Original Research Article

# Estimating the Plant Nutrient Uptake of Selected Maize Varieties in Sri Lanka's Dry Zone at Various Fertilizer Rates

**Comment [B1]:** It can be " Estimating the Plant Nutrient Uptake at Various Fertilizer concentration in Selected Maize Varieties of Sri Lanka's Dry Zone "

*Abstract*

A coarse cereal mostly grown in Sri Lanka's Dry Zone is maize. Input of maize has gained significance in the expanding livestock feed sector. Since intense agriculture quickly reduces the soil's fertility, it is crucial to implement appropriate fertilizer management techniques in order to sustain greater output levels.There have been no current research conducted to measure maize's nutrient absorption. Thus, at the Field Crops Research and Development Institute Mahailluppallama in the North Central Province of Sri Lanka (08.600N, 80.270E, 137m amsl) during Yala 2022, an experiment was carried out to estimate the nitrogen (N), phosphorous (P), and potassium (K) uptakes of selected maize varieties at the flowering stage under various nutrient management options.Three replicates of a two-factor-factorial experiment in a Randomized Complete Block Design were employed. The fertilizer level (F1 - Zero fertilizer, F2 - Present Department of Agriculture (DOA) inorganic fertilizer recommendation, F3 - 1.5 times of present DOA inorganic recommendation, and F4 - DOA organic fertilizer recommendation) and variety (V1Pacific 339, V2- MIMZHY 4, V3- Badra) were the two factors tested. The findings showed that whereas P and K uptakes were significantly ($P<0.05$) greater in Pacific 399 and Badra, respectively, there was no significant difference in N uptake between the maize types at the flowering stage. When no fertilizer was applied, total N was considerably ($P<0.05$) lower than in F2 and F3, but comparable to F4. Regarding varying fertilizer levels, no discernible significant variation in the overall uptake of P and K was found. All types had comparable total dry weights at 50% blooming; however, under F2 and F3, it was higher than under F1. As a result, whereas N uptake varied according to the various fertilizer application levels, P and K uptake varied amongst types. Overall, it can be said that varying fertilizer levels did not affect the variations' P and K uptake. Variations in fertilizer application levels did not affect N uptake, but varieties did. Thus, while the soil's natural fertility state can supply P and K, proper administration of N fertilizer is necessary for improved growth.

