# 8. Identification of yield-limiting nutrient for Onion (*Allium cepa*) and Tomato (*Solanum lycopersicum*) in Raya Kobo district under irrigation

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## Abstract

*Knowing the most yield-limiting soil nutrient is crucial process for feeling yield gap in all crop production systems. The proper supply of nutrients in balanced amounts is essential for the maximum production of onion and tomato. The study was conducted to know the response of onion and tomato to the omission of different nutrients to their growth and yield under open field conditions at Raya kobo District during 2020/21 under irrigation. The experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications. The soil samples were taken using an auger before planting for the analysis of the physicochemical properties. Analysis of variance was computed using R software. The analysis result showed that statistically the lowest marketable yield of onion was recorded from the omission of nitrogen and from the control treatment. In contrast, the highest total unmarketable yield of onion was recorded from the control treatments. Similarly, the combined analysis showed that the highest marketable yield was recorded from Boron omitted plots with significant difference from N omitted and the control and at par with the others. In contrast, the lowest total marketable yield was recorded from the control and N-omitted treatments. There was also a substantial and positive correlation between marketable yield and the number of clusters per plant and no fruit/cluster at (P <0.01). The analysis of variance indicates that N was the most yield-limiting nutrient for both onion and tomatoes production than any other nutrient. This study was conducted to know which nutrient was yield limiting and did not address what amount was needed. Therefore, optimum fertilizer rate determination on the yield-limiting nutrient should be conducted*

**Keyword:** Fertilizer, Nitrogen, Omission,

## Introduction

Soil fertility heterogeneity in smallholder farming systems is a major factor that affects productivity and the suitability of crop and nutrient management recommendations for different locations. The optimum productivity of any cropping system depends on an adequate supply of plant nutrients. Even if all other factors of crop production are optimal, the fertility of the soil largely determines the ultimate yield. It describes the available nutrient status of the soil and its ability to provide nutrients for optimum plant growth (Dev., 1997). Fertilizer is one of the most important sources to meet this requirement. However, indiscriminate use of fertilizers may cause adverse effects on soils and crops, both in terms of nutrient toxicity and deficiency, either through overuse or inadequate use (Ray *et al.,* 2000).

Diagnostic techniques (omission of nutrients), including identification of deficiency symptoms, soil and plant analysis, are helpful in determining specific nutrient stresses and the quantity of nutrients needed to optimize the yield (Havlin *et al.,* 2007). The optimal amount of nutrients is the main issue, particularly in Ethiopia, for the development of vegetables (Melkamu *et al.,* 2022). Soil fertility evaluation, thus, is the key to adequate and balanced fertilizer application in crop production.

Ethiopia has enormous potential to cultivate vegetable crops on a small as well as large commercial scale. The country has a high potential to benefit from onion production, and the demand for onions is increasing over time due to their high bulb yields, seed, and flower production potential (Lemma and Shimelis, 2003).

Among the common irrigated vegetables, onion accounts for the largest area coverage and local consumption in Ethiopia. In particular, onion it is a popular vegetable grown under irrigation in most of the traditional and recent modern irrigation schemes in the Amhara region.

Tomatoes are also of high economic importance vegetables in Ethiopia. The reward of tomato cultivation is a high yield, usually achieved by following the proper fertilizer recommendation. Fertilization of the tomato plant significantly impacts crop yield. In Ethiopia, farmers experience decreasing yields primarily due to pests, diseases, and inadequate fertilization (Yemane *et al*., 2016). According to Kassa (2018), limited use of agricultural inputs, particularly improved seeds and fertilizers, contributes to low tomato production and productivity.

Tomatoes have proven advantageous to societies in terms of sustenance, trade, and well-being. However, Ethiopia's tomato output falls considerably short of the average production levels seen in some other nations, and the fruits are of poor quality (Yebirzaf *et al*., 2016). Tomato production in Ethiopia is constrained by several factors, with sub-optimal fertilizer application and the selection of high-yielding varieties being the most important. Nutrient deficiencies limit agricultural yields worldwide, and the availability of these vital elements not only satisfies the nutritional needs of the tomato crop but also boosts its growth and productivity. The use of balanced fertilizers and appropriate variety recommendations are important agronomic practices used to increase the growth and quality of tomatoes (Tsedu *et al.*, 2021).

Onions and tomatoes are also of the most widely produced and highly commercialized vegetable crops in Kobo district, North Wollo Zone of the Amhara Region. The crop is grown in the area under irrigation. Among the different varieties of onion, Bombay Red has been the most widely cultivated commercial vegetable crop using pressurized (drip and sprinkler) and gravitational irrigation since the establishment of the Kobo Girana Valley Development Program Office (KGVDP) in 1999. However, the productivity of the crop in the district is 9.46 tons per hectare (KGVDP, 2013), which is far less than the regional average (12.3 tons per hectare) and the world average bulb yields (19.31 tons per hectare), respectively (CSA, 2020/21). There are a number of constraints that contribute to the low productivity of onions and tometoes in Ethiopia. The low yield of onions and tometoes in the country is reported to be due to low soil fertility, inappropriate fertilizer rates, lack of improved varieties, and poor management practices (Lemma and Shimelis, 2003). As a result, this study was conducted to determine the most yield-limiting nutrients for onion and tomato production.

