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Effect of split application of nitrogen on the different growth stages of *Kharif* Maize

Lalita Verma and Vijay Kumar

Abstract
The field experiment was conducted at Cotton Research Station, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. Dist. Parbhani during *Kharif* season of 2015 to study the effect of split application of nitrogen on growth stages of *kharif* maize (*Zea mays* L.)". The experiment was laid out in randomized block design with three replications. The treatment details of experiment factor comprised seven split application of nitrogen treatments *viz*., 100% Nitrogen at sowing (T_1), 75%N at sowing +25%N at 30 DAS (T_2), 50%N at sowing +50% N at 30 DAS (T_3), 25% N at sowing +75%N at 30 DAS (T_4), 25%N at sowing +50% N at 30 DAS + 25% at 60 DAS (T_5), 33%N at sowing + 33%N at 30 DAS + 33% at 60 DAS (T_6) and 25% N at sowing + 25% N at 30 DAS+25% at 60DAS +25% N at 60 DAS (T_7).The maximum effect of nitrogen found in the tesseling stage which occurs about 50 to 60DAS.Maximum vegetative growth cover in 60 DAS after that nitrogen use efficient decreases in the maize plant. Treatment T_6 recorded significantly the highest growth and yield attributes *viz*., plant height, number of functional leaves, leaf area, dry matter accumulation, stem girth, number of internodes as compare to other treatments. The maize requires the more nitrogen demand from emergence stage to tesseling stage (vegetative growth period) as compare to other crop-period. At the tesseling stage is very sensitive to nitrogen application for the better grain development.

Keywords: Maize, nitrogen use efficiency, split application

Introduction

Maize (*Zea mays* L) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions and successful cultivation in diverse seasons and ecologies for various purposes. Globally, maize is known as "Queen" of cereals because it has the highest genetic yield potential among the cereals. Maize is also known as Drosophila of crops. It efficiently utilizes solar energy and has immence potential for higher yield, so called as "Miracle crop". Maize ranks third in India in terms of production among cereals, Among the three major fertilizers, nitrogen, phosphate and potassium, application of nitrogenous fertilizers is the maximum. It is reported that China, India and Pakistan together consume approximately 70% of nitrogen fertilizer consumed globally. These figures of nitrogen fertilizer consumption point towards emerging environmental pollution issues.

In this study, N application to maize tended to improve vegetative growth. The response to N increased as level of N applied increased. Thus it is feasible to recommend N application to maize under similar conditions. In our survey area, the main fertilizer used at seeding is diammonium phosphate (DAP), and the main topdressing fertilizer is nitrogen, including predominant use of urea and ammonium bicarbonate. Potassium fertilizer application has been largely ignored on grain crops. Urea and other nitrogenous fertilizers are the need of the hour due to increased population and nutritional demand, but not at the cost of environmental health and life of living organisms. The blind use of nitrogenous fertilizers is only due to lack of scientific knowledge and awareness, poor management practices, Greediness and illiteracy among farmers. More efforts to increase the efficiency of nitrogen fertilizer use through modifications or use of inhibitors of biological processes as well as better management of rates, timing, and incorporation are needed to ensure increased food production while conserving natural resources. Different agronomic options are being recommended which make a way of precision application of nitrogen by using split application at different stage of crop cycle.

Split nitrogen (N) fertilizer applications can play an important role in a nutrient management strategy that is productive, profitable and environmentally responsible.

Dividing total nitrogen application into two or more treatments can help growers enhance nutrient efficiency, promote optimum yields and mitigate the loss of nutrients. Study in Marathwada region have shown that splitting of total recommended nitrogen into three equal proportions and applying as basal, 30 DAS and at 60 DAS found to produce highest yield attributes along with high NUE and observed that band placement of the fertilizer showed the better results, instead of other methods. Band placement reduce the denitrification, volatilization and leaching lossess. By more specifically synchronizing nitrogen supply with a plant's ability to utilize nutrients, split application can be an important component of 4R Nutrient Stewardship-right source, right rate, right time and right place. Depending on soil type, climate, agronomic practices and other factors, nitrogen fertilizer can be vulnerable to loss. Denitrification, leaching and volatilization impose costs that include lost productivity and negative environmental impact. Split-applying nitrogen fertilizer is one way to confront these challenges. When a crop's total nitrogen requirement is supplied with a single pre-plant or at-planting application, most of the N must "wait" for the target crop's future needs and that means the window for potential loss remains open longer. By postponing a portion of the N treatment until the crop is better able to utilize the nutrient, plants take up the nitrogen more quickly and efficiently.

