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## OPTIMIZING MAIZE (*Zea mays* L.) PRODUCTIVITY THROUGH DE-TOPPING AND FERTILIZER MANAGEMENT UNDER TEMPERATE RAINFED CONDITIONS

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### ABSTRACT

The field experiment was conducted during *kharif* 2024 at Agronomy Research Farm, Faculty of Agriculture, Wadura, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir to study the impact of de-topping and fertilizer levels on growth and yield of maize. The experiment was laid out in factorial randomized block design with three replications. The treatments consisted of four levels of de-topping viz. D<sub>1</sub>: No de-topping; D<sub>2</sub>: De-topping up to the base of top two leaves at 10 days after silking; D<sub>3</sub>: De-topping up to the base of top two leaves at 20 days after silking; D<sub>4</sub>: De-topping up to the base of top two leaves at 30 days after silking and four levels of fertilizers viz. F<sub>1</sub>: Control; F<sub>2</sub>: 75% of Recommended N P K; F<sub>3</sub>: 100% of Recommended N P K and F<sub>4</sub>: 125% of Recommended NPK. No de-topping () recorded significantly higher values of growth parameters, yield attributes and yield which was statistically at par with de-topping up to the base of top two leaves at 20 days after silking. However, the fresh weight and dry weight of de-topped portion was recorded significantly higher with de-topping up to the base of top two leaves at 10 days. Among the fertilizer levels, application of 125% recommended NPK recorded significantly higher values of growth parameters, fresh and dry weight of de-topped portion, yield attributes and yield which was statistically at par with application of 100% recommended NPK.

**Key words:** Maize, De-topping, Fertilizer levels, Growth, Yield, Fodder

### Introduction

Maize (*Zea mays* L.) is among the most widely consumed cereal grains worldwide and is believed to have originated around 8,700 years ago in Mexico and Central America. Being an annual short-day plant, it is one of the important cereal crops. It is a staple crop cultivated across various regions of the world due to its high yield potential and remarkable adaptability to diverse climatic conditions. Compared to rice and wheat, maize is relatively more versatile and multi-purpose crop (Erenstein *et al.*, 2022). In developing countries like India, maize provides employment to millions of people in farming, processing and marketing chains (Ali *et al.*, 2020). Jammu and

Kashmir is predominantly agrarian, with around 65% of its population dependent on agriculture. The state is 40% deficit in fodder on dry matter basis and the deficiency is more pronounced in the segments of green fodder and concentrates (Wani *et al.*, 2014). Maize serves as valuable fresh or preserved fodder (silage) for various livestock categories. As an important fodder crop, it requires optimized agronomic management practices such as de-topping to maximize productivity (Shesh *et al.*, 2020). De-topping serves as a valuable practice to provide emergency green fodder to livestock without compromising the grain yield. The stage and technique of maize de-topping play a vital role in determining both