## Materials and Methods

Description of the Study Area

The experiment was conducted at Raya kobo District in 2020/21 under irrigation.

The district is located at 571 km North of Addis Ababa, the capital city of Ethiopia, 360 km far from Bahir Dar (the capital city of Amhara region) and 50 km North of Woldia town. Geographically the experimental site is located at 12°09‘N latitude and 39°38‘E longitude with an elevation of 1468 meters above sea level (figure 1)

Based on the data from Kobo meteorological station the rainfall pattern is characterized by seasonal, poor distribution and erratic with a mean annual rainfall of 559.3 mm that ranges from 294-679 mm. The study district has a mean annual minimum and maximum temperature of 12.12 °C and 32.69 °C, respectively. The district receives high rainfall in July and August.

The district is characterized by mixed farming (that is crop and livestock production). The most commonly produced crops are sorghum (*Sorghum bicolor* (L.) Moench), teff (*Eragrostis tef* Zucc.Trotter), and pulse crops like chickpea (*Cicer arietinum* L.), mung bean (*Vigna radiata*) and lentil (*Lens culinaris*). Currently, farmers are tring producing additional vegetable crops such as onion *(Allium cepa)*, tomato *(Solanum lycopersicum)* and other horticultural crops for sale.

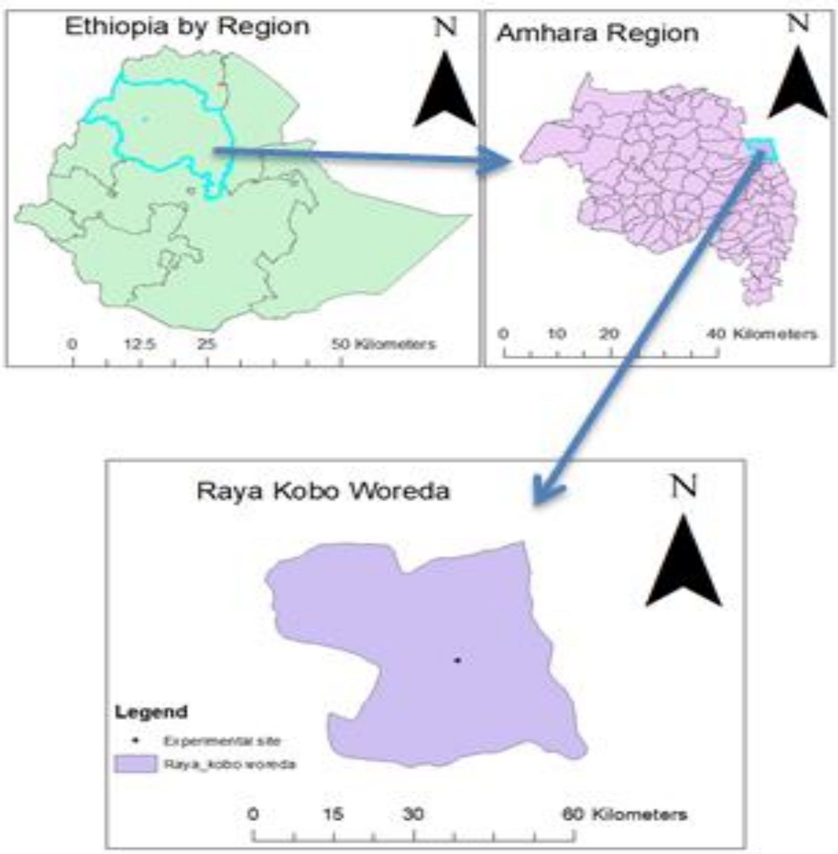


Figure 1. Location of the study area

*Treatments and Experimental Design*

The treatments were laid out in Randomized Complete Block Design (RCBD) replicated three times. The experiment consisted of nine treatments with the following arrangements.

1. NPKSZnB (all)
2. NPKSZn (-B)
3. NPKSB (-Zn)
4. NPKZnB (-S)
5. NPSZnB (-K)
6. NKSZnB (-P)
7. PKSZnB (-N)
8. RNP
9. No fertilizer

The full doses of all fertilizers with respective treatments except the nutrients to omit were applied as basal dose and remaining half rate of nitrogen was applied at knee height stage. Urea, Triple Super Phosphate (TSP), Murate of Potash (MOP), Calcium Sulfate ($CaSO_4.2H_2O$), Zinc Sulfate ($ZnSO_4.7H_2O$) and Borax ($Na_2B_4O_7.5H_2O$) were used as sources of fertilizer for supplying N, P, K, S, Zn and B, respectively. The detailed description of fertilizers and their amount is described in Table 1:

**Table 1. Detail description of fertilizer rate**

| Treatments | Nutrient rates (Kgha$^{-1}$) | | | | | |
|---|---|---|---|---|---|---|
| | N | P | K | S | Zn | B |
| NPKSZnB | 92 | 92 | 30 | 10 | 5 | 2 |
| NPKSZn | 92 | 92 | 30 | 10 | 5 | 0 |
| NPKSB | 92 | 92 | 30 | 10 | 0 | 2 |
| NPKZnB | 92 | 92 | 30 | 0 | 5 | 2 |
| NPSZnB | 92 | 92 | 0 | 10 | 5 | 2 |
| NKSZnB | 92 | 0 | 30 | 10 | 5 | 2 |
| PKSZnB | 0 | 92 | 30 | 10 | 5 | 2 |
| RNP | 92 | 92 | 0 | 0 | 0 | 0 |
| control | 0 | 0 | 0 | 0 | 0 | 0 |

*RNP = Recommended nitrogen and Phosphorus*

*Experimental Procedure for Onion:* Bombay Red onion variety was used as an experimental material. It was released by Melkasa Agricultural Research Center during 1980. The variety has a characteristic of medium-red bulb color, erect leaf arrangement and flat globe bulb shape. It is an early maturing variety taking less than 120 days to reach maturity (MoANRS 2011).

A nursery bed of 10 m long and 1 m wide was marked out and cleared. The land was ploughed thoroughly and made into a fine tilth. The onion seeds were drilled at 10 cm distance between rows lightly covered with the soil. The pots were irrigated daily using watering can. Weeds were frequently removed as they emerge in the nursery by hand pulling. Vigorous, healthy, good-looking seedlings and nursery beds were selected for transplanting and the seedlings were irrigated one day before removing to facilitate uprooting. After 55 days, the seedlings were transplanted late in the afternoon to reduce the risk of desiccation and poor establishments.

The experimental field was ploughed two times using oxen. Large sized clods were broken-down to make the land to fine tilth, and the field was then marked out into blocks and plots. The spacing between blocks and plots were 1.5 and 1 m respectively. Experimental plots with a size of 2.4 m × 3 m (7.2 $m^2$) were prepared and ridges were made with a spacing of 40 cm × 20 cm × 10 cm. The intra and inter-row spacing were 10 and 20cm respectively. There were six rows per plot each row having 20 plants with a total number of 120 plants with a net experimental area of 6.6 $m^2$. The experiment was conducted under furrow irrigation method and the source was river water. The irrigation interval after transplanting was two times in a week for the first 4 weeks for better establishment and then extended to five days' interval until 14 days remained to harvest. All other agronomic practices were applied uniformly for all plots

*Experimental Procedure for Tomato:* Seedlings were raised in nursery beds at Kobo sub center; the beds of 1×10 m size were well prepared and were raised 5 cm from the soil surface to provide good drainage for the removal of surplus irrigation water. The seeds were sown in rows spaced 15 cm apart and covered lightly with fine soil and then with two-three cm thick grass mulch before irrigation. The beds were irrigated every day until the seeds germinated fully and twice a week afterwards. Transplanting of seedlings on experimental field was done at 3-5 true leaf stage when seedlings attained the height of about 15-25cm. Recommended agronomic practices such as weeding, cultivation, irrigation, fertilizer application, staking and disease management were carried out uniformly during the growing season for all plots. The experimental sites were prepared using standard cultivation practices before planting. Trial fields were plowed using oxen-drawn implements by farmer as usual.

Seedlings were carefully transplanted after 7 weeks to the experimental plots (3×4m dimensions) which were prepared to accommodate 40 plants per plot (four rows) at a recommended spacing of 100 cm between rows and 30 cm between plants (Lemma, 2002). The spacing between two plots in each replication and between adjacent blocks was 1m and 1.5 m, respectively. The total amount of fertilizers was applied during transplanting while urea was applied in two equal splits. The first half of urea was applied at the time of planting while the remaining half was applied 21 days after transplanting of seedlings. Watering was done using furrow irrigation at three days interval. Experimental plots were irrigated every day for the first two weeks to secure uniform establishment and then at weekly interval. Experimental plots were kept free from weeds manually and other cultural practices such as disease and insect pest control were performed as per the recommendation for tomato production. Disease was managed by application of recommended fungicides (Ridomil) at a rate of 3.5 $Kgha^{-1}$ in seven days' intervals.

Data Collection

*Onion Yield and Yield-Related Data*

Plants in the central four rows were used for data collection, leaving aside plants in the border rows and those at the end of each row.

*Plant Height*: it was measured from the ground to the shoot tip of the main plant from randomly selected 10 plants at maturity.

Bulb diameter (polar and equatorial diameter): Bulb diameter of five sample bulbs was measured both vertically and horizontally using caliper.

*Marketable Bulb Yields*: it is the weight of healthy and marketable bulbs (20 g to 160 g in weight). Bulbs below 20 g in weight are considered too small to be marketed whereas those above 160 g were considered oversized according to Lemma and Shimeles (2003).

*Unmarketable Bulb Yield*: The total weight of unmarketable bulbs that are under-sized (< 20 g) and oversized (160 g)

*Total Bulb Yield* ($Mgha^{-1}$): The total bulb yield was measured from the total harvest of net plot as a sum weight of marketable and unmarketable yields in Kg per plot and finally converted into $tha^{-1}$.

