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Nutrient Uptake Rate and Relationship With Grain Yields of Hybrid Maize Under Drip Fertigation

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Field experiment was conducted at Agricultural College and Research Institute, Coimbatore during summer, 2007 to study the effect of drip fertigation levels and frequencies on nutrient uptake rate and relationship with grain yields of hybrid maize. Four fertigation frequencies (once in 6, 9,12 and 15 days), two fertilizer levels (100 and 150 percent of RDF), surface irrigation with 100 per cent RDF and absolute control (no fertilizer) were included as treatments in this study. Supply of 150 per cent of RDF once in 6 days (T_5) recorded significantly higher nutrient uptake than 100 per cent of RDF. Absolute control (T_{10}) recorded the lowest plant nutrient uptake rate followed by surface irrigation with 100 per cent RDF (T9) for NPK throughout the cropping period. The results revealed that application of nutrients through fertigation very frequently (once in six days) with 150 per cent RDF (T_5) recorded higher uptake rate for all nutrients. The uptake rate of nutrients during 30-60 DAS was twice higher than the initial stage (0-30 DAS) for Nitrogen (N) and Potassium (K). With respect to Phosphorus, it was higher during 30-60 DAS and the increment was slightly higher than initial stage unlike N and K. Correlation Analysis indicated that N and K were highly correlated with grain yield than P.

Key words: ~~Drip fertiga~~tion, hybrid maize, nutrient uptake.

Maize (*Zea mays* L) grain yields have increased steadily with application rate of nutrients, use of hybrid and better management practices *viz.,* drip fertigation. Maize is a nutrient loving crop, which pumps out more quantity of nutrients from soil. Nutrient requirement of a crop is not uniform in the growth period. Rate of N uptake is affected as the corn plant grows. Generally uptake is the greatest between V8 (vegetative stage with 8 leaves) and silking (Russelle *et al.,* 1983). Binder *et al*. (2000) reported that maximum yield was obtained when N was applied on or before 71 days after sowing (DAS) for maize crop, otherwise develops N deficiency during grain filling stage. Withholding N supply from V8 to maturity reduced the kernel yield by 22 per cent and N uptake by 53 per cent. Plants supplied with adequate N until silking (55-60 DAS) can maintain kernel yield and N concentration in kernels (Subedi and Ma, 2005). Maize accumulates only about 10-20 per cent by the four-leaf growth stage. While, during the next six weeks of growth prior to tasseling, N accumulation approaches 60 to 70 per cent of total N uptake.

Fertigation is a frontier technology, which saves the fertilizers and increases the use efficiency of applied nutrients and the yield of crop. Nutrients can be injected into the system at various frequencies. Basically the frequency to inject, whether once a day or once every two days or even once a week, depends on system design constraints, soil type and grower preference. Fertigation frequency is one major management variable with drip irrigation systems that has not been adequately investigated. The recovery of the nutrients from the applied fertilizers varies with the crop species, management practices, soil properties and nutrient sources (Jagadeeswaran *et al.*, 2005).

The present experiment was conducted to study the effect of drip fertigation levels and frequencies on hybrid maize to find out the effect of drip fertigation on nutrient uptake rate pattern and the relationship among grain yields and nutrient uptake.

Materials and Methods

Field experiment was conducted at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, during summer, 2007. The experimental soil was sandy clay loam with 1.41 g cc^{-1}, 22.6 and 11.4 per cent bulk density, field capacity and permanent wilting point, respectively. Soil was low (232 $kgha^{-1}$), medium (18.6 kg ha^{-1}) and high (445 kg ha^{-1}) in available nitrogen, phosphorus and pot assium, respectively.

The experiment was laid out in a randomized

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block design replicated thrice. Four fertigation frequencies and two fertilizer levels were included in this study. The treatments were T_1- 100 per cent RDF once in 6 days; T_2 - 100 per cent RDF once in 9 days; T_3 - 100 per cent RDF once in 12 days; $_4$T- 100 per cent RDF once in 15 days; T - 150 per cent RDF once in 6 days; T_6 - 150 per cent^5 RDF once in 9 days; T_7 - 150 per cent RDF once in 12 days; T_8 - 150 per cent RDF once in 15 days; T $_9$ - Surface irrigation with 100 per cent RDF; I_{10} - Absolute control (no fertilizer).

