

RESPONSE OF NITROGEN ON HYBRID MAIZE GROWN AT HIGH PLANT DENSITY UNDER SUPPLEMENTARY IRRIGATION

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ABSTRACT

Maize has become a major crop for lowlands under irrigation during *yala* season in Sri Lanka. Previous findings have proved the possibility of reaching high yields at high plant density (88,888 plants/ha). In these studies, the optimum N requirement has not been investigated. Therefore, an experiment was conducted during *yala* 2006 and *yala* 2007 seasons on lowland paddy lands at Field Crops Research and Development Institute, Mahailluppallama to identify an economical Nitrogen level for hybrid maize grown at high plant density under supplementary irrigation. The Treatments were 50, 100, 150, 200, 250, 300 and 350 kg of N/ha. Phosphorous and Potassium were applied at 45 kg/ha and 30 kg/ha respectively. The data revealed that the most important yield components responsible for total yield with varying N rates were the number of seeds per cob and 100 seed weight. Regression analysis showed that the Nitrogen levels at which the maximum harvest index (HI) and maximum yield were arrived were 190kg/ha (*yala* 2006), 230kg/ha (*yala* 2007) and 357 kg /ha (*yala* 2006), 330 kg /ha (*yala* 2007) respectively. The Benefit: Cost Ratio (BCR) >1 up to the level of 250 kg N/ha in *yala* 2006 whereas in *yala* 2007, BCR > 1 only up to 200 kg N/ha. These data suggested that the preferable N rate for hybrid maize grown at high density under irrigation at the given rates of P and K was 200 kg N/ha which leads to a BCR of 1.56 in *yala* 2006 and 1.55 in *yala* 2007 seasons.

KEY WORDS: High plant density, Hybrids, Nitrogen fertilizer

INTRODUCTION

Maize is the second most important cereal crop grown in Sri Lanka. It is mainly cultivated in *maha* season (From October to February) totally under rain-fed conditions on highlands in Sri Lanka. Nevertheless, there is a great potential to be grown in paddy lands which are kept fallow due to unavailability of

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sufficient water for paddy cultivation during *yala* season (March – August) under supplementary irrigation (Jayawardena, *et al.* 2000). Previous findings have proved the possibility of reaching higher yields at high plant densities (88888 plants/ha) under irrigated conditions (Malaviarachchi *et al.*, 2007), but an optimum N requirement has not been studied at that density. Nutrient uptake varies depending upon the number of plants per unit area. Close plant stands demand more N (Xu, 2001; Cooke, 1975). However, the present recommendation of Department of Agriculture, Sri Lanka (DOASL) for maize under irrigated condition (150 N kg/ha) would not meet the N requirement at above density because Hybrid varieties are highly fertilizer responsive (Tollenaar, 1991; Cooke, 1975). After the rapid acceptance of hybrid maize in USA closer spacing was used to increase yield along with a better fertilization and soil management (Berger, 1962). McCullough *et al.* (1994) reported that the new hybrids had greater N use efficiency than old hybrids during early stages of maize development due to greater N uptake per unit leaf area. Therefore, high leaf area index under high density requires high amount of N to increase yield per unit land area since low nitrogen supply affects most of the growth, physiological (Uhart and Andrade, 1995) and reproductive (Jacobs and Pearson, 1991; Pearson and Jacob, 1987) processes resulting a reduction in final grain yield.

Therefore, the objective of this study was to identify an optimum and economical N level for hybrid maize while maintaining the same P and K levels to enable an effective N utilization to maximize yield of maize grown at high plant densities with supplementary irrigation.

MATERIALS AND METHODS

The experiment was conducted during *yala* 2006 season on lowland paddy lands where the Great Soil group was Low Humic Gley soils (Panabokke, 1996) and was repeated in *yala* 2007 on the same soil type but at a different site at Field Crops Research and Development Institute (FCRDI), Mahailuppallama, Sri Lanka. The measured values of initial soil characteristics is given in the Table 1.

The crop was irrigated at 4 days intervals up to 3 months and thereafter no irrigation was given until harvesting in both experiments. Plots were arranged in the Randomized Complete Block Design with 3 replicates. Plot size was 4.2 m x 3.6 m. Rates of nitrogen applied per hectare were;

T1 - 50 kg; T2 - 100 kg; T3 - 150 kg; T4 - 200 kg; T5 - 250 kg; T6 - 300 kg; T7 - 350 kg.