***Keywords*:** Blooming stage, NPK uptake, fertilizer amounts, and maize



## 01.INTRODUCTION

Maize (Zea mays L.) is one of the world-leading crops and a critical source of food, feed, fuel, and fibers. As such, it has traditionally been used as a model for plant geneticists. Maize is unique in at least two respects.First, it has the broadest cultivated range of all crops, from the south of Chile 40°S to Canada 50°N, from the Andean mountains where it can grow at altitudes of 3400 m above the sea level to Caribbean islands. Second, it has unprecedented morphological, nucleotide, and structural diversity. Different types of maize are grown throughout the world, with one important difference being colour. Maize kernels can be of different colours, from white to yellow, red to black.Maize is a coarse cereal produced predominately in the dry zone of Sri Lanka. It is second only to rice in the country's total cereal-cropped area. Maize occupies 5.6% of the total cereal-cropped area in the country. Recently maize production hasyieldedcompellingsuccess with the adoption of hybrid varieties that have significantly increased smallholder maize production and the area cultivated by 258% and 73%, respectively (FAOSTAT, 2014). Maize has been assumed important as an input to the growing livestock feed industry, especially in the poultry sector. Moreover, the consumption of maize-based food items like locally produced ready-mix cereals (Thriposha and Samaposha), popcorn, and boiled maize cobs has increased during the past few years (Esham ., 2014).Maize is traditionally cultivated during the Maha season throughout Sri Lanka except in the southwest coastal districts. Major maize-cultivating districts are Anuradhapura, Ampara, Badulla, Monaragala, and Batticaloa. In 2019, the annual extent of maize was 82,539 ha (DOA statistic, 2019) and production was 313,000 tonnes (Central bank report, 2020) with an average yield of 3.87 t $ha^{-1}$. (AgStat., 2020). Maize production in Sri Lanka increased from 26,000 tonnes in 2001 to 313,000 tonnes in 2020 at an average annual rate of growth of 17.34% (Knoema, 2020).With intensive cultivation, the fertility of the soils declines rapidly and the useof fertilizer especially mineral nutrients, and optimizing cultural practices, are important to maintaining high yield levels. Maize hybrids differed in productivity and their response to nutrient applications in, Leaf area index, Leaf area duration, Net assimilation rate, Crop growth rate, Grain yield, etc.Soils of a major proportion of the highlands of the dry zone where maize is grown are Reddish-Brown Earth. These are sandy clay loams, slightly acidic to neutral reaction, low in organic matter, nitrogen, and phosphorous. Potassium, however, is present in fair amounts. Several fertilizer experiments were carried out to determine the optimum rate and the time of application of N, P, and K fertilizers for maize. The present fertilizer recommendation of the Department of Agriculture under supplementary irrigated conditions is 34.5 kg $ha^{-1}$, 45 kg $ha^{-1}$, and 30 kg $ha^{-1}$ of N,P2O5, and K2O, respectively as the basal application. A top dressing is applied at the rate of 16 kg $ha^{-1}$ of N at 4 – 5 weeks after seeding.With the harvest of every crop, a certain amount of nutrients is removed fromthe soil. With the current availability of high-yielding varieties and with the development of irrigation facilities that permit the cultivation of selected maize varieties on the same land, hence it is expected that more nutrients are taken from the soil than before. This indicates the necessity of maintaining the fertility of soils so that high crop yields can continuously be obtained. In this respect, it will be useful to know the amount of nutrients uptaken by different maize varieties. Such information is scarce for maize crops grown in tropical countries. Limited recent studies have been undertaken in Sri Lanka to estimate the nutrient uptake of maize except the report by Amarasiri and Perera (1974). Since crop growth and nutrient removal depend on the soil and climate where the crops are grown comparison of nutrient removal capacities of crops would be more valid if they were grown at the same location. Under the existing fertilizer crisis, the present fertilizer management practices should be fine-tuned to maximize efficiency. In this context, the amount of nutrientsuptakenby the maize varieties would be useful in giving a fertilizer recommendation.

This experiment was planned with the following broad and specific objectives.

To estimate nutrient uptakes of selected maize varieties at the flowering stage

broad objective.

To estimate nutrient uptakes of selected maize varieties at different fertilizer rates under dry zone conditions in Sri Lanka.

Specific objectives.

I. To study the partitioning of plant nutrients among leaf, stem, and cob.
II. To study growth and yield parameters with four different fertilizer levels.

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III. To determine total plant nutrient uptake.
IV. To determine the Agronomic Use Efficiency.

02. MATERIALS AND METHODS

2.1 Experimental site,

The experiment was conducted at Field Crops Research and Development Institute, *Mahailluppallma* (08.60 °N, 80.27 °E, 137 m MSL) in the Low Country Dry Zone (DL1b) Agro-climatic zone during *yala* season of 2022 on a well-drained sandy clay loamy soil.

**2.2.** Crop Management

The field site was ploughed approximately to a 20 cm depth using a disc plough followed by a rotovator. Fine seedbeds were prepared prior to the seed being established. The plot size was 3.6 x 3.6 m. Weeds were controlled manually and the stem borer was controlled by the application of Fipronil granules at 3 Week After establishment (WAS). The crop was grown under supplementary irrigation and irrigation schedule of twice a week during the first month and then at a five-day interval. Plant spacing used was the current recommendation of the Department of Agriculture (DOA) (45 cm x 30 cm) with a plant density of 74074 plants ha$^{-1}$.

