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Growth, Yield and Yield-Related Attributes of Tomato as Affected by Nitrogen Fertilizer in Ethiopia: A Review

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Abstract

Nitrogen is considered to be one of the most critical elements required by tomatoes for higher yield and quality since nitrogen is involved in numerous physiological metabolic processes and the crop's conformational structures. For the purpose of achieving this objective, a review was initiated to look into the effects of nitrogen application on the yield, yield components, and growth traits of tomatoes in many different parts of Ethiopia. Accordingly, as observed from this review, the impacts of nitrogen application on tomato yield and yield components vary tremendously, mostly due to differences in experimental and environmental variables. For example, the suggested nitrogen requirements for tomatoes, as noted in this review, vary greatly depending on experimental targets and environmental conditions. To enhance tomato yields, such as 69 kg ha-1, the use of nitrogen was advised. Other findings showed that nitrogen input of 110 kg ha-1 produced the maximum tomato yield. In addition, the research study also discovered that when fruit yield increased, 138 kg ha-1 of nitrogen application was recommended. As observed in this review, the experiment additionally demonstrated that 150 kg N ha-1 was necessary to provide the greatest yield of tomatoes and quality in general. In conclusion, according to this review, the ideal nitrogen rate was found to be between 69 and 207 kg ha-1, with the capacity to significantly improve tomato yield exceeding control in different areas of Ethiopia. It may, however, be inferred that a thorough study of tomatoes throughout the entire country should be conducted, taking into account season, spacing, fertilizer rate, agro-ecology, and variety of crops, in order to recommend a nitrogen fertilizer rate for maximizing tomato yield in Ethiopia.

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nitrogen fertilizer, tomato yield, rate, potatoes, vegetable crops, pests.

Introduction

The tomato (*Lycopersicon esculentum* Mill.) is one of the world's most commonly produced Solanaceae vegetable crops. Due to its enormous economic and nutritional significance, it is also the second-most significant vegetable in the world's human diet after potatoes (Barros *et al.*, 2012). According to the FAO (2018), the area of tomatoes harvested globally increased by more than six times between 1961 and 2018, from 27.6 million hectares to 182.2 million hectares, which coincided with an increase in both tomato yield and area harvested.

One of the most significant vegetable crops in Ethiopia is the tomato. Since it became the most lucrative crop and gave small-scale farmers a better income than other vegetable crops, the overall productivity of this crop in this country has increased significantly (Lemma *et al.*, 1992). When compared to the global average yield of 34 tons per hectare, Ethiopia's tomato yield of 8 a ton per hectare is incredibly low (FAOSTAT, 2012).

In the country of Ethiopia, diseases, pests, inadequate fertilization, and other factors all contribute to decreased yields for farmers. In the study by Sigaye *et al.,* (2022), fertilizer rates for nitrogen and phosphorus have a significant impact on tomato fruit yield. Similar to the aforementioned, Kebede and Woldewahid (2014) discovered that the dosage of nitrogen and phosphorus fertilizer used had an impact on the average fruit weight of tomatoes.

According to the research of Maathuis (2009), nitrogen is one of the elements that tomatoes need the most for greater yield and quality because it is involved in a number of physiological metabolic processes and the conformational structures of the crop. In light of the high demand and significance of nitrogen for tomatoes, fertilization excess is still an ongoing trend in traditional tomato planting in an effort to maximize productivity and profit (Rhoads *et al.,* 1996). Over-fertilization has thus produced a variety of potentially harmful impacts, including nitrate buildup in soils or leaching loss (Min *et al.,* 2012), as well as a decrease in other mineral nutrients and the production of secondary metabolites (anthocyanin, vitamins) (Xing *et al.,* 2015).

For the growth of tomato plants and the sustainability of the environment, nitrogen fertilization must be managed properly. For instance, it is well known that fertilizer treatments of nitrogen and phosphorus improve tomato yield and yield-related characteristics (Etissa *et al.,* 2013). It also has an impact on fruit quality (Ronga *et al.,* 2020). The effects of the optimum nitrogen rate varied, however, depending on the variety, soil type, season, meteorological factors, and other management approaches.