The experimental field was thoroughly ploughed using tractor drawn tiller and then properly leveled. After leveling the field, ridges and furrows were formed at 75 cm apart to accommodate furrow irrigated crop. Broad beds were formed in the dimension of 120 cm width, 30 cm furrow and 15 cm height. Buffer channels were formed to control the lateral seepage of water from one plot to another plot. The plot size was 6.0 x 4.5 m (27 m_2). Laterals were placed 1.5 m apart as one per two rows of crop. Emitters were inline, placed 60 cm apart and have the discharge rate of 4 lph (liters per hour). Healthy and viable seeds of Hi Shell maize hybrid were sown at the rate of 20 kg per hectare. Seeds were hand dibbled at the rate of one per hole. Paired row spacing of 120 +30 x 20 cm was followed.

Sowing irrigation was uniformly given to all treatments. The depth of irrigation was 5 cm. Under surface irrigation, water was applied based on IW/ CPE (IW - Irrigation Water; CPE - Cumulative Pan Evaporation) ratio of 0.75 and wetted area concept in case of drip irrigation. Drip irrigation system was operated once in three days at 100 per cent ET c (Crop Evapotranspiration).

Water requirement or ETc (lpd) = CPE x Kp x Kc x Wp x S

Where CPE - Cumulative pan Evaporation (m); Kp - Pan factor (0.8); Kc - Crop factor;

Wp - Wetting area percentage (80 per cent); S - Spacing (0.75 x.0.20 m).

Table 1. Kc values for different growth periods

Stage	Duration (days)	Kc value
Initial	20	0.40
Crop development	30	0.80
Mid season	40	1.15
Late season	10	0.70

Fertigation was done through venturi system to each plot. Fertilizer solution was filled in plastic bucket and connected with suction device of venturi. Fertigation was given as per the treatments. The fertilizer dose of 150:75:75 and 225:112.5:112.5 NPK kg per hectare was applied in 100 and 150 per cent level of RDF, respectively. Nitrogen, Phosphorus and potash were applied in the form of urea, single super phosphate and muriate of pot ash, respectively. Phosphorus was applied as soil application in all the treatments except absolute control. Urea and muriate of potash were applied through irrigation water as fertigation according to the schedule (Table 2). Fertigation schedule was started on 6 DAS.

Table 2. Fertigation schedule

Stage	Nutrient (per cent)	
	N	K
6-30 DAS	25	25
30-60 DAS	50	50
60-80 DAS	25	25

Atrazine 0.5 kg ha^{-1} was applied as pre emergence herbicide on 3 DAS. Hand weeding was done on 25 DAS. Gap filling was done on 10 DAS and optimum plant population of 66,666 ha^{-1} was maintained. Healthy crop stand was ensured by adopting need based plant protection and following the recommended package of practices.

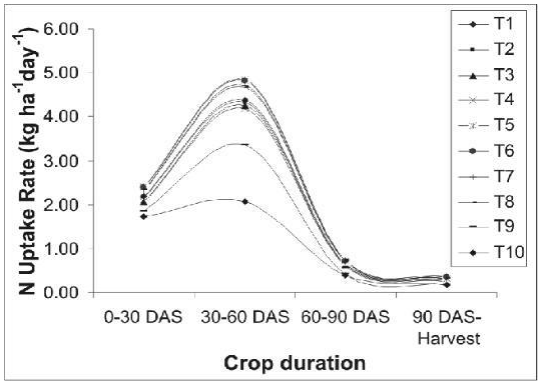
Plant uptake for nutrients (N, P and K) was worked out by multiplying the nutrient content with DMP and daily nutrient uptake rate was calculated for each nutrient dividing the duration. Analysis of nutrients in plant parts was carried out as suggested by Humphries (1956) for nitrogen and Jackson (1973) for phosphorus and potassium. Correlation analysis was carried out by SPSS 16.0 software for grain yields, and nutrients uptake using average values.

Results and Discussion

Nutrients uptake rate

Drip fertigation apparently increased the uptake rate of nutrients (N, P and K) when compared to surface irrigation (T_9). Application of nutrients through fertigation very frequently (once in six days) with 150 per cent RDF (T_5) recorded more uptake rate for all nutrients throughout the cropping period. Plotting the uptake rate of nutrients over the cropping period (Fig. 1) indicated that it was higher during the middle stage (30-60 DAS) for all the nutrients in all the treatments except absolute control (T_{10}) and thereafter decreased until the harvest of the crop.