**2.3.** Experimental Design and Treatments.

The experiment was carried out in a two-factor factorial Randomized Complete Block Design with three replicates. (The field experimental layout is illustrated in table 1) Three varieties (V1 - Pacific 339, V2 - MYMZHY4 and V3 - *Badra*) and four different fertilizer levels (F1 - Zero-fertilizer, F2 - DOA Recommendation, F3 - DOA recommendation x 1.5, F4 - Organic fertilizer recommendation) were used as treatments. (Table - 2) The crop was applied with 75 kg ha$^{-1}$ of Urea, 100 kg ha$^{-1}$ of TSP, and 50 kg ha$^{-1}$ of MOP in the basal dressing, and 4 weeks after planting 350 kg ha$^{-1}$ of Urea was applied as the top dressing in the F2 treatment. In F3, 1.5 times the above rates were applied in the same period. Organic fertilizer (Compost) was used in F4 at the rate of 20 t ha$^{-1}$ as a basal dressing (Incorporated into the soil at the 2$^{nd}$ ploughing) and 15 t ha $^{-1}$ at 3 weeks after crop establishment.

The plot size was 3.6 x 3.6 m. The number of plots was 36. The total experiment area was 466.56 m$^2$. Bunds were constructed around the plot to protect water and a drain was prepared in between plots to remove excess water.



| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **R1** | T1 | T6 | T11 | T2 | T7 | T12 | T3 | T8 | T10 | T4 | T5 | T9 |
| **R2** | T10 | T4 | T6 | T11 | T3 | T5 | T9 | T2 | T8 | T12 | T1 | T7 |
| **R3** | T8 | T10 | T4 | T5 | T9 | T3 | T6 | T12 | T2 | T7 | T11 | T1 |

**Table 1. Field Experimental Layout**

Table 2. Fertilizer Application Rates of the Field Experiment

| Treatment | Urea (kg $ha^{-1}$) | | TSP (kg $ha^{-1}$) | | MOP (kg $ha^{-1}$) | | Compost (t $ha^{-1}$) | |
|---|---|---|---|---|---|---|---|---|
| | Basal Application | Top Dressing (4-5wk after seeding) | Basal Application | Top Dressing | Basal Application | Top Dressing | Basal Application | Top Dressing |
| F1 | Zero | Zero | Zero | Zero | Zero | zero | | |
| F2 | 75 | 350 | 100 | - | 50 | - | | |
| F3 | 112.5 | 525 | 150 | - | 75 | - | | |
| F4 | | | | | | zero | 20 | 15 |



2.4. Data Collection and Laboratory Analysis

Four plants were selected from each plot, separated into stem and leaf, cut into small particles, and dried in an oven at 60°C for 48 hours. (Model-ADL_3610L). The drying plant parts were ground and separated into samples, each containing total nitrogen, which was tested using the Kjeldahl method. (Digestion unit, Model DK 6 and Distillation unit, Model-UPK 132). This method was based on the digestion of plant material in a sulfuric–salicylic acid mixture (Buresh *et al*. 1982). The reagent used was Sulfuric –Salicylic acid mixture (concentrated $H_2SO_4$ containing 2.5% w/v Salicylic acid). It dissolved 62.5 g reagent-grade salicylic acid ($C_7H_3O_3$) in 2.5 L concentrated $H_2SO_4$. The catalyst mixture was prepared by using $K_2SO_4$, and Selenium (100:1 w/w) and other reagents used were Sodium Thiosulfate (($Na_2S_2O_3$ $5H_2O$), 1%boric acid and 0.01N $H_2SO_4$.

The digestion process involved mixing and spreading finely ground plant samples uniformly, then systematically withdrawing a representative 0.5g sub-sample and placing it in a vial.The subsample was dried at 60□ in an oven (Overnight) and then cool in a Desiccator. An amount of 0.5 g of dry plant material was weighed and then transferred quantitatively into a dry 250 ml digestion tube. 20 ml sulfuric–salicylic acid mixture was added while rotating the tube to wash down any sample adhering to the neck of the tube and was allowed to stand for 2 hours or longer with occasional swirling. Sodium thiosulfate (2.5 g) was added through a long steam funnel to the contents of the tube and was swirled gently a few times and allowed to stand overnight. Catalyst mixture of 4g was added and placed in the tube on the block –digester which was preheated to 400 in 3 hrs. The digestion proceeded until the mixture clears. Tubes were removed from the Block- digester and were allowed to cool for about 20 minutes. After the digestion was finished, allowing the digestion was cooled, and allowed the tube to cool to room temperature. Each batch of samples for digestion contained one regent blank (no plant).

