

## Original Research Article

# Effects of Nitrogen Fertilizer Rates on Yield and Yield Components of Maize (*Zea mays* L.)

### ABSTRACT

Maize is one of the most important cereal crops in the world. To investigate the effects of nitrogen fertilizer rates on growth and yield of maize and to determine the suitable nitrogen fertilizer rate, the experiment was conducted by using Randomized complete block design (RCBD) with four replications at Shwe Baho village, Zayarthiri Township, Nay Pyi Taw in post monsoon season and monsoon season. The treatments were T<sub>1</sub> (no nitrogen application), T<sub>2</sub> (90 kg N ha<sup>-1</sup>), T<sub>3</sub> (120 kg N ha<sup>-1</sup>), T<sub>4</sub> (150 kg N ha<sup>-1</sup>) and T<sub>5</sub> (180 kg N ha<sup>-1</sup>) treatments. The tested maize variety was pacific-789 hybrid. According to the results, application of nitrogen gave the significant effect on grain yield and yield components of maize in both seasons. The superior maize yield was observed in all nitrogen treatments compared to control. The use of the highest nitrogen fertilizer rate (180 kg N ha<sup>-1</sup>) in T<sub>5</sub> gave the significant highest grain yield (7696.6 kg ha<sup>-1</sup>) in post monsoon season and (8764.5 kg ha<sup>-1</sup>) in monsoon season, respectively. In both seasons, the grain yield in T<sub>5</sub> treatment was significantly increased about 62% over T<sub>1</sub> treatment. Therefore, the application of nitrogen with the rate of T<sub>5</sub> (180 kg ha<sup>-1</sup>) might be the appropriate rate to maximize the maize production. Considering the increased grain yield of the hybrid maize, nitrogen rate of T<sub>5</sub> (180 kg ha<sup>-1</sup>) could be achieved in this study area.

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Keywords: hybrid maize, nitrogen rates, yield and yield components.

### 1. INTRODUCTION

Maize is the principal grain crop grown in Myanmar and a key commodity for both foreign exchange earnings and farmer income. As the primary feed crop in Myanmar, maize is the second most significant cereal crop after rice. As the first grain crop to be grown worldwide, maize (*Zea mays* L.) produced 1,125 million tons, or more than 40% of all grain produced. Hungary, the third-largest producer of the crop in Europe, produced 8.4 million tons of maize in 2020, accounting for nearly 12% of the total production of 67.8 million tons (Eurostat, 2021)[1]. As a result, maize is an important grain crop. Maize growing area was cultivated around 0.56 million ha in 2020-2021 (MOALI, 2020)[2]. Maize growing locations are Shan State, Chin State, Kayin State, Sagaing, Mandalay, Nay Pyi Taw, Ayeyarwady and Magway Region. Small-scale farmers are the primary producers of maize in tropical nations (Kumar & Jhariya, 2013)[3]. The production of maize increased from 1485 MT in 2011 to 2106 MT in 2021 (MOALI, 2020)[2]. The maize exported about 2.6 million MT (MOALI, 2020)[2]. The second most significant cereal crop in Myanmar is maize. In Myanmar, maize is grown which is grown for human food, animal feed for raising cattle, and a significant export commodity. Nitrogen is one of the main nutrients limiting maize yield. Because nitrogen is essential to

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many major processes involved in the growth and development of maize crops, it is a highly significant component of fertilizers (Jat et al., 2013)[4]. As a main nutrient, nitrogen (N) is essential for increasing growth and higher biomass crop yields. It directly influences the amino acid composition of protein and thereby nutritional quality of the economic produce (Szulc et al., 2016) [5]. Maize yield is significantly influenced by the timing of N application (Scharf et al., 2002)[6]. Due to its large role in the growth and development of the maize crop, nitrogen (N) is a very important ingredient (Jat et al., 2013)[4]. The growth, development, and grain production of maize ~~were~~ are significantly ~~impacted~~ influenced by the applications of inorganic fertilizers (Stefano et al., 2004)[7]. ~~Thus, the~~ the present study ~~initiated to was thus conducted to~~ investigate the effects of nitrogen fertilizer rates on growth and yield of maize and to determine the suitable nitrogen fertilizer rate to increase maize production in this study area.