*Tomato Yield and Yield Related Data*

*Plant Height* (cm): Heights of five randomly selected plants from the ground level to the apex grown in net plot area using meter were measured at maturity stage and the mean values were used for further analysis.

*Number of Clusters Per Plant:* The number of clusters in five randomly selected plants in the plot was counted at 50% flowering and the mean values were used for further analysis.

*Number of Fruits Per Cluster:* The number of fruits in lower, middle and upper clusters of five randomly selected tomato plants was counted and the mean values were computed and used for further analysis.

*Fruit Length* (cm): The fruit length of five randomly selected marketable fruits from each plot was measured using caliper meter from the neck of the fruit to bottom and their average was calculated in centimeter (cm).

*Fruit Diameter (Width)* (cm): The diameter of five randomly selected marketable fruits at the middle portion of fruits from each plot was measured using caliper and the mean values were taken for analysis.

*Marketable and Unmarketable Yield* ($tha^{-1}$): Diseased, insect pest, physiologically, and mechanically damaged fruits were considered as unmarketable (Lemma, 2000), while fruits free from any visible damages were considered as marketable. Both marketable and unmarketable fruits obtained from each net plot area were separately weighed with analytical balance in Kg and converted into hectare basis.

*Total Fruit Yield* ($tha^{-1}$): It was obtained by adding marketable and unmarketable fruit yields.

*Soil Sampling and Analysis:* Soil samples were collected from each of the selected farmers' fields. Soil samples from each site were randomly collected from the 0 to 20 cm deep plough layer using an auger. The collected soil samples were air dried at room temperature and were ground to pass through a 2 mm sieve for most parameters and through 0.5 mm sieve to determine total nitrogen and organic carbon. Soil pH was determined by a pH meter after extraction from a soil: water ratio of 1:2. Organic matter was determined using the Walkley and Black dichromate method (Nelson and Sommers, 1982) and total N using Kjeldhal's method (Bremner and Mulvaney, 1982) For available P determination, Olsen's (Olsen *et al*., 1954) method; exchangeable K was estimated by 1M ammonium acetate extraction followed by flame photometric determination.

*Statistical Data Analysis:* All the measured parameters were subjected to analysis of variance (ANOVA) appropriate to completely randomized block design using R software and the interpretations were made following the procedure described by Gomez and Gomez (1984). Treatment means that were significantly different were compared using Duncan's Multiple Range Test (DMRT) at 5% level.

## Results and Discussion

### *Physicochemical Properties of the Soils on Onion Site*

Results of pre-sowing soil analysis showed that soils of the experimental sites were clay loam in texture (Table 2). The total nitrogen was 0.14%, and this range is low level (Tekaligne *et al*., 1991). This implies that in the study area, nitrogen is deficient and onion yield is to be increase with the increasing of nitrogen up to certain range. The soil organic matter was found to be medium level according to Berhanu (1980). The soil reaction (pH) of the trial site was 6.4 and it is conducive for any agriculture. Available phosphorus is high according to (Olsen *et al.*, 1954). According to Jones (2003) all K, B and Zn are adequate in the study area.

**Table 2. Physico-chemical property of the trial site**

| $P^H$ | OM | T.N (%) | Avail P(ppm) | K (ppm) | Zn (mg $Kg^{-1}$ Soil) | B (mg $Kg^{-1}$ Soil) | %clay | %silt | %sand |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 32.5 | 32.5 | 35 |
| 6.4 | 1.85 | 0.14 | 17.3 | 210 | 1.2 | 3.1 | Clay loam | | |

### *Effect of Omission of Nutrients on Yield and Yield-Related Parameters of Onion*

Application of micronutrients and macronutrients for onion did not contribute for plant height and equatorial diameter as it is indicated in table (3). We find also application of all nutrients is not significantly affected polar diameter as compared to application of nitrogen and phosphorus. It was slightly affected when all nutrients are omitted. From table 3.3 it is clearly indicated that, only nitrogen and phosphorus may be required to improve yield related parameters of onion. Our result is contradicted with the result of ((Kiros *et al.*, 2018); MANNA *et al*., 2014) which stated application of boron and zinc significantly improve vegetative growth, plant height, bulb diameters. (Awatef *et al*., 2015) also contradicted with our result who showed that application of potassium increased plant height and diameters of onion.

The marketable yield of onion is influenced by the omission of nitrogen. Omission of nitrogen is statistically similar with the control treatment. Application of all nutrients in the study area is not statistically different from the recommended rates of nitrogen and phosphorus nutrients. Omission of phosphors was not found also to be yield-limiting nutrient as there was not yield reduction when it was omitted. This implies that to boost the yield of onion in the study area, only the nitrogen fertilizer is required with a maintenance application of P.

In agreement with the current finding, sole application of nitrogen can influence bulb yield of onion (Gateri *et al.,* 2018; Tekalign *et al*., 2012; Abdissa *et al*., 2011; Biesiada and Kołota, 2009). This may be attributed that the nitrogen content in the study area is low as it is indicated in critical nutrient range table (Table 2). But in contradicted to the finding of (Tilahun *et al.*, 2021), who stated the interaction of nitrogen and sulfur increases onion yield there was not interaction of any nutrients to increase bulb yield of onion as it was only influenced with nitrogen.