Next, the distillation process was done. Before distillation, the digestion tube was shaken thoroughly to mix its contents, and then carefully added 40ml of 10N Sodium Hydroxide solution was for aliquot respectively and immediately was contacted 25ml of 1% boric acid flask to distillation unit and began distillation. The distillation flask was removed and the distillate was titrated to pH 5.0 with standardized 0.01N $H_2SO_4$ using the burette and recorded titrate volume of acid. Nitrogen percentage was calculated by using the following Eq.2

$$N\% = (v1 - v2) * N * \frac{14.01}{w} * \frac{1}{1000} * 100\ \%$$ (Eq-2.1)

Where

V1- Burette $H_2SO_4$ volume

V2- Titrated $H_2SO_4$ volume

N- Normality of $H_2SO_4$ W- Sample weight.

(Bremner *et al*,. 1982)

Phosphorous and Potassium were analyzed by the Dry Ashing method. The apparatuses used were Spectrophotometer at 410 nm wavelength (Model- UVD 2960), a Flame photometer (Model-360), and Porcelain crucibles. The reagent used was Hydrochloric Acid, 2 N Diluted concentrated hydrochloric acid (37%v/v, specific gravity.1.19) in Distilled water. as explained by Chapman and pratt, (1961) with slight modifications. Ground plant materials (0.5 g were put in 30 – 50 ml porcelain crucibles. Then porcelain crucibles were placed into a cool muffle furnace and increased the temperature gradually to 550 for 5 hrs and continued ashing after attaining 550. The muffle furnace was shut off and opened the door cautiously for rapid cooling. When cooled porcelain crucibles were carefully taken out. The cooled ash was then dissolved in 5 ml portions of 2N HCl (Hydrochloric) and was mixed with a plastic rod. After 15 – 20 minutes, it was made up the volume (Usually 50 ml) using DI water. It was mixed thoroughly and allowed to stand for about 30 minutes and it was used the supernatant or filter through Whatsman No. 42 filter paper, discarding the first portions of the filters. The aliquots were analyzed for K by Flame Photometer and P by Spectrophotometer.

Based on the N, P, and K levels and the organic materials (dry weight basis), Agronomic Nutrient Utilization Efficiencies (ANUE) were determined for the inorganic fertilizer and organic manure as reported by Baligar*etal.*, (2001). The following formula were as used for the calculation.

$$ANUE = \frac{Yield\ in\ fertilized\ treatment\ (plot)(kg/ha) - Yield\ in\ unfertilized\ treatment\ (plot)\ (kg/ha)}{Total\ fertilizer\ applied\ kg/ha)}$$

(Eq-2.2)

Growth parameters, namely, leaf area index, SPAD meter value, and dry matter production were recorded from selected plants from each plot at the 50% flowering stage. The leaf area of each leaf was calculated by leaf area meter (Li-3100 c the Area Meter Li-COR environmental). Then the leaf area index (LAI) was calculated by dividing the leaf area per plant by the ground area covered by each plant (1350 sq. cm).

The chlorophyll content of the leaf was measured indirectly by SPAD meter (model502 plus). Five randomly selected plants from each plot were used to record the yield attributes (cobs plot$^{-1}$, grains cob$^{-1}$, and 100- grain weight (g), and the seed moisture percentage). The grain yield of each net plot was taken after sun-drying.

The data were statistically analyzed by following the ANOVA procedure using the software, Statistical Analysis System (SAS). Mean separation was done using Duncan Multiple Range Test (DMRT) at *P* = 0.05.

## 03. Results and Discussion

A soil analysis at the experimental site was carried out prior to the sowing of the crop and the results are shown in Table 3.

Soil phosphorous and potassium contents were higher than the requirement for maize crops pH, and EC values were very high while the organic matter content was very low. (*Malaviarachchi et al*.,2011).