## 2. MATERIALS AND METHODS

The field experiment was carried out from December to April (post monsoon season), 2022-2023 and from May to September (monsoon season), 2023. Both field experiments were conducted at Shwe Baho village, Zayarthiri Township, and Nay Pyi Taw. In both seasons, the five treatments were assigned on the same size of plots with four replications. Total numbers of the experimental plots were 20 plots and each plot size was 4 m x 5 m. Spacing xx m between blocks and xx between plots were used. The tested maize variety was pacific-789 hybrid maize variety with 120 days duration. Phosphorus fertilizer was applied at 125 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> and Potassium fertilizer 63 kg K<sub>2</sub>O ha<sup>-1</sup> was applied at basal in all treatments. Treatments were assigned as Table 1. Before conducting the experiment, the soil sample was randomly collected to investigate some physicochemical properties. The results are shown in Table 2.

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**Table 1. Treatments of the experiment in both seasons**

| Treatments                            | Basal (kg N ha <sup>-1</sup> ) | 20 Days After Sowing (kg N ha <sup>-1</sup> ) | 40 Days After Sowing (kg N ha <sup>-1</sup> ) |
|---------------------------------------|--------------------------------|---|---|
| T <sub>1</sub>                        | -                              | -   | -   |
| T <sub>2</sub> (Three equally splits) | 30                             | 30  | 30  |
| T <sub>3</sub> (Three equally splits) | 40                             | 40  | 40  |
| T <sub>4</sub> (Three equally splits) | 50                             | 50  | 50  |
| T <sub>5</sub> (Three equally splits) | 60                             | 60  | 60  |

Note. Urea was used as N fertilizer.

**Table 2. Physicochemical properties of the experimental soils before sowing at Shwe Baho Village, Zayarthiri Township, Nay Pyi Taw**

| Parameters    | Analytical Result | Description  | Analytical Methods |
|---------------|-------------------|--------------|--------------------|
| Texture class | Loamy sand        | Sand 84.82%, | Pipette method     |

|                                    |      |                              |                                     |
|------------------------------------|------|------------------------------|-------------------------------------|
|                                    |      | Silt 7.43% and<br>Clay 7.75% |                                     |
| pH                                 | 6.24 | Slightly acid                | 1:5 (soil: water) pH meter          |
| Organic matter (%)                 | 1.24 | Low                          | Walkley-Black Method                |
| Available N (mg kg <sup>-1</sup> ) | 69   | Medium                       | Alkaline permanganate method        |
| Available P (mg kg <sup>-1</sup> ) | 19   | Medium                       | 9C-Olsen's P-Malachite green        |
| Available K (mg kg <sup>-1</sup> ) | 94   | Low                          | 15Al-1N Ammonium acetate extraction |
| Total N (%)                        | 0.07 | Low                          | Kjaldahl distillation method        |

## 2.1 Statistical analysis

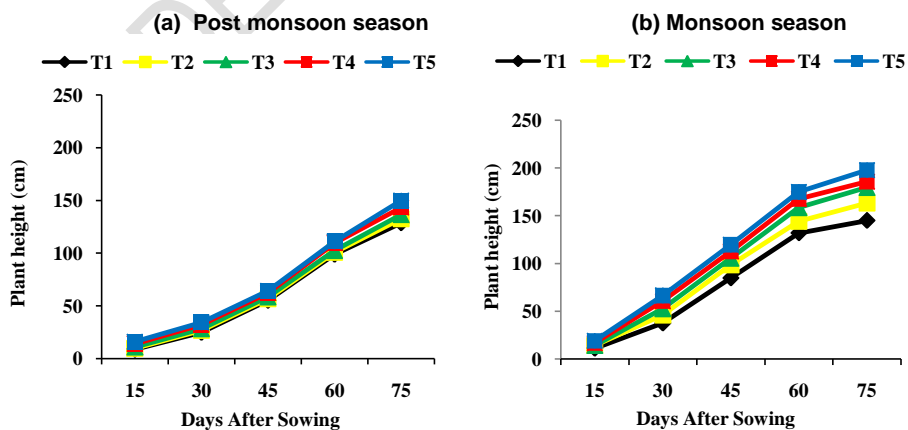
All experimental data were analyzed by using the Analysis of Variance (ANOVA) with Statistix-8 software. The differences in treatment means were separated by Least Significant Difference (LSD) at 5 % level.