**Table 1:** Plant height and number of leaves/plant of maize as influenced by de-topping and fertilizers levels.

| Treatments                                                           | Plant height (cm) |           |               | No. of leaves/plant |           |               |
|----------------------------------------------------------------------|-------------------|-----------|---------------|---------------------|-----------|---------------|
|                                                                      | 70<br>DAS         | 90<br>DAS | At<br>harvest | 70<br>DAS           | 90<br>DAS | At<br>harvest |
| <b>De-topping</b>                                                    |                   |           |               |                     |           |               |
| No de-topping                                                        | 190.82            | 227.23    | 236.32        | 14.03               | 12.93     | 10.73         |
| De-topping up to the base of top two leaves at 10 days after silking | 186.56            | 164.67    | 169.51        | 13.33               | 10.02     | 9.48          |
| De-topping up to the base of top two leaves at 20 days after silking | 190.53            | 170.24    | 175.28        | 13.83               | 12.60     | 10.68         |
| De-topping up to the base of top two leaves at 30 days after silking | 189.36            | 226.12    | 208.82        | 13.75               | 11.25     | 10.37         |
| CD (p=0.05)                                                          | NS                | 9.45      | 10.89         | NS                  | 0.49      | 0.69          |
| <b>Fertilizer Levels</b>                                             |                   |           |               |                     |           |               |
| Control                                                              | 177.06            | 184.08    | 184.39        | 12.83               | 10.68     | 9.30          |
| 75% of Recommended N P K                                             | 186.69            | 194.61    | 194.67        | 13.50               | 11.20     | 10.07         |
| 100% of Recommended N P K                                            | 195.83            | 204.52    | 204.78        | 14.22               | 12.25     | 10.80         |
| 125% of Recommended N P K                                            | 197.68            | 205.05    | 206.10        | 14.40               | 12.67     | 11.10         |
| CD (p=0.05)                                                          | 8.69              | 9.45      | 10.89         | 0.61                | 0.49      | 0.69          |

fodder and grain yield. Choosing the optimal stage is essential to maintain a balance between fodder availability and grain production. Despite the expansion of land under maize production, yield remains low especially under rainfed conditions. This low productivity is largely attributed to declining soil fertility and inadequate fertilizer use, leading to severe nutrient depletion of soils. However, factors such as poor fertilizer efficiency, outdated fertilizer recommendations, neglect of nutrients beyond N, P and K and deteriorating soil health continue to hinder maize yield. The most important agricultural input for producing food is still fertilizers. Hence, keeping the above facts in the forefront the present investigation was under taken to optimize the growth and yield of maize through de-topping and fertilizer management under rainfed temperate conditions of Kashmir valley.

### Materials and Methods

The field experiment was carried out at Agronomy Research Farm, Faculty of Agriculture, Wadura, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir during *kharif* season of 2024. The soil of experimental field was clay loam in texture, neutral in reaction (pH 6.75) and high in organic carbon (0.87 %) and medium in available nitrogen (293 kg ha<sup>-1</sup>), phosphorus (16 kg ha<sup>-1</sup>) and potassium (172 kg ha<sup>-1</sup>). The treatments consisted of four levels of de-topping viz. D<sub>1</sub>: No de-topping; D<sub>2</sub>: De-topping up to the base of top two leaves at 10 days after silking; D<sub>3</sub>: De-topping up to the base of top two leaves at 20 days after silking; D<sub>4</sub>: De-topping up to the base of top two leaves at 30 days after silking and four levels of fertilizers viz. F<sub>1</sub>: Control; F<sub>2</sub>: 75% of Recommended N P K; F<sub>3</sub>: 100% of Recommended N P K and F<sub>4</sub>: 125% of Recommended N P K. The experiment was laid out in factorial randomized block design with three replications with a

plot size of 5.4 m × 3 m. The maize cultivar “Shalimar composite maize-4” was sown with spacing of 60 cm × 20 cm. The de-topping was done at 73, 83 and 94 days after sowing. The recommended dose of NPK was 90: 45: 20 kg ha<sup>-1</sup>. Full dose of phosphorus and potassium through diammonium phosphate (DAP) and muriate of potash (MOP) was applied at the time of sowing as per the treatments. Since nitrogen was applied in three splits, 50% nitrogen was applied as basal through DAP and urea and the remaining 50% nitrogen was applied as top dressing through urea at knee high stage and tasseling stage as per the technical programme. The other recommended cultural practices were followed for raising the crop successfully. The data on various growth parameters (plant height, number of leaves per plant, dry matter accumulation and leaf area index), yield attributes and yield were recorded from five randomly selected plants in each plot. The analysis of variance for factorial randomized block design was performed using OPSTAT. The least significant difference (LSD) was used to compare treatment means at 5% level of significance.