Table 3. Initial Soil Nutrient Status of Experimental Site.

| Total Nitrogen (mg g$^{-1}$) | Oslen P (ppm) | Exchangeable K (ppm) | Organic matter (%) | pH | EC |
|---|---|---|---|---|---|
| 0.99 | 384 | 28 | 0.97 | 6.7 | 328.5 |

**3.1** Variation of Plant Growth Parameters as Effected by Different Varieties and Fertilizer Levels. LAI, SPAD value, and total plant dry weight ranged between 2.05 - 2.16, 39.9 - 46.3, and 2873 - 3218 kg ha$^{-1}$, respectively (Table 2). However, no significant variation was observed among varieties in LAI, SPAD value, and total dry weight. LAI was significantly higher when the DOA recommendation increased up-to 1.5 times whereas effects of zero fertilizer and Organic fertilizer application were similar (Table 3). SPAD value was higher in DOA recommendation and 1.5 times of DOA recommendation when compared to zero fertilizer application. however, similar to organic fertilizer application. The total plant dry weight showed the same trend. This indicates that maximum growth has not been achieved by the three varieties at the 50% flowering stage. Generally, it is expected that the growth of hybrid varieties is higher than open-pollinated varieties (Caleb *et al*., 1991). On the other hand, demand for nutrients increased after seed filling starts (Jones *et al*., 2015). Thus at 50 % flowering where samples were taken hybrids did not shown any difference in growth parameters except with zero fertilizer application.

Table 4. Variation of Plant LAI, SPAD Value, Total Dry Weight in Different Varieties.

Comment [B5]: Instead of repeating, MYMZHY4 can be replaced by v2 wherever it is mentioned.

| Variety | LAI | SPAD value | Total plant dry weight (kg ha-1) |
|---|---|---|---|
| Pacific | 2.11[a] | 43.3[a] | 3218[a] |
| MIMZHY 4 | 2.05[a] | 39.9[a] | 3333[a] |
| Badra | 2.16[a] | 46.3[a] | 2873[a] |
| CV (%) | 15.7 | 16.6 | 25.6 |

Table 5. Variation of Plant LAI, SPAD value, Total Dry Weight as affected by Different Fertilizer Rates

| | LAI | SPAD reading | Total plant Dry Weight (kgha-1) |
|---|---|---|---|
| F1 - Zero –fertilizer | 1.67[b] | 25.0[b] | 2486 [b] |
| F2 - (DOA recommendation) | 2.14[ab] | 56.0[a] | 3469 [a] |
| F3 - 1.5 (DOA) recommendation | 4.27[a] | 60.2[a] | 3460 [a] |
| F4 - Organic | 2.13[b] | 30.9[b] | 2989 [ab] |

3.2. Nitrogen, Phosphorous, and Potassium uptake by Different Maize Varieties

Stem and leaf N uptakes of an exotic hybrid and local hybrid were similar. StemP uptake was higher in the exotic hybrid when compared to local and leaf P uptake was similar in the exotic and local hybrids. Stem K uptake was similar in all varieties. However, leaf uptake was higher in Badra in comparison to exotic hybrids. Total N uptake was equal among varieties. Total P and K uptake were high in Pacific & Badra (Table 4).

Generally, Nitrogen used by OPV were significantly lower than that of the hybrid. Thus, they have the ability to utilize This important and limited nutrient to a greater extent due to tolerance for drier environments and thus produce higher yields. (Sangakkara et al., 2012).Hybrid and improved maize varieties are more nitrogen-responsive than local varieties of maize (Shrestha et al.,. P and K uptake were not affected by hybrids 2019).
However, in our study, the above observation was not made. Instead, it was observed that the total nitrogen uptake was similar among varieties or OPV varieties because the experimental site had higher amount of P and K (Table 1) than the maize plant required

Table 6. Nitrogen, Phosphorous, and Potassium uptake by Different Plant parts

Of Different Maize Varieties.