## 3. RESULTS AND DISCUSSION

### 3.1 Plant height (cm)

Plant height in all treatments increased progressively from 15 DAS to 75 DAS under both seasons (Figure 1). It was found that only control treatment (T<sub>1</sub>) gave the minimum plant height at all growth stages, while three equally splits of N fertilizer application (T<sub>5</sub>) possessed a highly significant difference in plant height among the other treatments similarly. Shivay et al., (2000)[8] discovered that higher doses of nitrogen application resulted in taller maize plants. Amanullah et al., (2014)[9] confirmed that growth and growth attributes of maize increases with higher nitrogen application rates. Thus, the right explanation was provided by the statement that supplying N in the right amounts and right moment could improve plant heights and increase plant reactivity to better use of other inputs than supplying it the entire N at sowing time.

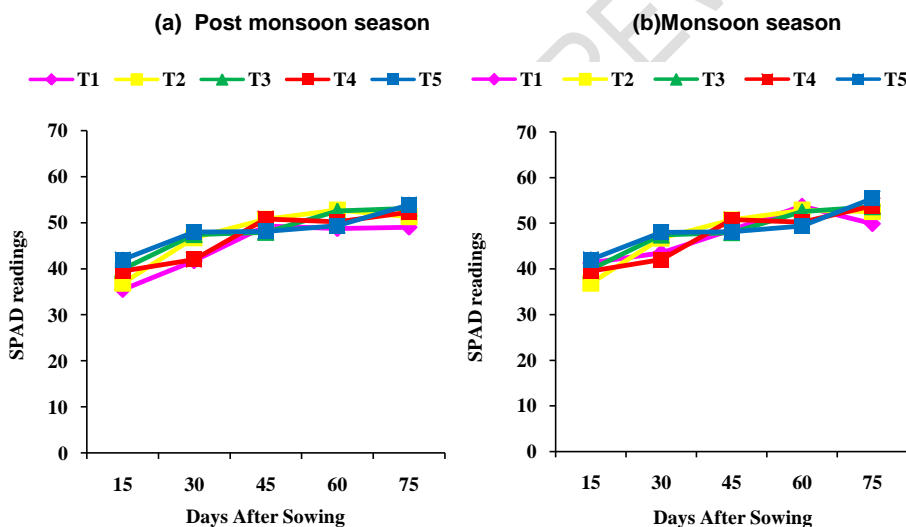
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**Figure 1. Mean values of plant height as affected by different rates of nitrogen fertilizer application in post monsoon and monsoon seasons, 2022-2023**

### 3.2 SPAD readings

The chlorophyll meter is a tool that can be used to evaluate crop N status and perhaps improve N use efficiency. SPAD readings in all treatments increased progressively from 15 DAS to 75 DAS under both seasons (Figure 2). ~~It was revealed that it was found that~~ only control treatment ( $T_1$ ) gave the minimum SPAD reading at all growth stages, while three equally splits of N fertilizer application ( $T_5$ ) possessed significant difference in SPAD readings among the other treatments similarly. Turner &Jund, (1994)[10] suggested that the leaf N concentration and SPAD values could predict the need for N top dressing at specific growth stages. Ghimire et al., (2015)[11] claim that maize's chlorophyll content has a positive and significant effect on grain yield. ~~In this study, Maize~~ leaves at different ages had considerably different SPAD values before and after anthesis. The results of the correlation indicated a significant positive association between grain yield and various stages of SPAD values (Figure xx).