To manage tomato crop systems at their best, specific agronomic methods and extension services are needed (Ronga *et al.,* 2020). For optimal plant growth and development, the amount of nutrients needed must be determined without causing additional expense, associated harmful health impacts, or adverse environmental effects.

This review was started to examine the effects of nitrogen application on the yield, yield components, and growth parameters of tomatoes in many parts of Ethiopia in order to achieve the afore mentioned objective.

Effects of nitrogen on the yield, and yield components of tomato

Marketable and total fruit yield: (t ha^{-1})

Sigaye *et al.,* (2022) conducted an experiment in the Meskan, Gurage districts of Ethiopia to determine the appropriate levels of nitrogen and phosphorus fertilizers under balanced fertilizer and to evaluate the economic viability of nitrogen and phosphorus fertilizer. Four nitrogen levels (0, 46, 92, and 138 kg ha^{-1}) and four phosphorous levels (0, 20, 40, and 60 kg ha^{-1}) were used in the treatments. They discovered that the use of 138 kg ha^{-1} of N and 40 kg P_2O_5 ha^{-1} resulted in the greatest marketable fruit yields of 55.1, 60.1, and 52.8 t ha^{-1} throughout the 2019, 2020, and 2021 growing seasons, respectively. Fortunately, the plot without fertilizer produced the lowest marketable yields. They came to the conclusion that the application of 138 kg ha^{-1} of nitrogen and 40 kg ha^{-1} of phosphorus fertilizers indicated that the fertilizer level appears to contribute to an appropriate balance of production and productivity and is, in economic terms, advisable for farmers in the Meskan and Gurage districts of Ethiopia for greater tomato production along with comparable soil types and agro-ecologies.

The other study was carried out by Kebede and Woldewahid (2014) in the cropping seasons of 2007 and 2008 to ascertain the effects of nitrogen and plant population on the quality and net income of tomato (*Lycopersicon esculentum* Mill). In a similar vein, when compared to the control, fruit yield measurements and net return profits were highest when nitrogen rate application (138 kg N ha^{-1}) was made use of. Similar to these findings, Gebremedhin *et al.,* (2020) did another trial in Hawzen district, Tigray Ethiopia, with four rates of nitrogen (0, 69, 138, and 207 kg ha^{-1}) and four rates of phosphorus (0, 46, 69, and 92 kg ha^{-1}). Likewise, the lowest values of marketable (16.33 t ha^{-1}) were achieved from the control treatment. On the other hand, the highest values of marketable (55.33 t ha^{-1}) were obtained with treatments of 138 and 92 kg ha^{-1}.

In order to determine the ideal nitrogen fertilizer rate for various tomato crop growth parameters, yield, and yield components, Beyene and Mulu (2019) conducted a field experiment in the West Showa zone, Toke Kutaye district of Ormia region, Ethiopia. Four levels of nitrogen fertilizer (0, 50, 100, and 150 kg ha^{-1}) were utilized as treatments in order to achieve the desired result. Based on the above-mentioned plan, their research findings revealed that there was a substantial ($P < 0.05$) difference in the nitrogen fertilizer rates' effects on the tomato fruit yield per hectare. The plot that received 150 kilograms of nitrogen per hectare produced the highest fruit yield (28.737 t ha^{-1}); however, it did not differ substantially from the plot that received 100 kg of nitrogen per hectare, which gave a fruit yield of 28.233 t ha^{-1}. Additionally, the plot that received no nitrogen fertilizer had the lowest fruit yield (8.393 t ha^{-1}). Tomato yield increased by 70.79 and 70.27%, respectively, compared to the control treatment when 150 and 100 kg N ha^{-1} were applied. Besides this, Balemi (2008) performed a field study on vertisol at Ambo University College (Ethiopia) in the growing seasons of 2003–2004 and 2004–2005 to explore how tomato cultivars with different growth habits responded to the amount of nitrogen and phosphorus fertilizers and plant spacing. Three spacing (100 cm x 30 cm, 80 cm x 30 cm, and 60 cm x 45 cm) and three fertilizer rates (50 kg N ha^{-1} + 60 kg P_2O_5 ha^{-1}, 80 kg N ha^{-1} + 90 kg P_2O_5 ha^{-1}, and 110 kg N ha^{-1} + 120 kg P_2O_5 ha^{-1}) were applied in the treatments. He observed that the best fertilizer rate (110 kg N ha^{-1} + 120 kg P_2O_5 ha^{-1}) greatly outperformed the lowest fertilizer rate (50 kg N ha^{-1} + 60 kg P_2O_5 ha^{-1}) in terms of mean marketable fruit yield (76.1 kg $plot^{-1}$), which was only 59.1 kg $plot^{-1}$. Also, compared to the larger spacing of 100 cm x 30 cm, closer spacing of 80 cm x 30 cm and 60 cm x 45 cm yielded a greater total as well as a higher marketable fruit yield.