| Variety | Nitrogen (kg ha$^{-1}$) | | | Phosphorous (kg ha$^{-1}$) | | | Potassium (kg ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Stem | Leaf | Total | Stem | Leaf | Total | Stem | Leaf | Total |
| $V_1$-Pacific | $3.6^{ab}$ | $15.2^{a}$ | $21.2^{a}$ | $5.5^{a}$ | $4.9^{a}$ | $10.1^{a}$ | $69.9^{a}$ | $38.8^{b}$ | $107.6^{b}$ |
| $V_2$-MIMZHY4 | $6.4^{a}$ | $11.4^{ab}$ | $17.8^{a}$ | $3.9^{b}$ | $4.1^{ab}$ | $7.4^{b}$ | $65.6^{a}$ | $47.9^{ab}$ | $109.6^{b}$ |
| $V_3$-Badra | $2.6^{b}$ | $4.6^{b}$ | $11.5^{a}$ | $3.8^{b}$ | $3.7^{b}$ | $7.5^{b}$ | $81.4^{a}$ | $54.9^{a}$ | $147.6^{a}$ |
| CV (%) | 23.3 | 20.2 | 23.6 | 24.4 | 28.6 | 23.9 | 27.7 | 23.9 | 28.3 |



3.3. Nitrogen, Phosphorous, and Potassium uptake by Different Plant Parts of Maize as Affected Different Fertilizer Levels

Total N uptake was significantly higher in the DOA recommendation and 1.5 times of the DOA recommendation compared to zero fertilizer applications. By Increasing the fertilizer dose, nitrogen content in dry biomass increased, too. As reported by Nenova*et al.*, 2019, the highest average content of nitrogen content was resulted in maize leaves (0.94%) and, followed by the cobs (0.71%) and the lowest was in the stems (0.58%). However, in our study the highest average nitrogen content of nitrogen resulted in maize leaves (0.65%) and followed by the stems (0.34%) at the flowering stage. Instead, it was observed that the total nitrogen uptake was equal among DOA fertilizers recommendation and 1.5 times of the DOA recommendation. Amarasiri*et al.*, (1975) reported that N uptake by maize variety 'thai-composite' yielding 4000 kg ha$^{-1}$ of rough maize is 64 kg ha$^{-1}$ by grain, 54 kg ha$^{-1}$ by others and total uptake was 118 kgha$^{-1}$. Figure 1. shows the total N uptake (kgha$^{-1}$) of different plant parts (leaf and stem) of maize. A maximum of nearly 25 kg ha$^{-1}$ at 50% flowering stage has been uptaken under F2 and F3 fertilizer levels. Further, there are statistically significant variations in stem and leaf N uptake among different fertilizer levels.

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No significant difference among fertilizer rates was found in total P and K uptakes. The reason behind this is that a sufficient amount of P and K nutrients were available at the experimental site (Table 1) Thus, the plant parts may have absorbed the required amount from the soil. Wei *et al*., (2022) found that, 50 – 85% of leaf P and 15 – 50% of stem P accumulated at the pre-silking stage. The average content of K in maize leaves is 1.24% and the stems 1.55% at the flowering stage. It was observed that the total P uptake was equal among all fertilizer recommendation levels. Amarasiri ., (1975) reported that P uptake by maize variety 'thai-composite' yielding 4000 kg $ha^{-1}$ of rough maize was 7 kg $ha^{-1}$ by grain, 4 kg $ha^{-1}$ by others and total uptakes was 11 kg $ha^{-1}$. It further reported that K uptake by maize variety 'thai-composite' yielding 4000 $kgha^{-1}$ of rough maize was 13 kg $ha^{-1}$ by grain, 142 kg $ha^{-1}$ by others and total uptake was 155 kg $ha^{-1}$