**Figure 2. Mean values of SPAD readings as affected by different rates of nitrogen fertilizer application in post monsoon and monsoon seasons, 2022-2023**

### 3.3 Ear height (cm)

In post monsoon season, ~~we observed~~ a significant difference in the ear height of maize plants;  $T_5$  had the greatest value (100.33 cm). The values of  $T_1$ (77.98 cm),  $T_2$ (85.09 cm),  $T_3$ (88.27 cm), and  $T_4$ (88.27 cm) for the ear height (cm) of the other treatments were significantly different. Significant impacts of nitrogen fertilizer were also found in ear height;  $T_5$  gave the highest values (100.33 cm), whereas  $T_1$ produced the lowest values (77.98 cm). In monsoon season, a significantly significant difference in the ear height of maize plants;  $T_5$  had the greatest value, (113.16 cm). The values of  $T_1$ (83.82 cm),  $T_2$ (88.52 cm),  $T_3$ (94.74 cm),

and T<sub>4</sub>(100.33cm) for the ear height (cm) were significantly different. Significant impacts of nitrogen fertilizer were given in ear height. T<sub>5</sub> recorded the highest values (113.16 cm), whereas T<sub>1</sub> produced the lowest values (83.82 cm).

### 3.4 Ear length (cm)

The hybrid maize variety Pacific-789 was examined and the difference in the mean effect of applied nitrogen was recorded in the ear length of the crop. In the post monsoon season, maximum ear length was measured from T<sub>5</sub> (20.75 cm). The longest ear length (20.75 cm) was achieved at a level of T<sub>5</sub>, while the shortest ear length 19.38 cm was recorded from the T<sub>1</sub> treatment. The longest ear length (20.25 cm) was achieved at a level of T<sub>5</sub>, while the shortest ear (19.63 cm) was received from the T<sub>1</sub> treatment. The results demonstrated that ear length increased with ~~rise the increase~~ in nitrogen level from T<sub>5</sub>. When nitrogen fertilizer was administered in three equally splits (basal, 20 DAS and 40 DAS), the longer ears length ~~were was~~ obtained than control. According to Li et al., (2018)[12] maize ear length is a significant agronomic feature that is directly correlated with total grain output.

**Comment [M9]:** You better talk about significant data in the post monsoon and monsoon season rather than reproducing all the data in the text. Readers have eyes to see all the tables or figures

### 3.5 Ear Diameter (cm)

The analysis of variance showed that, the effect of all treatments on ear diameter was not significant. In post monsoon season, the highest ear diameter value (4.88 cm) was obtained from T<sub>4</sub>. The lowest ear diameter value (4.68 cm) was obtained from T<sub>2</sub>. In monsoon season, the highest ear diameter value (4.75 cm) was obtained from T<sub>5</sub>. The lowest ear diameter value (4.63 cm) was obtained from T<sub>3</sub>. The other treatments yielded somewhat lower but similar ear diameter values. However, some researchers reported different results and they found that the nitrogen fertilizer application ~~increased the ear diameter values~~ (Saruhan&Sireli, 2005)[13].

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**Table 3. Mean values of ear height (cm), ear length (cm) and ear diameter (cm) as affected by different rates of nitrogen fertilizer application in post monsoon and monsoon seasons, 2022-2023**

| Treatments                                  | Ear height (cm)     |                | Ear length (cm)     |                | Ear diameter (cm)   |                |
|---|---------------------|----------------|---------------------|----------------|---------------------|----------------|
|   | Post monsoon season | monsoon season | Post monsoon season | monsoon season | Post monsoon season | monsoon season |
| T <sub>1</sub> (Control)                    | 77.98 d             | 83.82 d        | 19.38               | 19.63          | 4.75                | 4.68           |
| T <sub>2</sub> (90 kg N ha <sup>-1</sup> )  | 85.09 c             | 88.52 d        | 20.25               | 20.25          | 4.78                | 4.70           |
| T <sub>3</sub> (120 kg N ha <sup>-1</sup> ) | 88.27 b             | 94.74 c        | 19.88               | 19.88          | 4.68                | 4.63           |
| T <sub>4</sub> (150 kg N ha <sup>-1</sup> ) | 88.27 b             | 100.33 b       | 20.25               | 19.75          | 4.88                | 4.50           |
| T <sub>5</sub> (180 kg N ha <sup>-1</sup> ) | 100.33 a            | 113.16 a       | 20.75               | 20.25          | 4.75                | 4.75           |
| LSD <sub>0.05</sub>                         | <b>2.98</b>         | <b>5.11</b>    | <b>1.38</b>         | <b>0.96</b>    | <b>0.44</b>         | <b>0.19</b>    |
| Pr>F  | <b>**</b>           | <b>**</b>      | <b>ns</b>           | <b>ns</b>      | <b>ns</b>           | <b>ns</b>      |
| CV%   | <b>2.20</b>         | <b>3.45</b>    | <b>4.46</b>         | <b>3.13</b>    | <b>6.05</b>         | <b>6.08</b>    |

In each column, means followed by a different letter are significantly different at the ns non-significant difference, \*\*significant difference at 1% level.

