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RESEARCH PAPER

Effect of sap test based application of nitrogen on phenology and yield components in maize (*Zea mays* L.) genotype

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Abstract: The plant nutrient especially nitrogen in sufficient and balanced amounts is one of the key factors in increasing crop yield and decreasing adverse environmental effects. Therefore, current study was conducted to assess the effects of nitrogen on phenology and yield parameters on maize genotype at College of Agriculture, Vijayapur. The experiment was conducted with combinations of nitrogen levels 100, 75, 50, 25 and 0 kg per hectare with soil and foliar applications. Sap nitrate content was maximum at 40 DAS and decreased at 55 DAS and 70 DAS. Higher sap nitrate value of 1350 ppm was observed in the treatment T_8 *i.e.,* T_6 + rest of N in foliar application based on sap test at critical stages, whereas, at 0 kg N/ ha the sap nitrate value was 420 ppm. The increasing nitrogen rates showed reduce days for tasseling and silking. The significant short period of tasseling (49 DAS) and silking (53 DAS) was observed in T_1 (100:50:25 NPK kg ha^{-1}). However, nitrogen rates significantly affected the anthesis-silking interval. The treatment T_8 *i.e.,* T_6 + rest of N in foliar application based on sap test at critical stages showed significant higher cob length (22.35 cm), cob girth (15.95 cm), number of rows per cob (13.93), higher test weight value (38.19 g), grain yield per hectare (63.519 q ha^{-1}) as compared to T_{11} (0:50:25 NPK kg ha^{-1}). It was concluded that, sap test based application of nitrogen can reduce excess nitrogen application as well as environmental pollution.

Key words: Anthesis, Nitrogen, Silking, Tasseling

Introduction

Maize (*Zea mays* L.) is one of the versatile cereal crop grown in wide variety of environment conditions. Maize has robust growth habit with high requirement of nutrients, particularly nitrogen. Being an exhaustive crop it depletes a major portion of plant nutrients from soil by crop harvesting. Unless the soils are supplied with nutrients removed by the crop, it will be a great threat to sustain crop production. The use of more nitrogenous fertilizers is the quickest and surest way of boosting crop production. Nitrogen (N) management in maize production system is one of the main concerns since it is the most important and primary nutrient for growth and development of the crop. Agricultural production needs to be sustained with higher use efficiency of nutrients. Among them, as mentioned above the most important nutrient element is nitrogen. Hence, both soil fertility and plants health have to be managed in sustainable manner protecting the environment and human health (Abebe *et al.,* 2017).

Based on plant sap analysis application of nutrients is an alternate solution for nutrient management. Plant tissue analysis is a valuable tool for evaluating the nutritional status and quality of crops and is widely used for scientific and commercial purposes (Hansen *et al*., 2013). Quick tests to determine NO_3-N concentrations in fresh plant sap are alternatives to conventional analysis. These can be performed in the field without time lapse. A fresh tissue or sap may be more representative of living plant tissue than dried plant material. Testing fresh sap can be done on-farm where results can be obtained quickly and provide insight on the nitrogen dynamics of the crop. Plant sap analysis provides information that cannot be provided by routine soil or substrate analysis.

The response of maize plant to application of nitrogen fertilizer mainly depends on availability of nutriens. Research results have shown that various maize cultivars differ markedly in growth, phenological, physiological and yield response to nitrogen fertilization (Katsvairo *et al*., 2003). The aim of the present study was to evaluate the effect of different levels of nitrogen fertilizers on phenological and yield parameters of maize.

Material and methods

A field experiment was conducted during *Kharif* 2019 at College of Agriculture, Vijayapur, which is situated in Northern dry zone of Karnataka between 16°49' N latitude and 76°34' E longitude with an altitude of 678 meters above mean sea level (MSL). The experiment was laid out in a randomized block complete design (RCBD) with eleven treatments and three replications. The treatments were T_1 : 100:50:25 NPK kg ha^{-1} (100 % recommended dose NPK), T_2 : 75:50:25 NPK kg ha^{-1} (75 % N + 100 % PK), T_3: T_2 + rest of N in split application to soil based on sap test at critical stages, T_4 : T_2 + rest of N in foliar application based on sap test at critical stages, T_5 : T_2 + rest of N in soil and foliar application based on sap test at critical stages, T_6 : 50:50:25 NPK kg ha^{-1} (50 % N + 100 % PK), T_7 : T_6 + rest of N in split application to soil based on sap test at critical stages, T_8 :T_6 + rest of N in foliar application based on sap test at critical stages, T_9 : T_6 + rest of N in soil and foliar application based on sap test at critical stages, T_{10} : 25:50:25 NPK kg ha^{-1} (25 % N + 100 % PK) and T_{11} : 0:50:25 NPK kg ha^{-1} (0 % N + 100 % PK). Entire dose of PK and 50 % N was applied at the time of sowing and rest 50 % N was applied as top dress at 30 days after sowing.