Table 1. Initial soil characteristics of the research site

Location	Soil type	Season	Kjeldahl N (%)	Olsen P_2O_5 (ppm)	K_2O (Ammonium acetate extraction method) (ppm)	Organic matter (%)	pH
FCRDI	LHG	Yala 2006	1.1	40	115	1.9	6.0
FCRDI	LHG	Yala 2007	0.8	6	200	1.6	6.5

Phosphorous and K were applied at 45 P_2O_5 kg/ha as Triple Super Phosphate and 30 K_2O kg/ha as Murate of Potash, the present recommendation of the DOASL. The plant density was maintained as 88888 plants/ha at the spacing of 75cm X 15cm. Stem borer was controlled by application of Diazinon (5%) granules at 3 weeks after planting. The locally developed hybrid variety "Sampath" was used in the study. Yield components were measured at the harvest. Harvest Index (HI) was estimated using 10 randomly selected plants at the harvesting. All data were analyzed using SAS statistical software and an economic analysis was performed following the partial budget technique (CIMMYT, 1988) to determine the most economical dose of N.

RESULTS AND DISCUSSION

With respect to yield components, the correlation between total yield and number of seeds per cob and 100 seed weight was significant whereas there was no correlation found between number of cobs per plant, one of the important yield components, versus total grain yield (Table 2). The reason for non significant results between number of cobs per plant and yield is that each plant produced only one cob and therefore its contribution to yield variations remained same (Table 3). Thus, the most important yield components responsible for total yield with varying N rates were the number of seeds per cob and 100 seed weight

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which had a strong correlation with yields. Number of seeds per cob has increased significantly up to 200kg N /ha in *yala* 2006 and up to 250kg N /ha in *yala* 2007. With respect to 100 seed weight, the increasing trend was not significant beyond 200kg N /ha in both seasons (Table 3). Although Russell, (1968) reported that the grain yield was highly correlated with ears/plant under high population density, some authors have observed yield was more strongly associated with grain number per ear (Monneveux et al., 2005; Lemcoff and Loomis, 1986).

Table 2. Correlation between yield and yield components

	100 seed weight (g)		Seeds/cob		Cobs/plant	
	Yala	Yala	Yala	Yala	Yala	Yala
	2006	2007	2006	2007	2006	2007
Pearson Coefficient	0.794	0.788	0.892	0.885	0.117	-0.057
Probability	0.000	0.000	0.000	0.000	0.614	0.332

Table 3. Yield and yield components as affected by different Nitrogen rates

Nitrogen rate (kg/ha)	Number of cobs/plant		Number of seeds /cob		100 seed weight (g)	
	Yala	Yala	Yala	Yala	Yala	Yala
	2006	2007	2006	2007	2006	2007
50	0.98 a	0.96 a	291 c	234 d	18.3c	20.4b
100	0.95 a	0.97 a	313 bc	271 cd	22.0ab	20.6b
150	0.96 a	1.02 a	347 b	293 c	21.0bc	21.1b
200	0.98 a	0.99 a	425 a	352 b	25.0a	24.2a
250	0.95 a	1.00 a	444 a	481 a	25.0a	24.3a
300	0.96 a	0.98 a	434 a	467 a	24.7ab	24.6a
350	0.97 a	1.01 a	421 a	385 b	23.7ab	21.3b
CV (%)	6.6	8.2	7.9	9.0	8.6	12.6

Nitrogen affects growth parameters (Brady, 1974) and alters the C/N ratio promoting vegetative growth. Therefore, variation of Harvest Index with the applied N is a good indicator to determine the optimum N level that the crop requires. Thus the Nitrogen level at which the maximum HI was arrived were found as 190 kg/ha (equation 1) and 230 kg/ha (equation 2) in *yala* 2006 and *yala* 2007 seasons respectively (Figure 1).

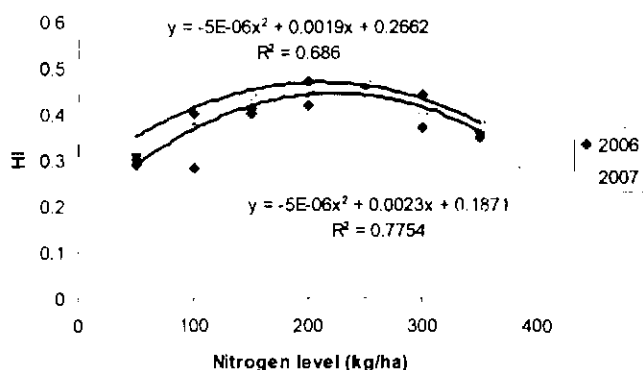


Figure 1. Variation of HI with the changing Nitrogen levels.