### Results and Discussion

#### Plant height

Plant height was significantly influenced by de-topping and fertilizer levels at different intervals (Table 1). At 70 DAS, no significant difference in plant height was observed in de-topping treatments. However, at 90 DAS and at harvest, considerably greater plant height was recorded for no de-topping (D<sub>1</sub>) which was statistically at par with de-topping up to the base of top two leaves at 30 days after silking (D<sub>4</sub>). This may have occurred because the apical part, which causes a notable rise in plant height was not removed. Similar results were also reported by Rajkumara *et al.*, (2020). Application of

**Table 2:** Dry matter accumulation and leaf area index of maize as influenced by de-topping and fertilizers levels.

| Treatments                                                           | DMA       |           |               | LAI       |           |               |
|----------------------------------------------------------------------|-----------|-----------|---------------|-----------|-----------|---------------|
|                                                                      | 70<br>DAS | 90<br>DAS | At<br>harvest | 70<br>DAS | 90<br>DAS | At<br>harvest |
| <b>De-topping</b>                                                    |           |           |               |           |           |               |
| No de-topping                                                        | 172.50    | 192.24    | 196.34        | 4.90      | 3.23      | 2.17          |
| De-topping up to the base of top two leaves at 10 days after silking | 161.42    | 168.71    | 174.92        | 4.76      | 2.80      | 2.02          |
| De-topping up to the base of top two leaves at 20 days after silking | 171.11    | 178.38    | 184.43        | 4.83      | 3.19      | 2.14          |
| De-topping up to the base of top two leaves at 30 days after silking | 164.25    | 183.66    | 188.13        | 4.78      | 3.01      | 2.06          |
| CD (p=0.05)                                                          | NS        | 8.76      | 9.87          | NS        | 0.29      | 0.11          |
| <b>Fertilizer Levels</b>                                             |           |           |               |           |           |               |
| Control                                                              | 150.00    | 158.08    | 161.55        | 4.17      | 2.60      | 1.53          |
| 75% of Recommended N P K                                             | 164.87    | 174.88    | 180.50        | 4.47      | 2.74      | 1.64          |
| 100% of Recommended N P K                                            | 176.57    | 190.41    | 197.51        | 5.20      | 3.28      | 2.50          |
| 125% of Recommended N P K                                            | 177.83    | 198.63    | 204.26        | 5.44      | 3.61      | 2.73          |
| CD (p=0.05)                                                          | 11.31     | 8.76      | 9.87          | 0.25      | 0.29      | 0.11          |
| DMA: Dry matter accumulation (g/plant); LAI: Leaf area index         |           |           |               |           |           |               |

125% of recommended N P K ( $F_4$ ) recorded significantly highest plant height at different intervals which was statistically at par with 100% of recommended NPK ( $F_3$ ). The control treatment where no fertilizer was applied recorded the lowest plant height. This might be due to increased vegetative growth in maize which was facilitated by improved nutrient availability. Since nutrient-poor conditions frequently result in stunted development. These findings are in agreement with those of Kumar *et al.*, (2005).

#### Number of leaves per plant

No significant difference in number of leaves per plant was observed in de-topping at 70 DAS (Table 1). However, at 90 DAS and at harvest, no de-topping ( $D_1$ ) recorded significantly higher number of leaves, which was statistically at par with de-topping up to the base of top two leaves at 20 days after silking ( $D_1$ ). Treatment without de-topping exhibited a considerably higher number of leaves per plant compared to the other treatments. The reduced leaf count in the de-topped treatment resulted from the removal of tops and the progressive senescence of older leaves might be responsible for lesser number of leaves in de-topping. These results were in corroborated with the findings of Rajkumara *et al.*, (2020) and Amulya (2018). Among the different fertilizer levels, application of 125% of recommended N P K ( $F_4$ ) recorded significantly higher number of leaves per plant which was statistically at par with 100% of recommended N P K ( $F_3$ ). The higher number of functional leaves with the increase in fertilizer levels may be due to increase in assimilation rates, cell division and metabolic activities in plant (Singh *et al.*, 2012).

