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OPTIMIZATION OF METHOD AND TIME OF NITROGEN APPLICATION FOR INCREASED NITROGEN USE EFFICIENCY AND YIELD IN MAIZE

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Abstract

Nitrogen application at 3 different times using 2 methods was used for increasing nitrogen use efficiency of maize in terms of above ground dry matter and grain yield. Side-drilling with 245 g N/plot at sowing and 123 g N/plot soil-dressed at silking significantly improved the vegetative and reproductive growth of maize except number of grains per cob and harvest index. Nitrogen use efficiency in above ground dry matter yield was positively related to plant height, cob length and above ground dry matter, whereas nitrogen use efficiency in grain yield showed positive relationship with cob bearing plants per plot, 1000 grain weight and total grain yield per plot. An increase in the above parameters was generally due to all nitrogen treatments but specifically due to the side-drilling of nitrogen at sowing followed by its soil-dressing at silking. Effectiveness of 245 g N/plot side-drilled at sowing led in the gradual release of nitrogen to the field during vegetative growth, while 123 g N/plot soil-dressed at silking proved an additional source for higher rate of photosynthesis and transport of photo-assimilates during grain filling. These properties were present to a lesser degree in other treatments.

Introduction

The use of nitrogenous fertilizers have proved beneficial for enhancing crop yield. However, the method and time of their application have always been crucial, as they play a pivotal role in determining final economic yield. Recently, attention has been focussed to find new ways and means to ensure the maximum use of nitrogenous fertilizers by plant in accruing higher yields. Many workers have attempted certain methods of applying nitrogenous fertilizers (Sanches & Owen, 1978; Bundy, 1986; Maddux *et al.*, 1991; Pearson, 1994), but with variable results. This may either be due to the prevailing agroclimatic conditions, method and time of nitrogen application or nitrogen use efficiency of the plant under investigation (Below, 1995).

Maize (*Zea mays* L.), being a C_4 plant, has a higher growth requirement for nitrogen (Dietz & Harris, 1997). Hence, it is imperative to find efficient ways of nitrogen application at appropriate intervals, which may prove beneficial in achieving higher yield without incurring additional cost. This study was an endeavour to optimize the nitrogen use by maize using two methods and three times of nitrogen application in order to obtain higher economic yield.

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Table 1. Effect of time intervals and methods of nitrogen application on the vegetative and reproductive characteristics of maize.

Nitrogen application method & plant growth stage	Vegetative characteristics: Plant height (cm)	Above-ground dry matter yield per plot (kg)	No. of cob bearing plants per plot	Reproductive characteristics: Average cob length (cm)	Average cob weight (g)	Average No. of grains per cob	1000 grain weight (g)	Total grain yield per plot (kg)	Harvest index (%)
1. Control (N not applied)	189.4c	33.1e	33.8d	15.2d	6.7d	448a	196.3f	6.6e	20.0a
2. 368 g N/plot soil-dressed at sowing	243.7b	52.4c	52.2bc	17.1b	11.0b	445a	282.5b	10.0bc	19.1a
3. 245 g N/plot soil-dressed at sowing and 123 g N/plot soil dressed at silking	242.9b	48.8d	67.0abc	15.7bcd	10.9b	445a	270.0c	10.4bcd	21.39a
4. 184 g N/plot soil-dressed each at sowing and silking	246.3b	53.3bc	68.3ab	16.5b	13.1a	472a	290.8ab	10.5ab	20.1a
5. 245 g N/plot side-drilled at sowing and 123 g N/plot soil dressed at silking	258.9a	59.5a	71.8a	19.0a	13.3a	454a	301.2a	10.9a	18.3a
6. 368 g N/plot side-drilled at sowing	243.7b	54.6b	61.8c	16.7bc	13.3a	450a	240.8d	9.3d	17.0a
7. 123 g N/plot soil each at sowing, knee high and silking	238.3b	51.7c	63.3bc	15.5cd	9.6c	477a	205.0e	9.6cd	18.6a

Mean sharing same letter show statistically non-significant difference.

Materials and Methods

Seeds of maize (*Zea mays* L. var. Golden) were sown in 7x3 m plots at the seed rate of 38 kg ha^{-1}, with single row hand-drill in 60 cm wide rows. Experiment was laid out in randomized complete block design with four replications. Loam soil (0.5% N content) was applied with 185 g phosphorus/plot and 130 g potash/plot (@ 80 and 62 kg ha^{-1} respectively) at sowing time. Thinning was carried out twice at 14 and 25 days after emergence of seedlings to accomplish 25 to 30 cm plant to plant distance. Nitrogen (as urea) was applied to the plots in a manner that, except control, each plot received 368 g nitrogen i.e., @ 175 kg ha^{-1}. The methods and times of nitrogen application were:

1. Control (no N added).
2. 368 g N/plot soil-dressed at sowing.
3. 245 g N/plot at sowing + 123 g N/plot soil dressed at silking.
4. 184 g N/plot soil dressed each at sowing and silking.
5. 245 g N/plot side-drilled at sowing + 123 g N/plot soil-dressed at silking.
6. 368 g N/plot side-drilled at sowing.
7. 123 g N/plot soil-dressed each at sowing, knee high and silking.