$$HI = -5 \times 10^{-6} N^2 + 0.0019 N + 0.2662 \text{ -----Equation (1)}$$

When the HI is maximum,

$$0 = d HI/d N = 1 \times 10^{-5} N + 0.0019$$

$$N = 190 \text{ kg}$$

$$HI = -5 \times 10^{-6} N^2 + 0.0023 N + 0.1871 \text{ ----- Equation (2)}$$

When the HI is maximum,

$$0 = d HI/d N = 1 \times 10^{-5} N + 0.0019$$

$$N = 230 \text{ kg}$$

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The pattern of grain yield (GY) variation with the changing N levels was showed in figure 2. The maximum yield was obtained where the N level was 357 kg N/ha (equation 3) and 330 kg N/ha (equation 4) in *yala* 2006 and *yala* 2007 respectively. This is considerably higher than the rates obtained at the maximum HI. Thus it becomes difficult to determine the optimum N level which maximizes the yield in the above experiment only based on the above biological outputs. Therefore, a simple economic analysis was done in order to come to a better conclusion with respect to the optimum N level.

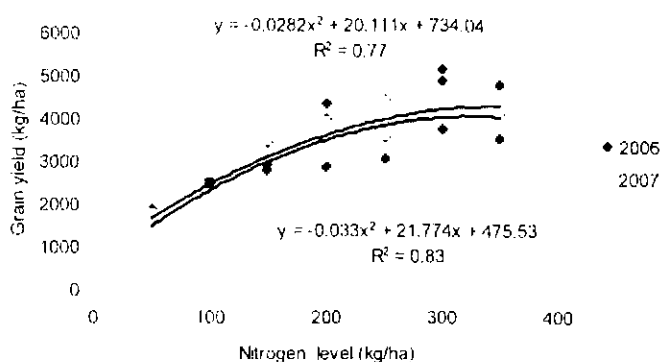


Figure 2. Yield as influenced by N application.

$$GY = -0.0282N^2 + 20.11N + 734.04 \dots \dots \dots (\text{Equation 3})$$

$$d\,GY/d\,N = -0.0564N + 20.11$$

$$\text{At the maximum yield, } 0 = d\,GY/d\,N = -0.0564N + 20.11$$

$$N = 357 \text{ kg/ha}$$

$$GY = -0.033N^2 + 21.77N + 475.53 \dots \dots \dots (\text{Equation 4})$$

$$d\,GY/d\,N = -0.066N + 21.77$$

$$\text{At the maximum yield, } 0 = d\,GY/d\,N = -0.066N + 21.77$$

$$N = 330 \text{ kg/ha}$$

Where GY = Grain yield; N = Nitrogen level

Table 4. Partial budget analysis for different Nitrogen rates during two seasons.

	Nitrogen level (kg/ha)	Yield (kg/ha)	Gross income (Rs./ha) at Rs. 30.00/kg	Fertilizer cost (Rs./ha) (Rs 4500/50kg)	Income increment at each level	Cost increment	Income increase per additional 1 rupee spent (Benefit Cost)
<i>Yala 2006</i>	50	1669	50070	9685	-	-	-
	100	2463	73890	19565	23820	9880	2.41
	150	3116	93480	29250	19590	9880	1.98
	200	3628	108840	39130	15360	9880	1.56
	250	4000	120000	48010	11160	9880	1.13
	300	4229	126870	58890	6870	9880	0.70
	350	4318	129540	68770	2670	9880	0.27
<i>Yala 2007</i>	50	1482	44460	9685	-	-	-
	100	2323	69690	19565	25230	9880	2.55
	150	2999	89970	29250	20280	9880	2.05
	200	3509	105270	39130	15300	9880	1.55
	250	3856	115680	48010	10410	9880	1.05
	300	4036	121080	58890	5400	9880	0.55
	350	4052	121560	68770	480	9880	0.049

Economic analysis

The optimum yield and the respective N level were achieved by a cost-benefit analysis. It was found that the BCR >1 up to the level of 250 kg N/ha in *yala* 2006 indicating an additional gain in grain yield from unit increase of N applied (Table 4). However, in *yala* 2007, BCR > 1 only up to 200 kg N/ha level. These N levels are more or less closer to the values obtained at maximum HI. Therefore, both biological and economical data generated and analyzed so far suggest that the preferable N rate to obtain a profitable yield from maize grown at high density would be 200 kg N/ha.

CONCLUSIONS

Based upon the economic analysis and other data on growth and yield parameters, application of N up to 200 kg/ha was economical for hybrid maize grown on lowland paddy lands at high density (88888 plants/ha) under supplementary irrigation at the given rates of P and K (45 P_2O_5 kg/ha and 30 K_2O kg/ha respectively) which lead to a BCR of 1.56 in *yala* 2006 and 1.55 in *yala* 2007.

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