Materials and Methods

An experiment was carried out on Experimental farm of cotton research station, Vasantrao Naik Marathwada Agriculture University, Parbhani during *kharif* season 2015. The soil was medium deep black and well drained. The topography of the experimental field was fairly uniform and levelled. Soil samples up to 30 cm were randomly collected from different locations of field before starts of the experiment.

Geographically Parbhani is situated at 409 m mean sea level altitude 19°16' North latitude and 76°47' E longitude. Its height from mean sea level is about 879 m and distributed in 57 rainy days mostly during june to September. The winter rains are low and uncertain. Most of the rainfall is received from South-West monsoon. The precipation is assured for *Kharif* crops. The mean daily maximum temperature was 36 ^{o}c. The temperature varies from 30.8^{o}c in winter (December) to about 45^{o}c in summer (may), whereas mean minimum temperature varies from 11.9^{o}c in winter to about 24.9^{o}c in summer. The mean relative humidity ranges from 30 to 90%. Thus Parbhani has hot dry summer and cool winter. However, July, August and September months are humid. Hence Parbhani is grouped in assured rainfall zone with *Kharif* cropping pattern.

The dose of the NPK for maize was worked out according to the present recommendation of Kargil (900M) on state level. The 100% NPK dose in kg ha^{-1} worked out was 100:75:75 for maize crop. The sources used for applying nitrogen by the urea.

Maize variety Kargil (900M) hybrid (Monsanto Company) was sown at the seed rate of 20 kg ha^{-1} at inter row of 60 and plant to plant spacing of 30 cm. Shallow furrows were opened and seeds were sown manually at the depth of 5 cm.

Growth studies

The periodical biometric observations were recorded at an interval of 15 days from 30 days after sowing to harvest from five observational plants in net plot.

Height of the plant (cm)

The height of the plants was measured in centimeter from the ground level to the base of last fully opened leaf still tasselling and then after the height was measured from ground level to base of tassel with an interval of 15 days from 30 days up to harvesting.

Number of leaves per plant

The functional leaves per plant were counted at an interval of 15 days from 30 DAS and onward from the observational plant and the mean was worked out.

Number of leaves per plant

The functional leaves per plant were counted at an interval of 15 days from 30 DAS and onward from the observational plant and the mean was worked out.

Leaf area per plant (d m^2)

Leaf area was calculated by using the plant samples labelled for studies from each net plot.

The leaves were grouped into three categories *viz*., small, medium and big. The maximum length of the leaf from auricle to top of the blade and width from middle portion was recorded from average sized leaves from each category and the mean was worked out. From this data, apparent leaf of maize was calculated and multiplied by the constant to get actual leaf area. The leaf area per plant was calculated by using formula suggested by Saxena and Singh (1965) [5].

$$A = L \times B \times K \times N$$

Where A- leaf area in dm^2 under particular group
L- length of leaf
B- Breath of leaf
K- Leaf area constant for maize (0.75)
N- Number of leaves under particular group.

Thus the summation of leaf area of the three groups. Leaf area in dm^2 per plant was derived.

Dry matter per plant (g)

One plant from each net plot was selected for dry matter study. The plant was cut from ground level, then dried in shed and then in hot air oven at 60 to 65°C till constant weights were obtained.

Number of nodes per plant

The number of nodes were increased upto harvest and recorded by counting from observational plants in each net plot.

Days required for tasseling

The number of days required for tasseling were recorded from observing plants of the net plot.

Days required for silking

The number of days required for silking were recorded from observing plants of the net plot.

Growth analysis

Data on growth characters namely height, dry matter and leaf area per plant were further subjected for the computation of different growth functions *viz*., AGR, RGR and LAI. Data on these growth fuctions were not statistically analysed and the inferences are drawn on the basis of mean values.