### 3.6 Number of ears plant<sup>-1</sup>

The mean number of ears plant<sup>-1</sup> was calculated by counting all the ears in each plot and dividing the total by the number of plants in each plot. Furthermore, Adekiya et al., (2020)[14] discovered that the greatest yield of maize grains were obtained by applying 180 kg N ha<sup>-1</sup> in three equally divided applications at baseline, 20 days after sowing, and 40 days after sowing.

### 3.7 Number of kernels row<sup>-1</sup>

In post monsoon season, there was a noticeable variation in the number of kernels row<sup>-1</sup> across all treatments, with the exception of the T<sub>1</sub> (control) treatment, which showed the minimum number of kernels row<sup>-1</sup>. Significant differences were found in T<sub>5</sub> giving the maximum number of kernels row<sup>-1</sup> during the monsoon season.

**Table 4. Mean values of row length (cm), number of ears plant<sup>-1</sup> and number of kernels row<sup>-1</sup> as affected by different rates of nitrogen fertilizer application in postmonsoon and monsoon seasons, 2022-2023**

| Treatments                                  | Row length (cm)     |                | Number of ears plant <sup>-1</sup> |                | Number of kernels row <sup>-1</sup> |                |
|---|---------------------|----------------|------------------------------------|----------------|-------------------------------------|----------------|
|   | Post monsoon season | monsoon season | Post monsoon season                | monsoon season | Post monsoon season                 | monsoon season |
| T <sub>1</sub> (Control)                    | 19.38               | 20.25          | 1.00 d                             | 1.00 d         | 37.75 b                             | 38.50 b        |
| T <sub>2</sub> (90 kg N ha <sup>-1</sup> )  | 20.13               | 20.63          | 1.08 c                             | 1.08 c         | 40.00 a                             | 40.75 b        |
| T <sub>3</sub> (120 kg N ha <sup>-1</sup> ) | 19.88               | 19.88          | 1.13 bc                            | 1.13 bc        | 40.50 a                             | 39.50 b        |
| T <sub>4</sub> (150 kg N ha <sup>-1</sup> ) | 20.25               | 20.50          | 1.15 b                             | 1.18 b         | 41.00 a                             | 41.50 ab       |
| T <sub>5</sub> (180 kg N ha <sup>-1</sup> ) | 20.75               | 21.00          | 1.23 a                             | 1.25a          | 41.50 a                             | 44.25 a        |
| <b>LSD<sub>0.05</sub></b>                   | <b>1.43</b>         | <b>1.47</b>    | <b>0.05</b>                        | <b>0.05</b>    | <b>1.83</b>                         | <b>2.81</b>    |
| <b>Pr&gt;F</b>                              | <b>ns</b>           | <b>ns</b>      | <b>**</b>                          | <b>**</b>      | <b>*</b>                            | <b>*</b>       |
| <b>CV%</b>                                  | <b>4.62</b>         | <b>4.68</b>    | <b>3.17</b>                        | <b>3.14</b>    | <b>2.96</b>                         | <b>4.48</b>    |

In each column, means followed by a different letter are significantly different at the ns non-significant difference, \* significant difference at 5% level, \*\* significant difference at 1% level.

### 3.8 1000 grain weight (g)

1000 grain weight (g) were shown in Table 5. At the 1% level ( $P < 0.01$ ) in both seasons, there were highly significant differences among all treatments. However, the  $T_5$  treatment produced the largest 1000 grain weight (g) while the  $T_1$  treatment produced the lowest 1000 grain weight (g).

### 3.9 Shelling percent

Table 5 showed mean values for shelling percent which were affected by different rates of nitrogen fertilizer application in both seasons. There were highly significant differences in all treatments. The highest shelling percent (78% and 88%) was obtained at  $T_5$  treatment in post monsoon and monsoon seasons. The lowest shelling percent was resulted at  $T_1$  treatment.

