson, M.L.,1973. “Soil Chemical Analysis”. Prentice Hall of India Pvt. Ltd., New Delhi. pp. 183-192.

Jassal, R.K., Singh, A., Kang, J.S., Singh, T., 2016. Response of fodder maize to different levels of nitrogen under various planting methods. Indian Journal of Agricultural Research 50(4), 340-344.

Karthika, K.S., Vageesh, T.S., 2014. Effect of different levels of nitrogen on leaf chlorophyll content and performance of maize under varying soil nitrogen status in rainfed *Alfisols* of Karnataka. Environment and Ecology 32(2), 477-480.

Khalili, A., Dhar, S., Dass, A., Varghese, E., 2017. Growth and yield of maize (*Zea mays* L.) under various nitrogen doses and application schedules. Annals of Agricultural Research 38(3), 304-309.

Kumar, B., Singh, G., Kumar, R., Nishad, K.K., 2016. Effect of nitrogen and sulphur nutrition on growth and yield of maize (*Zea mays* L.) genotypes under eastern plain zone of U.P. International Journal of Agricultural Sciences 12(2), 181-185.

Lalita, V., Asewar, B.V., Pradeep, K., 2017. Effect of split application of nitrogen in *kharif* maize (*Zea mays* L.). International Journal of Agriculture Sciences 9(9), 3966-3967.

MOAFW, 2016. Area and production of maize in India. Directorate of economics and statistics, Ministry of agriculture and farmer’s welfare. Government of India.

Nemati, A.R., Sharifi, R.S., 2012. Effects of rates and nitrogen application timing on yield, agronomic characterstics and nitrogen use efficiency in corn. International Journal of Agriculture and Crop Sciences 4(9), 534-539.

Niaz, A., Yaseen, M., Arshad, M., Ahmad, R., 2014. Variable nitrogen rates and timing effect on yield, nitrogen uptake and economic feasibility of maize production. Journal of Agricultural Research 52(1), 77-89.

Olsen, S.R., Col, C.V., Watanabe, F.S., Dean, L.A., 1954. Estimation of available phosphorus in soil by extraction with sodium bicarbonate. USDA Circ. No. 939.

Pal, M.S., Bhatnagar, A., 2015. Effect of nitrogen scheduling on productivity, profitability and nitrogen use efficiency in maize (*Zea mays* L.) under *Tarai* region of Uttarakhand. International Journal of Basic and Applied Agricultural Research 13(1), 5-9.

Rani, P.L., Reddy, D.R., Sreenivas, G., Rao, V.P., Surekha, K., Siva, S.A., 2012. Dry matter partitioning and grain yield potential of maize (*Zea mays* L.) as influenced by dates of sowing and nitrogen application. Journal of Research ANGRAU 40(1), 30-34.

Sharma, R., Choudhary, R., Jat, B.L., 2017. Effect of nitrogen and zinc fertilization on growth and productivity of maize. International Journal of Agricultural Sciences 13(2), 161-176.

Subbiah, B.V., Asija, G.L., 1956. A rapid procedure for the estimation of available nitrogen in soil. Current Science 25(8), 259-260.

Sunitha, N., Reddy, P.M., 2012. Effect of graded nutrient levels and timing nitrogen application on yield and quality of sweet corn (*Zea mays* L.). Madras Agricultural Journal 99(4/6), 240-243

USDA, 2016. Area, production and productivity of maize in world. United States Department of Agriculture. USA.