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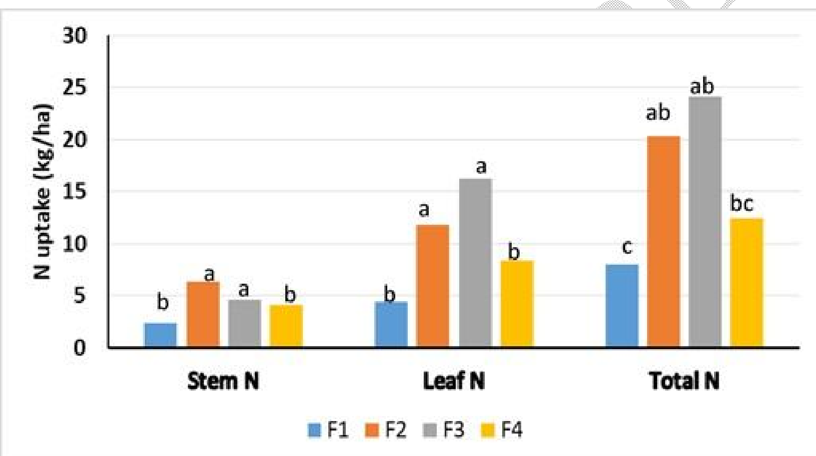
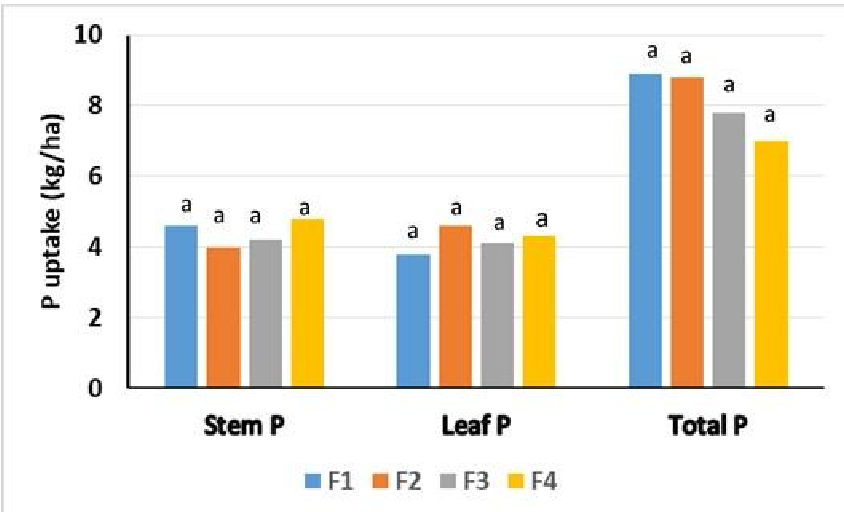
**Comment [B8]:** Put fullstop after 155 Kg ha ¯1

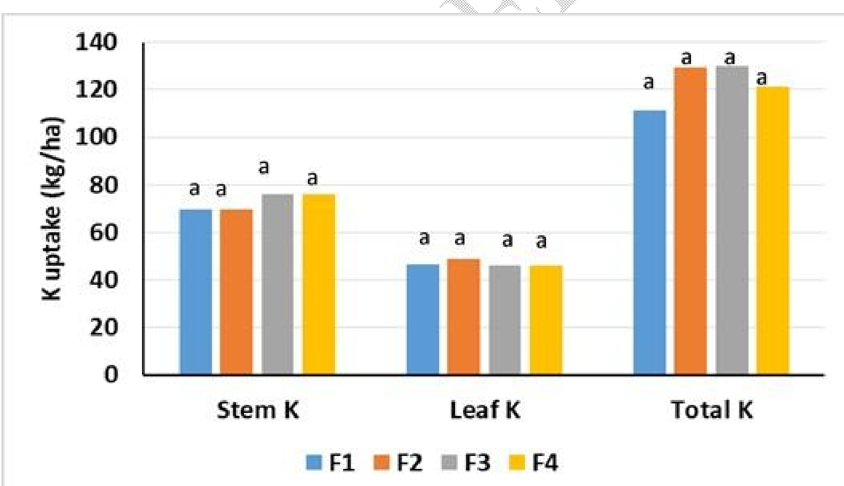
Total P uptake of other plant parts (stem and leaf) at 50% flowering stage of maize has reached 9 kg/ha under F1 and F2 fertilizer levels. (Fig. 2) while K uptake of different plant parts (stem and leaf) at the 50% flowering stage of maize was about 130 kg $ha^{-1}$ under F2 and F3 levels. (Fig. 3) whereas no statistically significant differences among fertilizer rates were found in total P and K uptakes.




figures 1.N uptake by different plant parts of Maize as affected by different Fertilizer Levels.




Figures 2 P uptake by different plant part of Maize as affected by different Fertilizer Levels.




figures 3 K uptake by different plant parts of Maize as affected different Fertilizer Levels.