### 3.10 Grain yield ( $\text{kg ha}^{-1}$ )

The results of the maize grain production ( $\text{kg ha}^{-1}$ ) for both seasons as a function of different nitrogen fertilizer application rates are shown in Table 5. The difference in grain yield between the two seasons was particularly apparent. The  $T_5$  treatment produced the highest grain yield ( $7696.6 \text{ kg ha}^{-1}$ ) with highly significant difference at 1% level, in post monsoon season, while the  $T_1$  treatment produced the lowest grain yield ( $4747.9 \text{ kg ha}^{-1}$ ). The  $T_5$  treatment produced the highest grain yield ( $8764.5 \text{ kg ha}^{-1}$ ) with highly significant difference at the 1% level, in the monsoon season, while the  $T_1$  treatment produced the lowest grain yield ( $5409.3 \text{ kg ha}^{-1}$ ). Zeidan et al., (2006)[15] also reported that the yield of maize grains increased in tandem with an increase in the N level. Many authors including, Abayomi et al., (2006)[16] have reported that increased N rates [improves maize grain yield with increase grain yield.](#)

**Table 5. Mean values of 1000 grain weight (g), grain yield ( $\text{kg ha}^{-1}$ ) and shelling % as affected by different rates of nitrogen fertilizer application in post monsoon and monsoon seasons, 2022-2023**

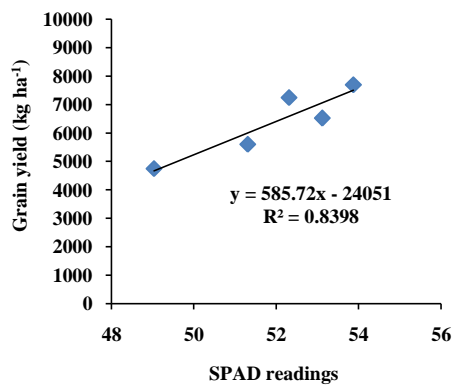
| Treatments | 1000 grain weight (g) |                | Grain yield ( $\text{kg ha}^{-1}$ ) |                | Shelling (%)        |                |
|------------|-----------------------|----------------|-------------------------------------|----------------|---------------------|----------------|
|            | Post monsoon season   | monsoon season | Post monsoon season                 | monsoon season | Post monsoon season | monsoon season |
|            |                       |                |                                     |                |                     |                |

|   |              |              |               |               |             |             |
|---|--------------|--------------|---------------|---------------|-------------|-------------|
| T <sub>1</sub> (Control)                    | 360.0 d      | 397.5 d      | 4747.9 e      | 5409.3 e      | 84 b        | 84 c        |
| T <sub>2</sub> (90 kg N ha <sup>-1</sup> )  | 405.0 c      | 440.0 c      | 5603.6 d      | 6310.8 d      | 85 b        | 86 b        |
| T <sub>3</sub> (120 kg N ha <sup>-1</sup> ) | 425.0 bc     | 465.0 b      | 6522.2 c      | 6885.6 c      | 85 b        | 86 b        |
| T <sub>4</sub> (150 kg N ha <sup>-1</sup> ) | 450.0 b      | 475.0 ab     | 7248.3 b      | 7632.9 b      | 85 b        | 86 b        |
| T <sub>5</sub> (180 kg N ha <sup>-1</sup> ) | 480.0 a      | 495.0 a      | 7696.6 a      | 8764.5 a      | 87 a        | 88 a        |
| <b>LSD<sub>0.05</sub></b>                   | <b>28.27</b> | <b>23.87</b> | <b>442.58</b> | <b>338.46</b> | <b>1.39</b> | <b>0.95</b> |
| <b>Pr&gt;F</b>                              | <b>**</b>    | <b>**</b>    | <b>**</b>     | <b>**</b>     | <b>**</b>   | <b>**</b>   |
| <b>CV%</b>                                  | <b>4.33</b>  | <b>3.38</b>  | <b>4.51</b>   | <b>3.14</b>   | <b>1.06</b> | <b>0.72</b> |

In each column, means followed by a different letter are significantly different at the \*\*significant difference at 1% level.