Our finding also differ from the findings of (Mandal *et al.,* 2020) who stated that addition of sulfur increases yield of onion. From the result, it is observed that application of macronutrients other than nitrogen did not impose significant marketable onion yield difference over the control. This may be attributed to the lowlands of Eastern Amhara which is rich with phosphorus, potassium and sulfur either depositing from highlands or it is naturally rich with those mineral nutrients

Micronutrients did not impose significant marketable bulb yield to onion in our study. This result contradicted with the findings of (Prusty *et al.,* 2020) who stated application of micro nutrients (Zn and B) brought significant yield difference over the control. Non responsiveness on the application of micronutrients in the lowlands of eastern Amhara on marketable onion yield, may be attributed to the natural richness of micronutrients on the study area as it is indicated in critical range table (Table 2).

**Table 3. Effects of nutrient omission on plant height, polar diameter and equatorial diameter**

| Treatments | PH(cm)* | Polar diameter(cm) | Equatorial diameter(cm) |
|---|---|---|---|
| NPKSZnB (all) | 45.2 | 4.6ab | 4.7 |
| NKSZnB (-P) | 45.0 | 4.6ab | 5.0 |
| NPKSZn (-B) | 43.8 | 4.5ab | 4.9 |
| RNP | 43.9 | 4.7a | 4.8 |
| NPKSB (-Zn) | 44.3 | 4.4ab | 4.9 |
| NPKZnB (-S) | 45.1 | 4.8a | 5.1 |
| NPSZnB (-K) | 44.4 | 4.5ab | 4.9 |
| PKSZnB (-N) | 41.5 | 4.6ab | 4.9 |
| Control | 41.5 | 4.3b | 4.8 |
| CV | 5.6 | 4.6 | 5.1 |
| Sig. Levele (5%) | ns | * | ns |

**PH= Plant height, means with the same letters are not significantly different*

**Table 4. Effect of nutrient omission on total yield, marketable and unmarketable yield of onion (ton/ha)**

| Treatments | Un marketable yield (ton/ha) | Marketable yield (ton/ha) |
|---|---|---|
| NPKSZnB (all) | 0.5ab | 17.5 a |
| NKSZnB (-P) | 0.4ab | 17.0 a |
| NPKSZn (-B) | 0.3 b | 14.7 ab |
| RNP | 0.5 ab | 15.7 ab |
| NPKSB (-Zn) | 0.4 ab | 17.5 a |
| NPKZnB (-S) | 0.4 ab | 15.6 ab |
| NPSZnB (-K) | 0.4 ab | 14.3ab |
| PKSZnB (-N) | 0.4 ab | 12.5 b |
| Control | 0.6 a | 12.4 b |
| CV | 28 | 13.5 |
| Sig. Levele (5%) | * | * |

*Means with the same letters are not significantly different*

*Physico-Chemical Properties of the Soil on Tomato Sites:* The experimental site analysis results indicated that soil particle size distribution of the experimental sites was in proportions of 35% of sand, 32.5% of silt, and 32.5% of clay with the textural class of clay loam (Table 5). The analysis result shows that the available P content was 17.3 mg Kg-1 (Table 5) which is rated as medium according to (Cottenie, 1980). The total nitrogen content was 0.11% which is ranged at low level according to Tekalign’s (1991) classification. Similarly, organic carbon content was 1.85% which is ranged at a low level according to Tekalign’s (1991) classification.

**Table 5. Physico-chemical properties of the soil before planting**

| Ph* | OM | T.N (%) | Avail.P (mg $Kg^{-1}$) | %clay | %silt | %sand |
|---|---|---|---|---|---|---|
| | | | | 32.5 | 32.5 | 35 |
| 6.4 | 1.85 | 0.11 | 17.3 | Clay loam | | |

*: *pH = Power of Hydrogen, OM=organic matter, T. N=Total Nitrogen, Avail. P=Available phosphorous*

*Effect of Omission of Nutrients on Yield and Yield-Related Parameters of Onion*

*Effects of Omission of Nutrients on Number of Clusters per Plant:* The Number of clusters produced per plant deferred among the tested treatments. Among the treatments NPKSB produced the highest number of clusters per plant (20.1) followed by NPSZnB, NPKSZnB and NPKSZn treated plots (Table 6). On the other hand, smallest number of cluster per plant (9.6) was obtained from the control plot (no fertilizer plot). The observed difference in the production of clusters is probably due to the application of nitrogen fertilizer. The maximum number of clusters per plant might be due to the effects of fertilizers in promoting flower bud formation. In line with this Nishat *et al*., (2021) noted that the number of cluster $plant^{-1}$ in tomato increased as the rates of NPSBZn fertilizer increased and the plants in plots which did not receive fertilizer showed minimum number of cluster $plant^{-1}$.