#### Dry matter accumulation

Dry matter accumulation was significantly influenced

by de-topping and fertilizer levels at different intervals (Table 2). At 90 DAS and harvest, the maximum dry matter accumulation was recorded in no de-topping ( $D_1$ ) which was statistically at par with de-topping up to the base of top two leaves at 30 days after silking ( $D_4$ ). However, among the different times of de-topping, de-topping up to the base of top two leaves at 30 days after silking ( $D_4$ ) resulted in a considerably greater dry matter accumulation, which was statistically comparable to de-topping up to the base of top two leaves at 20 days after silking ( $D_3$ ). No de-topping showed noticeably the highest dry matter accumulation. This could be because there were more leaves, which improve light absorption and allow for the accumulation of more photosynthates (Rajkumara *et al.*, 2020). De-topping up to the base of the top two leaves after 30 days of silking ( $D_4$ ) resulted in a significantly higher dry matter accumulation which might be due to the greatest number of leaves available for optimal absorption of sunlight for photosynthesis and accumulation of stored assimilates to the grain, as well as the completion of anthesis at 65 DAS. Similar findings were reported by Amulya (2018). Among the fertilizer levels, application of 125% of recommended N P K ( $F_4$ ) resulted in highest dry matter accumulation at different intervals, significantly surpassing other fertilizer levels and was statistically at par with 100% of recommended N P K ( $F_3$ ). Enhanced fertilization supplies vital nutrients that facilitate increased plant development and biomass accumulation (Kanannavar, 2013 and Verma and Singh, 2014).

#### Leaf Area Index

The leaf area index was increased rapidly up to 70 DAS and then succeeded by a drop till the maturation phase (Table 2). Among the de-topping treatments, there

**Table 3:** Fresh weight, dry weight and grain equivalent yield of de-topped portion of maize as influenced by de-topping and fertilizer levels.

| Treatments                                                           | Fresh weight of              | Dry weight of                | Grain equivalent yield                |
|----------------------------------------------------------------------|------------------------------|------------------------------|---------------------------------------|
|                                                                      | de-topped<br>portion (kg/ha) | de-topped<br>portion (kg/ha) | of de-topped green<br>portion (kg/ha) |
| <b>De-topping</b>                                                    |                              |                              |                                       |
| No de-topping                                                        | -                            | -                            | -                                     |
| De-topping up to the base of top two leaves at 10 days after silking | 2512.75                      | 805.13                       | 439.73                                |
| De-topping up to the base of top two leaves at 20 days after silking | 2322.92                      | 724.28                       | 406.51                                |
| De-topping up to the base of top two leaves at 30 days after silking | 2117.00                      | 637.92                       | 370.48                                |
| CD (p=0.05)                                                          | 171.19                       | 51.56                        | 29.96                                 |
| <b>Fertilizer Levels</b>                                             |                              |                              |                                       |
| Control                                                              | 1513.25                      | 481.93                       | 264.82                                |
| 75% of Recommended N P K                                             | 1695.75                      | 525.98                       | 296.76                                |
| 100% of Recommended N P K                                            | 1788.83                      | 556.95                       | 313.05                                |
| 125% of Recommended N P K                                            | 1954.83                      | 602.48                       | 342.10                                |
| CD (p=0.05)                                                          | 171.19                       | 51.56                        | 29.96                                 |