According to a report from a study by Degefa *et al.*, (2019), the research study took place in 2016 and 2017 on peasant land in the Harar People Regional State's Sofi district in Harawe. Nitrogen rates (0, 39, 69, and 99 kg $ha^{-1)}$ and intra-row spacing (25, 30, 35, and 40 cm) were the variables used in the treatments. The results showed that the lowest fruit production (18.8 t ha^{-1}) was at 0 and 40 cm intra-row spacing, and the highest fruit yield (38.1 t ha^{-1}) was at 69 kg N ha^{-1} and 30cm intra-row spacing. A combination of 69 kg N ha^{-1} and 30cm intra-row spacing was chosen for the study region based on fruit yield and economic return.

Total fruit yield (t ha^{-1})

Many researchers confirmed that the pace of nitrogen fertilizer application affects commercial productivity. According to Gebremedhin *et al.*, (2020), there was substantial nitrogen and phosphorus ($P < 0.01$) in tomato total fruit. The control treatment yielded the lowest total fruit yield (17.87 t ha^{-1}), while the highest rates of 138 kg N ha^{-1} and 92 kg P_2O_5 ha^{-1} yielded the highest total fruit yield (57.00 t ha^{-1}).In accordance with these results, Sigaye *et al.*, (2022) also reported that the maximum overall fruit yield (59.7 t ha^{-1}) was achieved at the highest rate of 138 kg N ha^{-1} and 40 kilograms P2O5 ha^{-1}, while the lowest total fruit yield (25.1 t ha^{-1}) was obtained at the lowest rate of 0 kg N ha^{-1} and 0 kg P_2O_5 ha^{-1}. The results also demonstrated that tomato yield steadily rose with higher nitrogen fertilizer doses. In connection with nutrient availability, Haydar *et al.*, (2007) noted a large range of variance in tomato variety yield and fruit yield-related parameters.

Unmarketable fruit yield (t ha^{-1})

The results of Sigaye *et al.*, (2022) suggested that the largest yield of unmarketable fruit (10.6 t ha^{-1}) was obtained at 0 kg N ha^{-1} and 0 kg P_2O_5 ha^{-1}; however, the smallest yield of unmarketable fruit (18.8 t ha^{-1}) was achieved with 138 kg N ha^{-1} and 40 kg P_2O_5 ha^{-1}. The results of this research are consistent with those of Kahsay *et al.*, (2016), who found that the nitrogen rate of 150 kg ha^{-1} resulted in the maximum yield of unmarketable fruit (130.78 g/plot), whereas the control treatment resulted in the lowest yield (93.83 g/plot).

Fruit length (cm)

In the study conducted by Kahsay *et al.*, (2016), the tallest tomato fruit length (6.600 cm) was measured at 150 kg nitrogen per hectare, although the shortest tomato fruit length (6.1917 cm) was at 0 kg nitrogen per hectare. This finding lines up with that of Kebede and Woldewahid (2014), who noted that the size of the fruits was strongly affected by the addition of nitrogen fertilizer. Similar to this, the untreated treatment resulted in the narrowest fruit (4.1 cm), whereas the nitrogen rate of 92 kg ha^{-1} generated the widest fruit (4.5 cm). According to the study, the highest increase was observed in plots treated with 108.6 kg urea, while the control plots recorded the least value of fruit length, fruit weight, and number of fruits per plant and fruit yield per hectare (Metson, 1961).