*Effects of Omission of Nutrients on Number of Fruits per Cluster:* Omission of nutrient showed variations in the number of fruits per cluster. The highest number of fruits per cluster (67.7) was recorded from potassium omission plots, while control treatment produced the lowest fruit number per cluster (23.3) (Table 6). The results are in agreement with the findings of Islam *et al*., (2018) minimum no of fruit per cluster was found in control treatment. Additionally, Yemane *et al*., (2018) reported that statistically least number of fruits per plant was observed at the zero rate of urea.

*Effects of Omission of Nutrients on Plant Height:* There was a significant effect ($P < 0.05$) of fertilizers on tomato plant height via application of mineral fertilizers as compared to each treatment. Significantly, the longest plant height (102.7cm) was obtained from plots treated with NPSZnB as compared to other treatments, while the shortest plant height (81.9cm) was recorded from non-fertilized plot (Table 6). This might be due to the application of nitrogen mainly related to the production of new shoots and improvement of vegetative growth, which is directly related to the increase in plant height. The results of this study coincide with the findings of Aman and Rab, (2013) who reported that the longest plant height was observed with the application of N while lowest plant height was observed with control. The findings were in line with Nishat *et al.*, (2021) who reported that with increase of nitrogen level up to 300 Kg/ha, the plant height increased while Phosphorus had no significant influence on plant height. The findings of the present investigation are in conformity with the reports of Manoj *et al.*, (2013) who reported that plants under the lowest level of fertilizer remained significantly dwarf when compared with the rest of the treatments and also the height of tomato plants increased significantly with the increased levels of nitrogen.

*Effects of Omission of Nutrients on Number of Branches per Plant:* The number of branches per plant is an important parameter which indicates the yielding capacity of tomato variety (Shushay *et al.*, 2013). The highest number of branches per plant (7.5) in this study was counted in NPSZnB treated plots which is significantly different from the control but not with other treatments (Table 6). The result of this experiment is in conformity with the findings of Manoj *et al.,* (2013) who reported that the branching was increased due to the application of inorganic fertilizers and Tsedu *et al.,* (2021) stated that non-fertilized plots produce the lowest number of branches.

**Table 6. Effects of omission of nutrients on plant height, number of cluster plant$^{-1}$, number of fruit cluster$^{-1}$ and number of branch plant$^{-1}$ combined over sites**

| Treatments | Plant Height | Polar diameter | Equatorial diameter | No of cluster/plant | no fruit/cluster | no branch/ plant |
|---|---|---|---|---|---|---|
| NPKSZnB (all) | 97.3$^{ab}$ | 9.4 | 5.2 | 18.7$^{a}$ | 50.8$^{ab}$ | 7.3$^{a}$ |
| NKSZnB (-P) | 90.7$^{abc}$ | 8.9 | 5.5 | 16.4$^{ab}$ | 49.2$^{ab}$ | 6.2$^{ab}$ |
| NPKSZn (-B) | 99.4$^{a}$ | 9.3 | 5.4 | 16.9$^{a}$ | 48.7$^{ab}$ | 6.6$^{ab}$ |
| RNP | 93.9$^{abc}$ | 8.9 | 5.4 | 15.9$^{ab}$ | 47.8$^{ab}$ | 5.8$^{ab}$ |
| NPKSB (-Zn) | 97.2$^{ab}$ | 9.1 | 5.6 | 20.1$^{a}$ | 60.3$^{a}$ | 7.4$^{a}$ |
| NPKZnB (-S) | 85.2$^{bc}$ | 8.9 | 5.4 | 15.5$^{ab}$ | 50.0$^{ab}$ | 6.6$^{ab}$ |
| NPSZnB (-K) | 102.7$^{a}$ | 8.9 | 5.4 | 19.5 $^{a}$ | 67.7$^{a}$ | 7.5$^{a}$ |
| PKSZnB (-N) | 92.1$^{abc}$ | 8.7 | 5.4 | 11.2$^{bc}$ | 34.1$^{bc}$ | 5.5$^{ab}$ |
| Control | 81.9$^{c}$ | 8.7 | 5.2 | 9.6 $^{c}$ | 23.3$^{c}$ | 4.7$^{b}$ |
| CV (%) | 7.2 | 4.2 | 3.8 | 18.8 | 24.5 | 21.1 |

*Effects of Omission of Nutrients on Marketable, Unmarketable and Total Yield of Tomato:* In the present study the analysis of variance revealed that the highest marketable fruit yield was recorded by application of NPKSZnB which were statistically different when compared with omission of N and non-fertilized plots but not with others (Table 7) in both sites. The lowest fruit yield was recorded from non-fertilized plots followed by omission of nitrogen (Table 7). This experiment indicates that fertilizer application is one of the most important factors for obtaining economical yield of tomato. The result of this experiment is in conformity with the findings of Nemomsa Beyene and Tilahun Mulu 2019 and Nishat *et al.*, (2021) who reported that the lowest fruit yield was found in no fertilized plots or nil nitrogen fertilizer. Fertilizer N application affected, total and marketable fruit yields of tomato (Edossa *et al.*, 2013). Acedo and Benitez (2021) stated that with inorganic NPK fertilizer marketable yields increased with increasing rates of application by more than two to three folds.