Absolute Growth Rate (AGR)
The total gain in growth variable i.e. height (cm) or dry weight (g) of a plant within specific time (t) interval is called as Absolute Growth Rate. It is expressed as cm per day in case of plant height and g per day in case of dry matter production per plant. AGR of two growth variables *viz*., height of plant and total dry matter per plant were worked out by the formula given by Richards (1969).

$$\text{AGR (Plant height)} = \frac{H_2 - H_1}{t_2 - t_1} \quad (\text{cm day}^{-1}\ \text{plant}^{-1})$$

$$\text{AGR (Dry matter)} = \frac{W_2 - W_1}{t_2 - t_1} \quad (\text{cm day}^{-1}\ \text{plant}^{-1})$$

Where, H_2, H_1 and W_2, W_1 refers to the plant height (cm) and dry matter accumulation plant^{-1} at time t_2 and t_1 (days), respectively.

Relative growth rate (RGR)
Blackman (1919) expounded the mathematical principles underlying it and RGR of dry matter accumulation is in exponential function of growth, the increase being continuous and analohous to the accumulation of capital invested at compound interest. He called RGR as the efficiency index. Fisher (1921) [2] pointed out the important corollary of the exponential values of the growyh and formulated RGR based on logged values of the growth characteristics. The incorporation of dry matter into the substance of a plant is measured by Relaive Growth Rate (RGR) and is expressed mathematically by Fisher (1921) [21].

$$\text{RGR (dry matter)} = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1} \quad (\text{g /g /day})$$

Where, W_1 and W_2 are the total dry weight of the plant at t_1 and t_2 times respectively $\log_e$ is natural logarithm to the base e is 2.3026.

Leaf area index (LAI)
Leaf area index is the measure of crop growth per unit land area since the p yield is to be assessed per unit land area, instead of per plant. Therefore, leaf area existing on one plant was considered as leaf area produced on unit ground area (actual area of plant). This was proposed by Watson (1952) [7]. It was calculated by using formula as under:

$$\text{LAI} = \frac{\text{Leaf area plant}^{-1}\ \text{in dm}^2}{\text{Ground area plant}^{-1}\ \text{in dm}^2}$$

LAI express the ratio of leaf surface to the ground area occupied by the crop. It is the index of the productive part of plant

Results and Discussion
The results of the present investigation entitled "Effect of split application of nitrogen on growth stage of *kharif* maize (*Zea may*. L)" was conducted during *kharif* 2015 at experimental farm of cotton research station, College of Agriculture, Vasantrao Marathwada Agricultural University, Parbhani, are discussed in this chapter. An attempt has been made to evaluate and to offer the experimentation with experimental evidence wherever possible for noted variations in growth stages.

Soil
A glance at the Table 1 of the soil properties revealed that the soil of experimental plot was low in available nitrogen (165.9 kg ha^{-1}), low in available phosphorus (12.2 kg ha^{-1}), high in available potassium (387.3 kg ha^{-1}) and slightly alkaline (pH 7.98) in reaction. The soil was clayey in texture with moderate moisture holding capacity which was good for normal growth of the crop.

Weather
Weather data (Table 2) indicated that mean maximum and minimum temperature prevailed during crop growing season was 31.7 ^{0}C and 20.7 ^{0}C, respectively. The morning and evening mean relative humidity was 59.11 and 36.77 percent, respectively. The total rainfall during the experimental period was 268.9 mm which was spread over 17 rainy days. The distribution of rainfall was not normal for growth of maize crop. In general, the climatic conditions were not favorable for the maize growth.
Sowing of maize was successfully done on 04-08-2015, after receiving 104.5 mm rainfall in the first fortnight of August. Due to sufficient moisture in soil received through rainfall at seedling stage the growth was satisfactory. There was even distribution of rainfall during the crop growth hence the yield level of maize crop was normal. The plant stand was satisfactory. The emergence count and final plant stand was 95.80 and 71.63 percent respectively. The emergence and final plant stands were statistically non significant.

Crop growth and development
Growth of the crop in general could be understood if series of physiological processes involved are seen critically at various growth stages.
The critical scrutiny of data on different growth parameters and yield attributes recorded periodically showed that growth pattern of maize can be divided into three growth phases as below.