was no significant difference up to 70 days after sowing (DAS). However, at 90 DAS and at harvest leaf area index was significantly varied by de-topping. No de-topping ( $D_1$ ) recorded significantly higher leaf area index which was statistically at par with de-topping up to the base of top two leaves at 20 days after silking ( $D_3$ ) and de-topping up to the base of top two leaves at 30 days after silking ( $D_4$ ) followed by de-topping up to the base of top two leaves at 20 days after silking ( $D_3$ ). Significantly lower leaf area index was observed in de-topping up to the base of top two leaves at 10 days after silking ( $D_2$ ). Highest leaf area index in maize without defoliation and varied with defoliation level and leaf position (Bhargavi *et al.*, 2017 and Barimavandi *et al.*, 2010). Application of 125% of recommended N P K ( $F_4$ ) recorded highest leaf area index which was statistically at par with application of 100% of recommended N P K ( $F_3$ ) at different intervals. Using 125% of recommended N P K recorded the highest leaf area index and the combine influence of higher rates of both nitrogen and phosphorus might have encouraged more vegetative buds resulting in a greater number of green leaves which resulted in enhanced leaf area index. These results are in line with the findings Choudhary *et al.*, (2007).

#### Fresh weight, dry weight and grain equivalent yield of de-topped portion

Fresh weight, dry weight and grain equivalent yield of de-topped portion of maize was significantly influenced by de-topping and fertilizer levels (Table 3). Among the different de-topping treatments, de-topping up to the base of top two leaves at 10 days after silking ( $D_2$ ) recorded significantly highest fresh weight, dry weight and grain equivalent yield of the de-topped portion followed by de-topping up to the base of top two leaves at 20 days after

silking ( $D_3$ ). The highest fresh weight of de-topped portion by de-topping up to the base of top two leaves at 10 days after silking ( $D_2$ ) might be due to the maximum leaf water content at early stage of de-topping (Barimavandi *et al.*, 2010). Highest grain equivalent yield of de-topped green portion may have occurred because of more leaves being de-topped, which increased the yield of grain equivalent and green feed. These outcomes closely align with the findings of Amanullah (2020). Among the different fertilizer levels, application of 125% of recommended N P K ( $F_4$ ) recorded highest fresh weight, dry weight and grain equivalent yield of de-topped portion which was statistically at par with the application of 100% of recommended N P K ( $F_3$ ). This was might be due to application of increased rates of fertilizer promote growth of plants. Similar results were reported by Umesh *et al.*, (2014).

#### Yield attributes

The data presented in table 4 indicate that both de-topping and fertilizer levels had significantly influenced the yield attributes viz. number of cobs/plant, number of grains/cob and 100-grain weight. De-topping treatments had no significant influence on number of cobs /plant and 100-grain weight. Among the different de-topping treatments, no de-topping ( $D_1$ ) produced notably high number of grains per cob which was statistically at par with de-topping up to the base of top two leaves at 20 days after silking ( $D_3$ ) and de-topping up to the base of top two leaves at 30 days after silking ( $D_4$ ). Whereas, de-topping up to the base of top two leaves at 10 days after silking ( $D_2$ ) was recorded lowest number of grains per cob. By better allocating resources to reproductive organs, modest and well-timed de-topping can increase the number of grains per cob. Similar findings were