Accordingly, the highest unmarketable fruit yield was recorded in non-fertilized plots (Table 7) while the lowest marketable yield was noted by application of all nutrients (NPKSZnB) in farm one but, for farm two there were not statically significant different in terms of un marketable yield. The results are generally in agreement with Melkamu *et al.*, (2022) who reported that the more unmarketable yield was recorded at the unfertilized or controlled treatments.

Among all the treatments, the highest total marketable yield (34.8 $tha^{-1}$) was obtained from application of recommended NP fertilizers but not statically significant from omission of K, ZN, B, S and fully fertilized plots however, both treatments gave values significantly higher than the control. Similarly, the lowest total marketable yield (18.9 &19.9 t $ha^{-1}$) was found from nitrogen missing plots and non-fertilized plots respectively in farm one. On the other hand, in farm two highest total marketable yield (33.1t $ha^{-1}$) were obtained from the application of NPKSZn (B omitted) fertilizer which is significantly different from omission of N and control treatments but not with others (Table 7). Like farm one significantly lowest total marketable yield was recorded from control treatment followed by N omitted plot. Based on the combined analysis, the highest marketable yield was recorded from B omitted plots with significantly differ from N omitted and control treatments. Similarly, the combined analysis of total marketable yield shows that omission of N and control gives lower total yield compared to other treatments (Table 8). As illustrated in Table 8 below even if the highest total yield were obtained from omission of B it was not significantly differ from omission of P, K, S, Zn, recommended NP and application of NPKSBZn. This study indicates that the yield of tomato crop was affected by fertilization especially by nitrogen this might be the presence of low quantity of nitrogen in the soil of study site. The lowest yield in the unfertilized plot indicates that the indigenous soil is unable to supply sufficient amount of nutrients while the lower yield of N omitted plots indicates that N application cannot substitute by any other nutrient and has highest contribution to tomato yield.

The result of the present investigation agrees with the findings of Melkamu (2022) who reported that the maximum total fruit yields of tomatoes were obtained from the combined nitrogen and phosphorous application. In line with the present study Bilalis *et al*., (2018) noted that the highest fruit yield was obtained under inorganic fertilization. Ilupeju *et al*., (2015) also stated that application of fertilizer (organic or inorganic) improved the growth and fruit yield of tomato.

**Table 7. Effects of omission of nutrients on marketable, unmarketable and total yield of tomato**

| Treatments | Marketable yield (t ha$^{-1}$) | | unmarketable yield (t ha$^{-1}$) | | total yield (t ha$^{-1}$) | |
|---|---|---|---|---|---|---|
| | Farm 1 | Farm 2 | Farm 1 | Farm 2 | Farm 1 | Farm 2 |
| NPKSZnB (all) | 24.3$^{a}$ | 30.5$^{a}$ | 5.4$^{b}$ | 5.6 | 29.6$^{ab}$ | 36.2$^{a}$ |
| NKSZnB (-P) | 16.9$^{ab}$ | 24.7$^{ab}$ | 6.8$^{ab}$ | 4.4 | 23.7$^{bc}$ | 29.1$^{abc}$ |
| NPKSZn (-B) | 24.2$^{a}$ | 27.9$^{a}$ | 7.8$^{ab}$ | 5.2 | 31.9$^{ab}$ | 33.1$^{a}$ |
| RNP | 26.2$^{a}$ | 23.8$^{abc}$ | 8.7$^{a}$ | 3.5 | 34.8$^{a}$ | 27.4$^{abc}$ |
| NPKSB (-Zn) | 23.3$^{a}$ | 23.6$^{abc}$ | 9.2$^{a}$ | 4.8 | 32.5$^{ab}$ | 28.5$^{abc}$ |
| NPKZnB (-S) | 23.9$^{a}$ | 26.0$^{ab}$ | 8.3$^{ab}$ | 4.9 | 32.2$^{ab}$ | 30.9$^{ab}$ |
| NPSZnB (-K) | 16.9$^{ab}$ | 25.2$^{ab}$ | 8.4$^{a}$ | 5.8 | 25.4$^{abc}$ | 31.0$^{ab}$ |
| PKSZnB (-N) | 11.5$^{b}$ | 17.4$^{bc}$ | 7.5$^{ab}$ | 5.3 | 18.9$^{c}$ | 22.7$^{bc}$ |
| Control | 10.5$^{b}$ | 15.5$^{c}$ | 9.4$^{a}$ | 4.1 | 19.9$^{c}$ | 19.5$^{c}$ |
| CV (%) | 24.5 | 21.7 | 19.8 | 30.4 | 18 | 20.33 |