1. Emergence to early vegetative growth phase up to 30 days.
2. Grand growth phase from 31 to 60 days.
3. Reproductive Phase from 61 days onwards.

In order to know the growth of crop, the data recorded at various growth stages are presented.

Effect of split application of nitrogen on emergence and final plant stand: Plant stand was recorded at 10 days after emergence and at harvest in percentage. Data presented in table No.5 revealed that there was no significant difference between plant stand at both the stages. This indicated that the difference in biometric and post harvest studies were due to treatment behaviour and not because of plant population variation.

Effect of split application of nitrogen on Plant height (cm)
At 45 DAS the plant height (cm) was increased by 46.22 due to split application of nitrogen i.e. T_6 (33% N at sowing + 33%N at 30 DAS + 33% at 60 DAS) over treatment T_1 i.e.100% nitrogen at the time of sowing.

At harvest the plant height was increased by 37.58 due to split application of nitrogen i.e. T_6 (33%N at sowing + 33%N at 30 DAS + 33% at 60 DAS) over treatment T_1 i.e.100% nitrogen at the time of sowing. Plant height was increased continuously up to harvest. The rate of increase in plant height (cm) in between 45 DAS to at 60 DAS indicating growth period was 49.84 percent of maximum in T_6 (33%N at sowing + 33%N at 30 DAS + 33% at 60 DAS).

The Plant height (cm) increased continuously up to harvest. It was 41.71, 41.99 and 37.75 percent over treatment at 60, 75, 90 DAS, respectively. It confirms the findings of several researchers like Tadesse *et al*., (2013) [6]. Maximum plant height was observed in the application of nitrogen fertilizer in three splits. These results are in conformity with those recorded by Joshi *et al*., (2014) [4]. It confirms the findings of several researchers like Harikrishna and Patil (2005) [3]. The result also confirms the results of Amanullah *et al*., (2009).

Effect of split application of nitrogen on functional leaves per plant

At 45 DAS the number of functional leaves per plant was increased by 37.07 percent due to split application of nitrogen i.e. T_6 (33% N at sowing + 33%N at 30 DAS + 33% at 60 DAS) over treatment T1 i.e.100% nitrogen at the time of sowing.

Number of functional leaves per plant was found to be increased up to 75 DAS and decreased thereafter due to falling of older leaves. At harvest functional leaves were 49.79 percent. Maximum numbers of functional leaves were recorded at 75 DAS.

At harvest the number of functional leaves per plant was increased by 99.2 due to split application of nitrogen i.e. T_6 (33%N at sowing + 33%N at 30 DAS + 33% at 60 DAS) over treatment T1 i.e.100% nitrogen at the time of sowing.

The rate of increase in number of functional leaves per plant in between 45 DAS to at 60DAS indicating growth period was 18 percent of maximum in T_6 (33%N at sowing + 33%N at 30 DAS + 33% at 60 DAS).

The number of functional leaves per plant increased continuously up to harvest. It was 42.24, 51.76 and 20.76 percent of maximum at 60, 75, 90 DAS, respectively. It also confirms the findings of several researchers like Amanullah *et al*. (2007) [1].

Effect of split application of nitrogen on Leaf area per plant (dm2)

At 45 DAS the Leaf area per plant was increased by 46.22 due to split application of nitrogen i.e. T_6 (33%N at sowing + 33%N at 30 DAS + 33% at 60 DAS) over treatment T_1 i.e.100% nitrogen at the time of sowing.

Leaf area per plant in between 45 DAS to at 60 DAS indicating growth period was 31.16 percent of maximum in T_6 (33%N at sowing + 33%N at 30 DAS + 33% at 60 DAS).

Leaf area per plant was found to be increased up to 75 DAS. Maximum leaf area was recorded at 75 DAS and thereafter decreased.

At harvest the Leaf area per plant was increased by 40.36 due to split application of nitrogen i.e. T_6 (33%N at sowing + 33%N at 30 DAS + 33% at 60 DAS) over treatment T_1 i.e.100% nitrogen at the time of sowing. The rate of increase

at 60, 75, 90 DAS and at harvest it was 83.91, 41.73 and 40.86 percent of its maximum respectively. Maximum leaf area was observed in the application of nitrogen fertilizer in three splits. These results are in close conformity with those recorded by Joshi *et al*., (2014) [4]. It also confirms the findings of several researchers like Amanullah *et al*. (2007) [1].