### 3.11 Relationship between SPAD readings and grain yield (kg ha<sup>-1</sup>) of maize in post monsoon and monsoon seasons, 2022-2023

#### a. Post monsoon season



#### b. Monsoon season

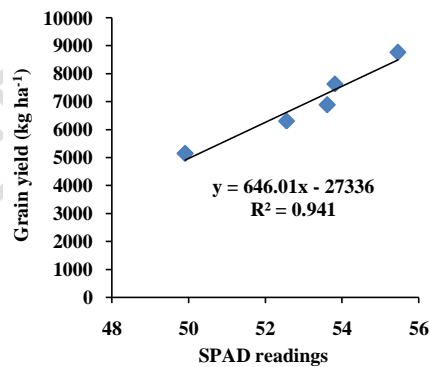
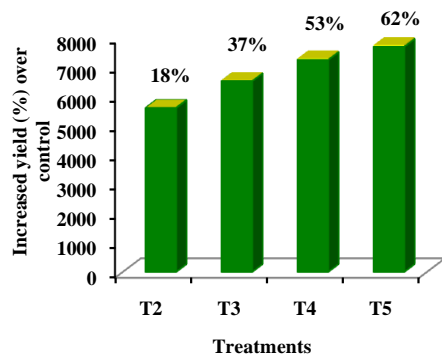


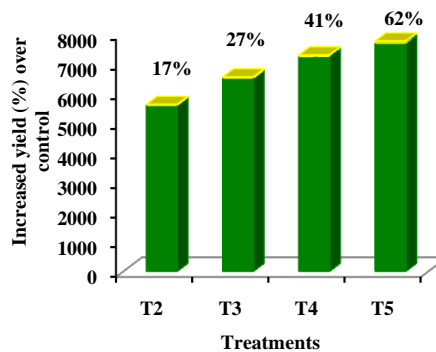
Figure 3. Relationship between SPAD readings and grain yield (kg ha<sup>-1</sup>) as affected by different rates of nitrogen fertilizer application in post monsoon and monsoon seasons, 2022-2023

### 3.13 Increased yield (%) over control as affected by different rates of nitrogen fertilizer application in post monsoon and monsoon seasons, 2022-2023

#### a. Post monsoon season



#### b. Monsoon season



**Figure 4. Mean values of increased yield (%) over control as affected by different rates of nitrogen fertilizer application in post monsoon and monsoon seasons, 2022-2023**

#### 4. CONCLUSION

In both seasons, T<sub>5</sub> (180 kg N ha<sup>-1</sup>) gave the highest values for plant height, SPAD readings, number of ear plant<sup>-1</sup>, ear height, ear length, ear diameter, row length, number of kernels row<sup>-1</sup>, number of rows ear<sup>-1</sup>, 1000 grain weight, shelling % and grain yield. In both seasons, the highest grain yields % over control were obtained with the T<sub>5</sub> treatment (180 kg N ha<sup>-1</sup>). In post monsoon season, the grain yield were observed at T<sub>2</sub> (90 kg N ha<sup>-1</sup>) 18 %, T<sub>3</sub> (120 kg N ha<sup>-1</sup>) 37 %, T<sub>4</sub> (150 kg N ha<sup>-1</sup>) 53 % and T<sub>5</sub> (180 kg N ha<sup>-1</sup>) 62 % treatments was resulted over control treatment. In monsoon season, the grain yield were resulted at T<sub>2</sub> (90 kg N ha<sup>-1</sup>) 17 %, T<sub>3</sub> (120 kg N ha<sup>-1</sup>) 27 %, T<sub>4</sub> (150 kg N ha<sup>-1</sup>) 41 % and T<sub>5</sub> (180 kg N ha<sup>-1</sup>) 62 % treatments was achieved over control treatment, respectively. It increasing was concluded that increasing nitrogen levels rates significantly enhanced the growth and yield parameters of pacific-789 hybrid maize variety. Considering the increased seed yield of the cultivar (pacific-789) hybrid maize, nitrogen rate of 180 kg N ha<sup>-1</sup> is recommended to could be achieved the highest grain yield for both seasons this study area.

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