The plant sap indices were observed during the maize crop growth. Focal point of the present experiment is sap nitrate content, which has been used for application of nitrogen in maize. To measure the nitrate in fresh sap of maize a specific ion electrode meter (B-731 "LAQUA twin" Cardy meter, of Horiba Scientific, Irvine, CA) will be used. Maize plant sap will be collected in between 8-10 am using garlic press at three different stages *viz.,* (40 DAS, 55 DAS, 70 DAS). Stem of the selected plant will be cut at 15 cm above the ground level or where fully expanded second leaf from top is situated. Two to three drops of sap will be placed on the sensor pad of four ion-specific electrode meters, for NO_3-N measurement. Prior to the measurement the meters will be calibrated using standard solutions. Eventually, phenological parameters *viz*., number of days to 50% tasseling, silking, anthesis to silking and yield parameters *viz*., cob length, cob girth and harvest index and kernel yield were recorded to know their variability and relation along with nitrate content in maize.

Results and discussion

Nitrate content was influenced by different levels of nitrogen and significantly varied at all the growth stages in the maize genotype (Table 1). Nitrate content was maximum at 40 DAS and decreased at 55 DAS and further decreased at 70 DAS. Among the treatments, T_1 (100:50:25 NPK kg ha^{-1}) had shown significantly higher nitrate content (2033 ppm) at 40 DAS. While, significant lower nitrate value (700 ppm) was observed in treatment T_{11} (0:50:25 NPK kg ha^{-1}) at 40 DAS. However at 55 DAS T_8 - T_6 + rest of N in foliar application based on sap test at critical stages had significant higher nitrate content (1520 ppm) whereas, T_{11} (0:50:25 NPK kg ha^{-1}) had significant lower nitrate content (510 ppm). Similar trend was recorded at 70 DAS.

Maize crop recorded initially high nitrate content, later it was gradually decreased in mid stage and at maturity. Crop at initial stage accumulated nitrate content and later it was metabolized into amino acids, amides and utilized for further growth and development of the crop and was witnessed from the increase in the height, girth of the plant, number of leaves as well leaf area in the present investigation. Similar results were reported by Baker *et al*. (1972) and Lopez *et al*. (2010) in cotton petioles and Prasad & Spiers, 1985; Hochmuth, 1994; Goffart *et al*., 2008 in vegetable crops. Eventually, treatment T_8 - T_6 + rest of N in foliar application based on sap test at critical stages had significant higher nitrate content indicating that cuticular membrane which are present on the leaves are permeable to both organic and inorganic ions. This property helped in rapid absorption transportation of nutrients to all other parts. These results were in close proximity with Fageria *et al*. 2009.

The different phenological parameters *viz*., days to 50% tasseling, days to 50% silking and anthesis to silking interval at different levels of N differed significantly and represented in Table 1. As application of nitrogen and increase in its rate induced earliness in tasseling stage. Significant short period of tasseling (49 DAS) was observed in T_1 (100:50:25 NPK kg ha^{-1}). Furthermore significant longest period of tasseling (53 DAS) was recorded in T_7 - T_6 + rest of N in split application to soil based on sap test at critical stages and T_{11} (0:50:25 NPK kg ha^{-1}) and these two treatments are on par with each other. The increasing rates of nitrogen showed reduced days for silking. Significant short period to silking (53 DAS) was recorded in T_1 (100:50:25 NPK kg ha^{-1}). Like wise, significant longest period of silking (59 DAS) was observed in T_{10} (25:50:25 NPK kg ha^{-1}) and T_{11} (0:50:25 NPK kg ha^{-1}). Different level of nitrogen was significantly affect the anthesis to silking interval in maize genotype. Increase in anthesis to silking interval (7 DAS) was recorded in treatment which receives 25 % N + 100% PK (T_{10}) followed by T_{11} (0:50:25 NPK kg ha^{-1}) 6 DAS. Lowest ASI