The vegetative and reproductive growth parameters were determined at maturity. Harvest index was calculated as, (total grain yield)/(total biomass of above ground parts) x 100. Nitrogen use efficiency (kg yield/kg N used) in giving above ground dry matter and grain yield was computed as (yield of N-treated plots - yield of control plots)/amount of N applied.

Data collected for various characteristics were subjected to statistical analysis using Minitab computer programme (Anon., 1989), to find significant differences, if any. To establish correlations between different variables and nitrogen use efficiency in terms of above ground dry matter and grain yield, the data for growth and yield parameters were transformed by dividing with respective controls.

Results

Although all the time intervals and methods of N application were useful in enhancing vegetative characteristics, but 245 g N/plot side-drilled at sowing + 123 g N/plot soil-dressed at silking was the most effective treatment which enhanced plant height, above ground dry matter and number of cob bearing plants per plot to 38%, 80% and 112% over respective controls (Table 1). This was followed by treatments of 184 g N/plot soil-dressed each at sowing and silking stage for plant height and cob bearing plants, and 368 g N/plot side-drilled at sowing for above ground dry matter yield.

Reproductive characteristics were significantly enhanced with the time and method of N application except number of grains per cob and harvest index (Table 1). Average cob length, cob weight and total grain yield per plot were greatly increased by side-drilling of 245 g N/plot at sowing followed by 123 g N/plot soil-dressed at silking. This showed an increase of 25, 53 and 65% over respective controls of the above parameters.

Table 2. Nitrogen use efficiency of maize (kg yield/kg N used) in giving above ground dry matter and grain yield under different methods and intervals of nitrogen application.

Nitrogen application methods & time of application	Above ground dry matter	Grain yield
1. Control (N not applied)	-	-
2. 368 g N/plot soil-dressed at sowing	67.32c	20.01c
3. 245 g N/plot soil-dressed at sowing + 123 g N/plot soil-dressed at silking	60.51d	22.35b
4. 184 g N/plot soil-dressed each at sowing and silking	79.36b	22.86b
5. 245 g N/plot side-drilled at sowing+ and 123 g N/plot soil-dressed at silking	89.88a	25.22a
6. 368 g N/plot side-drilled at sowing	68.99c	15.62e
7. 123 g N/plot soil-dressed each at sowing, knee high and silking	63.09d	17.73d

Mean sharing same letter show statistically non-significant difference.

Although all the times and methods of N application significantly increased the growth and yield of maize over controls, the application of 245 g N/plot side-drilled at sowing + 123 g N/plot soil-dressed at silking was the most effective treatment in increasing nitrogen use efficiency in giving greater above ground dry matter and grain yield (Table 2). Correlations worked out for different parameters revealed that nitrogen use efficiency determined in terms of above ground dry matter was positively related to plant height, cob length and above ground dry matter and that of grain yield had synergistic relationship with number of cob bearing plants per plot, 1000 grain weight and total grain yield per plot (Table 3).

Table 3. Correlation of nitrogen use efficiency measured in terms of above ground dry matter and grain yield with some vegetative and reproductive characteristics of maize under different time intervals and methods of nitrogen application (n=6).

Characteristics	Correlation co-efficient (r) Above ground dry matter	Grain yield
Plant Height	0.862*	ns
Cob bearing plants per plot	ns	0.960**
Cob length	0.912*	ns
Above-ground dry matter yield	0.999**	ns
1000 grain weight	ns	0.811*
Total grain yield per plot	ns	0.999**

Significant at *, 5%; **, 1% level of probability; ns, non-significant.

Discussion

The method and time of N application to fields is contentious and therefore warranted comprehensive studies (Below, 1995). In the present study, conducted at 3 different times using 2 methods of N application in maize fields, revealed that side-drilling of 245 g N/plot at sowing + 123 g N/plot soil-dressed at silking enhanced all the vegetative and reproductive characteristics. This treatment was followed by soil-dressing of 184 g N/plot each at sowing and silking, and 368 g N/plot side-drilled at sowing time (Table 1). This was reflected by the enhanced efficiency of plant in giving higher above ground dry matter and grain yield (Table 2). Similar observations have been reported by Bundy (1986) and Pearson (1994) who found higher yield and yield components with side-dressing of N fertilizers to the corn fields.

Side-drilling of major quantity of N at sowing followed by minor quantity applied at silking was far more effective due to a gradual release of side-drilled N to whole of the field with irrigation water and by avoiding its loss due to leaching. The application of small quantity of N at silking proved an additional source for higher rate of photosynthesis and transport of photo-assimilates to grain filling in giving bold grains and higher economic yield (Dietz & Harris, 1997). In contrast, other method and time of application did not prove much beneficial in enhancing nitrogen use efficiency of maize.

The above findings were further substantiated by establishing correlation of nitrogen use efficiency in terms of above ground dry matter and grain yield with various vegetative and reproductive parameters (Table 3). This indicated that although all the methods and times of N application were generally effective in promoting growth and yield, but the most effective combination was side-drilling of fields with major quantity of N at sowing coupled with minor quantity soil-dressed at silking. These findings suggest that this strategy can be better exploited to obtain higher yields through increased nitrogen use efficiency of maize.

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