Effects of nitrogen on the growth performance of tomato

Plant height (cm)

As researchers have noted, for example, Etissa *et al.*, (2013) discovered that insufficient nitrogen in the soil inhibits plant growth. Degefa *et al.*, (2019) found that nitrogen fertilizer application significantly ($P < 0.05$)

increased plant height, with 99 kg N ha^{-1} yielding the highest plant height and 0 kg N ha^{-1} yielding the lowest. Additionally, plant height was raised by 13.6% above no treatment of nitrogen when nitrogen was applied at a rate of 99 kg ha^{-1}. In agreement with this, Gebremedhin *et al.*, (2020) observed that various nitrogen rates considerably (P <0.01) affected plant height. The results showed that the maximum nitrogen rate, which created the longest plant height, was recorded at 207 kg ha^{-1}, while the least amount of nitrogen was applied to the plots that produced the shortest plant height, which was observed there. When nitrogen was applied at rates of 69, 138, and 207 kg ha^{-1}, tomato plants grew taller than controls by 12.1%, 19.5%, and 31.2%, respectively. This may be because nitrogen fertilizer creates conditions that are conducive to the elongation of stems and the best vegetative growth. The longest (61.26 cm) and shortest (47.53 cm) tomato plants were measured from the plots treated with 150 and 0 kg N ha^{-1}, respectively (Beyene and Mulu, 2019). With an increase in nitrogen fertilizer rate, the tomato plant grew taller. In comparison to 0 kg, 50 kg, and 100 kg N ha^{-1} treatments, applying 150 kg N ha^{-1} raised plant height by 22, 41, 19, 03, and 9.5%, respectively.

Primary branches

A study by Gebremedhin *et al.*, (2020) found that the rates of N had a significant (p 0.05) impact on the number of primary branches per plant. A primary branch did not grow any more when N was given above the rate of 69 kg ha^{-1}, although the nil fertilizer treatment produced the least number of branches compared to the other N treatments. The increased nitrogen supply may have benefited the tomato branch by stimulating meristematic growth and the development of new branches and leaves. According to Degefa *et al.*, (2019), the tomato plant's largest branches (5.57) and lowest branches (3.96) were found in the plots treated with 150 and 0 kg N ha^{-1}, respectively. When compared to no nitrogen application, tomato branches grew by roughly 28.9% when nitrogen was applied at a rate of 99 kg ha^{-1}. As noted by Kahsay *et al.*, (2016), the least number of branches (4.65) was recorded with no nitrogen fertilizer, while the greatest branches (5.64) were recorded with 150 kg of nitrogen per hectare. This study's findings were consistent with those of Iqbal *et al.*, (2021), who additionally found that 4.33 primary branches were produced as a result of applying 90 kg of nitrogen per hectare. As nitrogen application was raised until it reached the ideal level, the number of branches per plant rose as well. The increased nitrogen supply may have benefited the tomato branch by stimulating meristematic growth and the development of new branches and leaves. Similar to this study, Metson (1961) found that as the urea concentration grew, so did the number of branches and leaves.

Generally, as observed from this review, the impacts of nitrogen application on tomato yield and yield components vary tremendously, mostly due to differences in experimental and environmental variables. For example, the suggested nitrogen requirements for tomatoes, as noted in this review, vary greatly depending on experimental targets and environmental conditions. To enhance tomato yield, such as 69 kg ha^{-1}, the use of nitrogen was advised. Other findings showed that nitrogen input of 110 kg ha^{-1} produced the maximum tomato yield. Additional the research study also discovered that when fruit yield increased, 138 kg ha^{-1} of nitrogen application was recommended. As observed in this review, the experiment additionally demonstrated that 150 kg N ha^{-1} was necessary to provide the greatest yield of tomatoes and quality in general. In conclusion, according to this review, the ideal nitrogen rate was found to be between 69 and 207 kg ha^{-1}, with the capacity to significantly improve tomato yield exceeding control in different areas of Ethiopia. It may, however, be inferred that a thorough study of tomatoes throughout the entire country should be conducted, taking into account season, spacing, fertilizer rate, agro-ecology, and variety of crops, in order to recommend a nitrogen fertilizer rate for maximizing tomato yield in Ethiopia.

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