**Table 4:** Yield attributes and yield of maize as influenced by de-topping and fertilizer levels.

| Treatments                                                                                                                                                         | NCP  | NGC    | GW    | GY   | SY   | GEY  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|--------|-------|------|------|------|
| <b>De-topping</b>                                                                                                                                                  |      |        |       |      |      |      |
| No de-topping                                                                                                                                                      | 1.23 | 217.22 | 21.84 | 4.80 | 7.71 | 0.77 |
| De-topping up to the base of top two leaves at 10 days after silking                                                                                               | 1.10 | 180.18 | 18.98 | 3.78 | 6.74 | 0.67 |
| De-topping up to the base of top two leaves at 20 days after silking                                                                                               | 1.20 | 216.37 | 21.46 | 4.71 | 7.48 | 0.75 |
| De-topping up to the base of top two leaves at 30 days after silking                                                                                               | 1.17 | 211.00 | 20.64 | 4.64 | 7.45 | 0.75 |
| CD (p=0.05)                                                                                                                                                        | NS   | 15.55  | NS    | 0.23 | 0.38 | 0.04 |
| <b>Fertilizer Levels</b>                                                                                                                                           |      |        |       |      |      |      |
| Control                                                                                                                                                            | 1.02 | 183.23 | 17.00 | 3.53 | 6.58 | 0.66 |
| 75% of Recommended N P K                                                                                                                                           | 1.13 | 197.79 | 20.15 | 4.20 | 6.97 | 0.70 |
| 100% of Recommended N P K                                                                                                                                          | 1.25 | 221.70 | 22.47 | 5.00 | 7.75 | 0.77 |
| 125% of Recommended N P K                                                                                                                                          | 1.30 | 222.05 | 23.31 | 5.21 | 8.09 | 0.81 |
| CD (p=0.05)                                                                                                                                                        | 0.10 | 15.55  | 2.22  | 0.23 | 0.38 | 0.04 |
| NCP: No. of cobs/ plant; NGC: No. of grains/cob; GW: 100 grain weight (gm); GY: Grain yield (t/ha);<br>SY: Stover yield (t/ha); GEY: Grain equivalent yield (t/ha) |      |        |       |      |      |      |

reported by Umashankara (2007). Regarding fertilizer levels, the application of 125% of recommended N P K recorded ( $F_4$ ) significant greater number of cobs/plant, number of grains/cob and 100-grain weight as compared to other fertility levels which was statistically at par with the application of 100% of recommended N P K ( $F_3$ ). The higher growth characters (plant height, LAI, dry matter) under the application of 125 % of recommended N P K ( $F_4$ ) might have played a significant role in producing more photosynthates thereby increasing yield attributes. These results are in close conformity with the findings of Sahoo and Mahapatra (2007) and Mathukia *et al.*, (2014).

### Yield

De-topping and fertilizer levels significantly influenced the grain yield, stover yield and grain equivalent yield of maize (Table 4). Among the different de-topping treatments, no de-topping ( $D_1$ ) recorded significantly highest grain yield, stover yield and grain equivalent yield of maize which was statistically at par with de-topping up to the base of top two leaves at 20 days after silking ( $D_3$ ) and de-topping up to the base of top two leaves at 30 days after silking ( $D_4$ ). No de-topping recorded higher grain yield which might be due over all improvement in yield attributes. The decrease in yield caused when maize plants leaves are removed in the early stages of reproduction. Removing functional leaf area reduces assimilate availability and plant photosynthetic area. Bhargavi *et al.*, (2017) reported similar results. Application of 125% of recommended N P K ( $F_4$ ) recorded maximum grain yield, stover yield and grain equivalent yield of maize surpassing all other fertilizer levels and which was statistically at par with the application of 100% of recommended N P K ( $F_3$ ). Up to the application of 125%

of recommended N P K ( $F_4$ ), the yield attributes rose noticeably which in turn boosted yield. In all treatments except no de-topping, a portion of the leaves that have already been removed by de-topping will result in a decrease in stover output. Similar results were reported by Umesh *et al.*, (2014).

### Conclusion

Based on the experimental results obtained from the study, it may be concluded that no de-topping with 125 % of recommended NPK was found superior in terms of growth, yield attributes and yield of maize being at par with the de-topping up to base of the top two leaves at 20 days after silking and de-topping up to base of the top two leaves at 30 days after silking with 100% of recommended NPK. In order to achieve the addition green fodder, the farmer can go for de-topping at 20 days after silking without compromising the grain yield of maize.

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### Credit authorship contribution statement:

Sandeep Kumar: Performed the experiment, data collection, Ashu Sharma: Designed the research, drafted the manuscript, Tauseef Ahmad Bhat: Revised the manuscript, Vikas Sharma: Reviewing and Aijaz Nazir: Editing.

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Statement on generative AI and AI-assisted technologies in the writing process

The authors declare that no artificial intelligence tools were used to write this manuscript.

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