3.4. Grain Yield as Affected by Different Varieties and Fertilizer Levels.

The grain yield of Pacific, and MIMZHY 4 were comparatively higher when compared to the Open-pollinate variety (Table 5). On the other hand, *Badra* recorded the lowest yield among different varieties. Grain yields of hybrids are similar and 43% compared to OPV.

Among fertilizer f levels, grain yield was higher in DOA recommendation (F2), 1.5 times of the DOA fertilizer recommendation (F3) and Organic recommendation (F4) when compared to zero fertilizers (F1) (Table 6). This clearly shows that fertilizer application directly affected on grain yield. However, organic fertilizers (F4) resulted a lower yield compared to inorganic fertilizers. Grain yield was 153%, 171% and 58.5%, respectively higher in DOA recommendation, 1.5 times of the DOA recommendation and organic fertilizers compared to zero fertilizer application.

3.5. Agronomic Fertilizer Use Efficiency AFUE) as affected by Different Varieties and Fertilizer Levels

AFUE is used to describe the capability of yield increase per kilogram of nutrient applied. The Agronomic Nitrogen Fertilizer Use Efficiency AFUE for – N of Pacific, MIMZHY 4, and *Badra* ranged from 14.48, 13.68, and 10.74 kg N kg $^{-1}$, respectively (Table 5). Vanlauwe*et al.*, (2010) reported that AFUE for local and hybrid varieties.

Table 7. Grain yield (kg/ha) and AFUE as affected with different Maize Varieties

| | Grain yield (kg ha$^{-1}$) | Agronomic Fertilizer Us | | |
|---|---|---|---|---|
| | | Nitrogen (kg N kg $^{-1}$) | Phosphorous (kg $P_2O_5$ kg $^{-1}$) | Potassium (kg $K_2O$ kg $^{-1}$) |
| $V_1$ –Pacific | 4344$^a$ | 14.48$^a$ | 14.7$^a$ | 29.3$^a$ |
| $V_2$-MIMZHY 4 | 4678$^a$ | 13.68$^a$ | 8.9 $^b$ | 17.9$^b$ |
| $V_3$-Badra | 3153$^b$ | 10.74$^b$ | 18.6$^a$ | 31.0$^a$ |
| CV (%) | 12.6 | 20.0 | 18.2 | 22.5 |

Table 8. Grain yield and Agronomic Fertilizer Use Efficiency (AFUE) as affected with different fertilizer levels

| | Grain yield (kg ha$^{-1}$) | Agronomic fertilizee efficiency | | |
|---|---|---|---|---|
| | | Nitrogen (kg N kg $^{-1}$) | Phosphorous (kg $P_2O_5$ kg $^{-1}$) | Potassium (kg $K_2O$ kg $^{-1}$) |
| $F_1$-Zero –fertilizer | 2074$^c$ | _ | - | - |
| $F_2$-DOA rec. | 5252$^a$ | 14.94 $^a$ | 21.0$^a$ | 34.7$^a$ |
| $F_3$-1.5 DOA rec. | 5619$^a$ | 16.66 $^a$ | 13.1$^b$ | 27.4$^b$ |
| $F_4$-Organic rec. | 3288$^b$ | 6.48 $^b$ | 8.0$^b$ | 16.1c |
| CV (%) | 12.6 | 20.0 | 18.2 | 22.5 |

## 04. CONCLUSIONS

Phosphorous and potassium uptake varied among the varieties but not with different fertilizer levels. N uptake varied with different fertilizer application levels but not with varieties. Accordingly, the inherent fertility status of the soil has the capability of supplying P and K however, N fertilizer management is essential to have a better growth.

AFUE of N was comparatively higher in the tested hybrids when compared to the open-pollinated variety whereas AFUE of P and K was similar in exotic hybrid varieties and the open pollinated variety. Inorganic fertilizers resulted in a higher AFUE in N when compared to organic fertilizers while AFUE of both P and K were lower in 1.5 times DOA recommendation and organic fertilizer recommendation in comparison to DOA recommendation. However, under the existing fertilizer crisis, the present fertilizer management practices could be fine-tuned to maximize the productivity and profitability of maize farming based on nutrient uptakes.

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**Comment [B9]:** Please give more references, especially latest ones


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