Effect of split application of nitrogen on total dry matter production

At 45 DAS the total dry matter production was increased by 22.27 due to split application of nitrogen i.e. T_6 (33%N at sowing + 33%N at 30 DAS + 33% at 60 DAS) over treatment T_1 i.e.100% nitrogen at the time of sowing.

At harvest the dry matter production was increased by 38.42 due to split application of nitrogen i.e. T_6 (33%N at sowing + 33%N at 30 DAS + 33% at 60 DAS) over treatment T_1 i.e.100% nitrogen at the time of sowing.

The total dry matter production increased continuously up to harvest. Dry matter production in between 45 DAS to at 60 DAS indicating growth period was 71.90 percent of maximum in T_6 (33%N at sowing + 33%N at 30 DAS + 33% at 60 DAS).

It was 29.95, 32.75 and 34.81 percent of maximum at 60, 75, 90 DAS, respectively. It also confirms the findings of several researchers like Harikrishna and Patil (2005) [3].

Effect of split application of nitrogen on tasseling and silking

Data presented in table No.6 revealed that their was no significant difference between different treatments at both the stages. The split application of nitrogen 33%N at sowing + 33%N at 30 DAS + 33% at 60 DAS (T_6) recorded lesser number of days to 50 percent tasseling than other treatments. Whereas treatment (T_5) recorded 50 percent silking it might be due to better utilization of nitrogen which is resulted in earlyness. It confirms the findings of several researchers like Amanullah *et al*., (2007) [1].

Effect of split application of nitrogen on Leaf area index

At 45 DAS the Leaf area index was increased by 61.75 due to split application of nitrogen i.e. T_6 (33%N at sowing + 33%N at 30 DAS + 33% at 60 DAS) over treatment T_1 i.e.100% nitrogen at the time of sowing.

Leaf area index was found to be increased up to 75 DAS. Maximum leaf area index was recorded at 75 DAS and thereafter decreased.

At harvest the Leaf area index was increased by 66.53 due to split application of nitrogen i.e. T_6 (33%N at sowing + 33%N at 30 DAS + 33% at 60 DAS) over treatment T_1 i.e.100% nitrogen at the time of sowing. The rate of increase of Leaf area index in between 45 DAS to at 60 DAS indicating growth period was 31.33 percent of maximum in T_6 (33%N at sowing + 33%N at 30 DAS + 33% at 60 DAS).

At 60, 75, 90 DAS and at harvest it was 84.4, 41.75 and 40.86 percent of its maximum respectively. It confirms the findings of several researchers like Amanullah *et al*., (2007) [1].

Effect of split application of nitrogen on weight of stover per plant

The weight of stover per plant was observed to be increased by 28.49 percent. This might be possible due to split application of nitrogen i.e. T_6 (33%N at sowing + 33%N at 30 DAS + 33% at 60 DAS) over treatment T_1 i.e.100% nitrogen at the time of sowing. These results are in conformity with those recorded by Joshi *et al*., (2014) [4].

Effect of split application of nitrogen on weight of spindle per plant

The weight of spindle per plant was maximum by 46.94 percent due to split application of nitrogen i.e. T_6 (33% N at sowing + 33%N at 30 DAS + 33% at 60 DAS) over treatment T1 i.e.100% nitrogen at the time of sowing.

Effect of split application of nitrogen on stover yields

The stover yield was increased by 27.47 percent due to split application of nitrogen i.e. T_6 (33% N at sowing + 33%N at 30 DAS + 33% at 60 DAS) over treatment T_1 i.e.100% nitrogen at the time of sowing. Higher stover yield was observed in the application of nitrogen fertilizer in three splits. These results are in conformity with those recorded by Joshi *et al*. (2014) [4].

Effect of split application of nitrogen on biological yield

The biological yield was increased by 28.19 percent due to split application of nitrogen i.e. T_6 (33% N at sowing + 33%N at 30 DAS + 33% at 60 DAS) over treatment T_1 i.e.100% nitrogen at the time of sowing. These results are in conformity with those recorded by Iqbal *et al*. (2014).

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