Maize is a nutrient responsive crop and it responded well to the applied higher nutrients in addition to native soil fertility. This increase in uptake



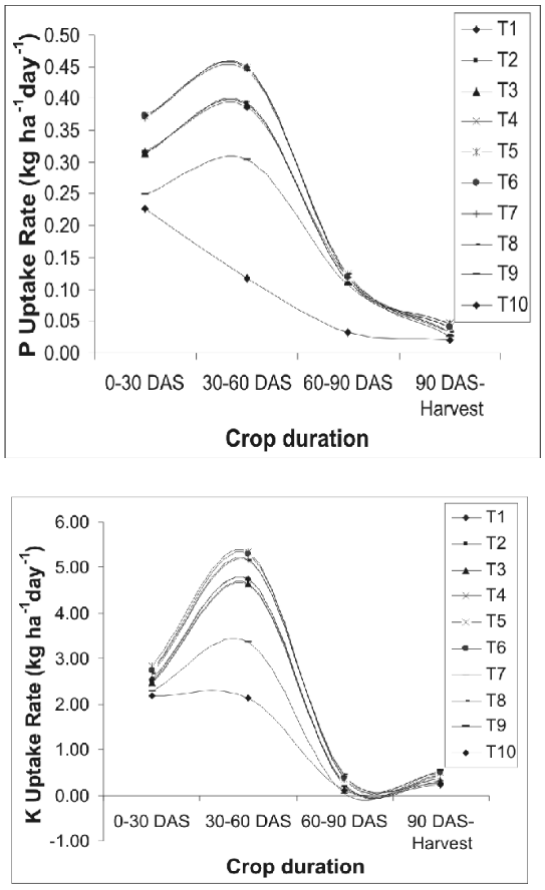


Fig. 1. Nutrient uptake rate of maize under drip fertigation

per plant was due to the better availability of nutrients in root zone as a result of frequent application of nutrients coupled with better root activity . Further, it was also due to the reduced loss of nutrients due to leaching in fertigation compared to soil application of fertilizer. The same was reported by Binder et al. (2000). They found that maximum growth was observed when nutrients were applied on or before 71 DAS, otherwise nutrient deficiency (especially nitrogen) will develop during grain filling stage.

Table 3. Correlation analysis of grain yield and nutrient uptake of maize under drip fertigation

Parameter	Grain yield	N	P	K
Grain yield	1.0	0.998*	0.993*	0.998*
N	0.998*	1.0	0.991*	0.999*
P	0.993*	0.991*	1.0	0.988*
K	0.998*	0.999*	0.988*	1.0

Note: * Significant at 0.01 level probability

Negative trend of uptake rate for nutrients from initial stage (0-30 DAS) to harvest in absolute control was mainly because of no external application of fertilizers and initially native soil pool supplied the nutrients to the crop and thereafter it depleted towards harvest. The uptake rate of nutrients during 30-60 DAS was twice higher than the initial stage (0-30 DAS) for N and K. With respect to P , it was higher during the 30-60 DAS and the increment was slightly higher than initial stage unlike N and K where it was twice higher than the initial stage. This trend indicated the demand of nutrients over the periods and releasing capacity of nutrients from soil. The release of P was slower than the other two nutrients (N and K) and it was apparent from the trend of uptake rate.

Grain yields and nutrients uptake relations

Correlation analysis was carried out among grain yields and plant nutrient uptake to find out the highly correlated nutrients to the grain yields. The correlation analysis indicated that N and K were highly and positively correlated (T able 3) with grain yield than P . Higher correlation co -ef ficient values (0.998) were obtained for N and K than P (0.993). It indicated that among the different major nutrients, N and K are most demanding followed by P .

Conclusion

The results revealed that application of nutrients through fertigation very frequently (once in six days) with 150 per cent RDF (T_5) recorded more uptake rate for all nutrients throughout the cropping period. The uptake rate of nutrients during 30-60 DAS was twice higher than the initial stage (0-30 DAS) for N and K. With respect to P it was higher during the 30-60 DAS and the increment was slightly higher than initial stage. The correlation analysis indicated that N and K were highly correlated with grain yield than P.

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