Table 1. Effect of nitrogen on phenological parameters and sap nitrate content in maize genotype

Treatments	Sap nitrate content (ppm)			Phenological content		
	40 DAS	55 DAS	75 DAS	40 DAS	55 DAS	75 DAS
T_1 - 100:50:25 NPK kg ha^{-1} (100 % recommended dose NPK)	2033	1005	850	49	53	3.67
T_2 - 75:50:25 NPK kg ha^{-1} (75 % N +100 % PK).	1767	910	790	50	54	3.33
T_3 - T_2 + rest of N in split application to soil based on sap test at critical stages	1710	968	700	52	56	3.67
T_4 - T_2 + rest of N in foliar application based on sap test at critical stages	1600	1120	1020	50	55	5.67
T_5 - T_2+ rest of N in soil and foliar application based on sap test at critical stages	1698	1430	1100	49	53	3.67
T_6 - 50:50:25 NPK kg ha^{-1} (50 % N+100 % PK).	1233	779	630	52	58	5.67
T_7 - T_6 + rest of N in split application to soil based on sap test at critical stages.	1127	848	1180	53	57	3.67
T_8 - T_6 + rest of N in foliar application based on sap test at critical stages	1200	1520	1350	51	56	5.00
T_9 - T_6+ rest of N in soil and foliar application based on sap test at critical stages.	1100	1345	900	51	55	4.67
T_{10} - 25:50:25 NPK kg ha^{-1} (25 % N+100 % PK).	833	650	500	52	59	7.00
T_{11} - 0:50:25 NPK kg ha^{-1} (0 % N+100 % PK).	700	510	420	53	59	6.00
Mean	1363	1007	858	51	55	4.73
S.Em.±	16.99	16.31	14.29	0.87	0.65	0.13
C.D. @ 0.05	50.13	48.13	42.16	2.58	1.91	0.38

Table 2. Effect of nitrogen on yield parameters in maize genotype

Treatments	Cob length (cm)	Cob girth (cm)	No. of rows per cobs	Test weight (g)	Grain Yield (q/ha)
T_1 - 100:50:25 NPK kg ha^{-1} (100 % recommended dose NPK)	17.70	14.79	12.20	32.45	54.16
T_2 - 75:50:25 NPK kg ha^{-1} (75 % N +100 % PK).	17.52	14.67	12.33	31.62	52.31
T_3 - T_2 + rest of N in split application to soil based on sap test at critical stages	16.83	14.60	12.40	30.98	48.42
T_4 - T_2 + rest of N in foliar application based on sap test at critical stages	18.43	15.05	13.60	34.50	58.88
T_5 - T_2+ rest of N in soil and foliar application based on sap test at critical stages	18.56	15.01	13.80	35.12	60.74
T_6 - 50:50:25 NPK kg ha^{-1} (50 % N+100 % PK).	16.17	14.50	12.40	30.44	47.31
T_7 - T_6 + rest of N in split application to soil based on sap test at critical stages.	19.50	15.48	13.87	36.92	61.94
T_8 - T_6 + rest of N in foliar application based on sap test at critical stages	22.35	15.95	13.93	38.19	63.51
T_9 - T_6+ rest of N in soil and foliar application based on sap test at critical stages.	18.00	14.82	12.40	33.86	57.03
T_{10} - 25:50:25 NPK kg ha^{-1} (25 % N+100 % PK).	15.97	14.17	12.27	29.74	46.29
T_{11} - 0:50:25 NPK kg ha^{-1} (0 % N+100 % PK).	13.84	13.63	12.27	28.67	38.05
Mean	17.72	14.79	12.86	32.95	53.51
S.Em.±	0.51	0.18	0.18	0.98	0.71
C.D. @ 0.05	1.51	0.53	0.54	2.90	2.09

(3.3 DAS) was observed in T_2 (75:50:25 NPK kg ha^{-1}) followed by T_1 (100:50:25 NPK kg ha^{-1}) 3.61 DAS.