**Table 8. Effects of omission of nutrients on marketable, unmarketable and total yield of tomato combined over sites**

| Treatments | Marketable yield (t ha$^{-1}$) | unmarketable yield (t ha$^{-1}$) | total yield (t ha$^{-1}$) |
|---|---|---|---|
| NPKSZnB (all) | 28.1$^{ab}$ | 7.1$^{ab}$ | 29.6$^{ab}$ |
| NKSZnB (-P) | 24.7$^{abc}$ | 4.4$^{bc}$ | 23.7$^{bc}$ |
| NPKSZn (-B) | 32.2$^{a}$ | 8.1$^{a}$ | 31.9$^{ab}$ |
| RNP | 23.8$^{abc}$ | 3.5$^{c}$ | 34.8$^{a}$ |
| NPKSB (-Zn) | 23.6$^{abc}$ | 4.8$^{abc}$ | 32.5$^{ab}$ |
| NPKZnB (-S) | 26.0$^{abc}$ | 4.9$^{abc}$ | 32.2$^{ab}$ |
| NPSZnB (-K) | 25.2$^{abc}$ | 5.8$^{abc}$ | 25.4$^{abc}$ |
| PKSZnB (-N) | 17.4$^{c}$ | 5.2$^{abc}$ | 18.9$^{c}$ |
| Control | 20.4b$^{c}$ | 6.3$^{abc}$ | 19.9$^{c}$ |
| CV (%) | 21.3 | 31.4 | 18.0 |

*Correlation among Growth, Yield and Yield Components of Tomato:* Crop yield is the result of the cumulative interactions between all of the experimentally determined dependent and independent factors (characters). According to the available data, most tomato yield and yield components had a significant positive and linear association (Table 9). As a result, there was a substantial and positive correlation between marketable yield and the number of clusters per plant and no fruit/cluster (r = 0.60 and 0.51, respectively) at (P <0.01). On the other hand, marketable yield showed significant (P <0.05) correlations with plant height (r = 0.40*), number of branches per plant (r = 0.46*), and polar diameter (r = 0.46*). The presence of significant and positive correlation among yield and yield components indicates that increased growth parameters and yield components might contribute to tomato yield increment.

**Table 9. Pearson Correlation Coefficients between growth and yield component of Tomato**

| parameters | | NCP | NFC | NBP | Ph | Pd | Ed | My | Umy | Ty |
|---|---|---|---|---|---|---|---|---|---|---|
| NCP | Pearson Correlation | | | | | | | | | |
| | Sig. (2-tailed) | | | | | | | | | |
| NFC | Pearson Correlation | .909** | | | | | | | | |
| | Sig. (2-tailed) | .000 | | | | | | | | |
| NBP | Pearson Correlation | .742** | .810** | | | | | | | |
| | Sig. (2-tailed) | .000 | .000 | | | | | | | |
| Ph | Pearson Correlation | .679** | .720** | .642** | | | | | | |
| | Sig. (2-tailed) | .000 | .000 | .000 | | | | | | |
| Pd | Pearson Correlation | .511** | .386* | .191 | .388* | | | | | |
| | Sig. (2-tailed) | .006 | .047 | .341 | .046 | | | | | |
| Ed | Pearson Correlation | .408* | .388* | .015 | .294 | .305 | | | | |
| | Sig. (2-tailed) | .034 | .046 | .940 | .137 | .122 | | | | |
| My | Pearson Correlation | .603** | .509** | .464* | .403* | .465* | .326 | | | |
| | Sig. (2-tailed) | .001 | .007 | .015 | .037 | .015 | .098 | | | |
| Umy | Pearson Correlation | -.107 | -.036 | -.226 | -.019 | -.009 | .378 | .132 | | |
| | Sig. (2-tailed) | .596 | .858 | .257 | .923 | .963 | .052 | .511 | | |
| Ty | Pearson Correlation | .544** | .471* | .385* | .376 | .436* | .394* | .973** | .356 | |
| | Sig. (2-tailed) | .003 | .013 | .047 | .053 | .023 | .042 | .000 | .069 | |

*** = significant at P < 0.01, *= significant at P < 0.05. Ph = Plant Height, NCP = No of cluster/plant, NFC = no fruit/cluster, NBP = no branch/ plant, Pd = Polar diameter Ed = Equatorial diameter, my = marketable Yield, Umy = unmarketable yield.*

## Conclusion and Recommendation

Conducting of omission trial is indispensable to identify most yield limiting nutrients in specific area. From the result marketable yields of onion is influenced by only the omission of nitrogen in the study area. The lowest marketable yield of onion is recorded in omission of nitrogen and from the control treatment. However, yield of onion did not increase due to application of secondary (K&S) and micronutrients (B & Zn) than Recommended Nitrogen and Phosphorous fertilizer alone. From the application of phosphorus, yield and yield related parameters of onion did not also significantly differ compared to the control.

Higher mean total yield and marketable yields of tomato were also recorded with the application of nitrogen contain fertilizers whereas the lowest was recorded from the control and N-omitted treatments indicating that N was the most yield limiting nutrient for tomato production than any other nutrient in the study areas. However, yield of tomato did not increase due to application of secondary (K&S) and micronutrients (B & Zn) than Recommended Nitrogen and Phosphorous fertilizer alone. This indicated that the most yield-limiting nutrient in the study area is nitrogen for onion and tomato production. Overall, the results revealed that omitting N leads to significant yield penalty and application of nitrogen and phosphorous (for soil nutrient maintenance) should be adopted for achieving higher yield and profitability of onion. This study was conducted to know which nutrient was yield limiting and did not address what amount was needed. Therefore, optimum fertilizer rate determination on the yield limiting nutrient should be conducted.

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