In current study it was noted that, application of nitrogen and increase in its rate induced earliness in tasseling and silking stage. The treatment which receives 100 % recommended nitrogen fertilizer had significant short period of tasseling (49 DAS) and silking (53DAS). Similarly, treatment which receives 0 % nitrogen had longer days to tasseling (53DAS) and silking (59 DAS). Similar results were reported by increase in N rate and number of split application may cause vigorous growth and might have increased the rate of photosynthesis (Oikeh *et al.,* 1997) which influences earliness in tasseling and silking. Jiban Shrestha *et al.* (2018) reported that, higher amount of nitrogen rates had short period of tasseling and silking due to quick growth.

The N application time and rates significantly affected the anthesis-silking interval. A shorter ASI with higher N was because of inducing early and rapid growth. Gungula *et al.* (2007) reported that there will be more synchrony in flowering with higher nitrogen. So, results indicated that the minimum of ASI (3.33 days) in (75:50:25 NPK kg ha^{-1}) and the maximum of it 7 days in (25:50:25 NPK kg ha^{-1}) In agreement with the results of the present study, decrease in ASI has been reported with increasing of N levels by Gokmen *et al.* (2001) and Akbar *et al.* (2002).

The yield attributes like cob length, cob girth, number of rows per kernel, test weight, grain weight and grain yield were differed significantly accordingly with different nitrogen levels is tabulated in Table 2. Among all the treatments, T_8 - T_6 + rest of N in foliar application based on sap test at critical stages showed significant higher cob length (22.35 cm), cob girth (15.95 cm), number of rows per cob (13.93), higher test weight value (38.19 g), grain yield per hectare (63.519 q ha^{-1}) whereas, lowest values of yield parameters were recorded in T_{11} (0:50:25 NPK kg ha^{-1}). These results were confirmative with the findings of Subhanullah *et al.* (2017) who reported that, the increase in cob length might be due to the delayed growth period and improved leaf area with the application of foliar urea. Application of foliar urea enhanced vegetative growth, plant height and leaf area of maize which might have improved the number of grains per cob. Earlier studies suggested that application of foliar N spray increased number of grains per cob in maize (Sanjeev *et al.,* 1997, Amanullah *et al.,* 2010a). In wheat crop, highest numbers of grains per spike were reported (Arif *et al.,* 2006) with the application of foliar NPK sprays. Our results are in line with the findings which found signiûcant effects of N application on the number of grains per cob in maize. Higher 1000 grain weight was recorded with foliar urea application. The increase in grain weight might be due to the longer grain filling period resulting in more photosynthates allocation to the grains. About 90% of the required N for ear development is allocated from the stored N in stalks and leaves during anthesis and grain filling stages (Ta *et al.,* 1992). Foliar N application had increased photo-assimilates accumulation in grains resulting in improved grain weight of maize. The improved vegetative growth period, average leaf area, grains per cob and 1000 grain weight might have resulted in higher grain yield of maize. Significantly higher grain yield had been reported in maize with foliar urea application (Gooding *et al.,* 1992 ; Amanullah *et al.,* 2010b). Lower values of yield parameters were recorded in treatment which receives 0 % nitrogen fertilizer which mainly because of vegetative growth, carbon assimilation, mobilization of nutrients were decreased due to lack of nitrogen as it is an essential nutrient for growth and development of maize crop.

Conclusion

The current study indicated that the sap nitrate content differed significantly among the treatments. Increase in nitrogen rates induced the earliness in tasseling and silking stages. The yield parameters were higher in the treatment T_8 *i.e* T_6 {50:50:25 NPK kg ha^{-1} (50 % N + 100 % PK)} + rest of N in foliar application based on sap test at critical stages as compared to T_{11} (0:50:25 NPK kg ha^{-1}). It was found that sap test based application of nitrogen helps in quantification of nitrogen requirement based on crop demand and can reduce environment pollution.

References

Abebe Z and Feyisa H, 2017, Effects of nitrogen rates and time of application on yield of maize: rainfall variability influenced time of N application. *International Journal of Agronomy,* 46: 345-353.

Akbar H, Maftihullah M, Jan T, Jan A and Hsanul-lah I, 2002, Yield potential of sweet corn as influenced by different levels of nitrogen and plant popula-tion. *Asian Journal Plant Science*, (6): 631- 3.

Amanullah, Khan A Z, Jan A, Shah A, Ahmad, Khalil S K, Ali S, Hidayatullah, Ahmad and Nawaz A, 2013, Foliar application of nitrogen at different growth stages influences the phenology, growth and yield of maize (*Zea mays* L.). *Soil Environment,* 32(2): 135-140.

Amanullah M, Yasir S K, Khalil M T, Jan and Khan A Z, 2010, Phenology, growth and grain yield of maize as influenced by foliar applied urea at different growth stages. *Journal of Plant Nutrition,* 33: 71-79.

Arif M, Imran S, Khan A, Khan M A and Shah W, 2015, Effect of nitrogen levels and plant population on yield and yield components of maize. *Advances in Crop Science and Technology,* 3: 170.

Baker J M, Reed R M and Tucker B B, 1972, The relationship between applied nitrogen and the concentration of nitrate-N in cotton petioles. *Soil Science and Plant Analysis,* 3(4): 345-350.

Fageria N K and Baligar V C, 2005, Enhancing nitrogen use efficiency in crop plants. *Advances in Agronomy*, 88: 97-185.

Goffart J, Olivier M and Frankinet M, 2008, Potato crop nitrogen status assessment to improve N fertilization management and efficiency: Past–present-future. *Potato Research*, 51, 355-383.

Gokmen S, Sencar O and Sakin M A, 2001, Response of popcorn (*Zea mays* everta) to nitrogen rates and planting densities. *Turkish Journal of Agriculture and For*estry, 25: 15-23.

Gooding M J and Davies W P, 1992, Foliar urea fertilization of cereals: A review. *Nutrient Cycling in Agroecosystems,* 32: 209-222.

Gungula D T, Togun A O and Kling J G, 2007, The ef-fect of nitrogen rates on phenology and yield components of early maturing maize cultivars. *Crop Science,* 13(3): 319-24.

Hansen T H, de Bang T C, Laursen K H, Pedas P, Husted S and Schoerring J K, 2013, Multi element Plant Tissue Analysis Using ICP Spectrometry. *Plant Mineral Nutrients, Methods in Molecular Biology,* 953: 121-141.

Hochmuth G J, 2003, Progress in mineral nutrition and nutrient management for vegetable crops in the last 25 years. *Horticultural Sciences*, 38: 999-1003.

Jiban S, Nath Y D, Prasad A L and Sharma J P, 2018, Effects of nitrogen and plant density on maize (*Zea mays* L.) phenology and grain yield. *Current Agriculture Research Journal,* 6(2) 175 - 182.

Katsvairo T W, Cox W J, Van Es H M and Glos M, 2003, Spatial yield response of two corn hybrids at two nitrogen levels. *Agronomy Journal,* 95:1012-1022.

Lopez M, Castro J C, Gutierrez J C and Leidi E O, 2010, Nitrate and potassium concentrations in cotton petiole extracts as influenced by nitrogen fertilization sampling date and cultivar. *Spanish Journal of Agricultural Research*, 8(1): 202-209.

Oikeh S O, Kling J G, Chude V O and Horst W J, 1997, Yield and N-use efficiency of five tropical maize genotypes under N levels in the moist savanna of Nigeria. Proceedings, 5th Eastern and Southern Africa Regional Maize Conference, 3-7 June 1996, Arusha, Tanzania, CIMMYT, Addis Ababa, Ethiopia, pp. 163-167.

Prasad M and Spiers T M, 1985, A rapid nitrate sap test for outdoor tomatoes. *Scientia Horticulturae,* 25: 211-215.

Sanjeev K A, Bangarwa S and Kumar S, 1997, Yield and yield components of winter maize as influenced by plant density and N levels. *Agriculture Science,* 17: 181-184.

Subhanullah, Muhammad R K and Hamid U R, Influence of foliar urea on the phenology, growth and yield of maize applied at various growth stages. *Pure and Applied Biology*, Vol. 6, Issue 1, pp. 247-255.

Ta C T and Weiland R T, 1992, Nitrogen partitioning in maize during ear development. *Crop Science,* 32: 443-451.