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Effect of plant staking and N fertilizer rates on tomato cultivars (Lycopersicon esculentum Mill.) in Fafen center, fafen zone, county 05, Ethiopia.

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ABSTRACT

The study was conducted on the effect of plant staking and nitrogen fertilizer rates on tomato cultivars (Roma Vf and local cherry tomatoes) in fafen center, gursum district, fafen zone, SRS, Ethiopia in 2020-22. The experiment was carried on nitrogen fertilizer rates for a factorial combination of four levels of nitrogen (0, 46, 92 and 138 kg N ha-1) and two growing systems (staking and non-staking for Roma vf) and eight fertilizer rates for local cherry cultivar. The experiment was then laid out in 4 X 4 factorial arrangements using a randomized complete block design with three replications. Each treatment combination was assigned randomly to experimental units within a block. A 1.8 m X 2.2 m (3.96 m2) plot was used for each experimental unit. The blocks were separated by 1 m width whereas the space between each plot within a block was 0.5m. Different levels of N were applied as Urea (46%N). Nitrogen was applied as a single application at the time of early vegetative growth after 6 weeks of planting. The tomato seedling was planted in rows with spacing of 45 cm between rows and 25 cm between plants within a row for Roma vf and 45 cm between rows and 25cm within the rows for cherry tomatoes. In each plot there were four rows and the total numbers of plants in each row was 6. The middle two rows were considered for recording the agronomic data. Water application was based on irrigation mainly furrow irrigation. The data was collected from yield, yield components and related traits consisting of plants' height yield per plot and weight of the marketable and non-marketable yield. Plant height was measured once after the plants' vegetative growth. Yield per plot was measured and converted to mean value and recorded as yield per treatment. Total weight of the marketable and non-marketable yield was determined and recorded and then converted into kilograms per ha. The parameters considered in the experiment were subjected to statistical analysis. ANOVA and correlation analyses were performed for selected parameters using SPSS software. Mean differences was tested following least significant difference (LSD) procedure. There is a significance difference among the treatment, the highest productive fertilizer rate is (250kg/ha and 150kg/ha) of nitrogen fertilizer rate for cherry and Roma vf tomatoes respectively, though 100kg/ha and 200 kg/ha were the 2nd and 3rd highest productive rate among the rate for cherry tomatoes. So 250kg/ha and 150kg/ha of nitrogen fertilizer rate is recommend for cherry and Roma vf tomatoes respectively In the fafen center, gursum district, SRS, Ethiopia.

Key Words: Fertilizer, Cherry, Tomatoes, Rates, LSD, Parameters, Plot, RCBD, Staking, Urea, Tomatoes.

1. Introduction

The origin of tomato and the early history of its domestication are obscure, evidences suggests that Mexico is the origin (Villareal, 2019) . The tomato belongs to Solanaceae family and to the genus Lycopersicon,.The genus comprises a few species of annual or short-lived perennial herbaceous plants **(Wien, 1997)**. Tomato belongs to the species most frequently referred as Lypcopersicon esculentum Miller. Tomatoes are usually annual in temperate or short-lived perennial in tropics. Plants are grown from 0.5 to 2.0 m tall, with solid and thick stems (Rubatzky and Yamaguchi, 1997). The many branches are procumbent or partly erect (Atherton and Rudich, 1986).Cherry tomato (*Solanum lycopersicum var. cerasiforme*) is a highly priced culinary as well as ornamental vegetable. One of the most popular high value exotics, it is a favorite among chef's who cook for high profile restaurants and hotels. Nevertheless, it is becoming increasingly popular among common people, who are now interested in garnishing their dishes and diversifying their nutritional intake.

Cherry tomatoes look not only attractive in kitchen gardens but are commercially valuable horticultural commodity and have impressive nutritional and pharmaceutical properties. According to the USDA nutritional information, one cup of cherry tomatoes (149 g) provides 26.8 calories, 1.3 g protein,4.5 mg omega-3 fatty acids, 119 mg omega-6 fatty acids, 1241 IU of vitamin A, 18.9 mg vitamin C, 22.3 mcg

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folic acid, 11.8 mg vitamin C, 353 mg potassium, 35.8 mg phosphorus and 14.9 mg calcium. All these nutrients and additives put cherry tomato into the category of functional foods. Whole cherry tomatoes are sold afresh as well as preserved in brine. The fruit shape ranges from spherical to oblong to pear and the colors include red, pink, yellow, grape green and brown.

Cherry tomato can be grown in open or protection in poly or glass or shade houses. However, yield and fruit quality are higher when cultivated under protection. Many varieties of cherry tomato have been popularized by private and public sector. Tomatoes are the world's most widely grown vegetables, other than the white potato. They are nutritionally valuable for their high vitamin A and C contents. Also the acid sweet test and unique flavours account for its high per-capita consumption. Commercially, 45 million metric ton of tomatoes are produced each year from 2.2 million hectares, but only15% of the output occurs in the tropics (Rubatzky and Yamaguchi, 2012).

The tomato is commercially important throughout the world both for fresh fruit market and processing. It is grown in a wide range of climates in the field, under protection in plastic greenhouse and heated glasshouse (Atherton and Rudich, 1986). It is widely accepted and commonly used in variety of dishes as row, cooked or processed products more than any other vegetables (Lemma, 2002).Tomatoes thrive under a wide range of environmental conditions, but for optimum production they require plenty of sunshine, moderately cool night temperature, warm day, and well-drained soil. They suffer from frost or prolonged chilling temperatures (Villareal, 2019). Ware and**McCollum (1968)** indicated that the tomato is a warm-season plant, which requires three to four months from the time of seeding to produce the first ripe fruit. It thrives best when the weather is clear and rather dry and temperatures are uniformly moderate 18.50 to 29.5 0C. Plants are usually frozen at temperatures below 0 0C and they do not increase in size at temperatures above 350 C. High temperatures accompanied by high humidity favour the development of foliage disease.Tomato cultivation can be classified by whether the plants are grown out-door or under protection, whether the plants are grown with support or on the ground, and whether the plants are transplanted or direct-seeded (Villareal, 2019). According to (Rubatzky and Yamaguchi, 1997), tomatoes are usually planted as seedling (also called transplants).

Most of the world's tomatoes come from transplanted, unsupported plants grown outdoor (Villareal, 2019).There is no definite time recorded regarding the introduction of cultivated tomato to Ethiopia. However, cherry-type tomatoes have been growing for a long time around big cities and in small gardens. Recently, the crop has expanded to commercial production for home use, export and processing industries. Small-scale farmers produce the bulk of fresh market tomatoes. Processing types are mainly produced in large-scale horticultural farms. Farmers are interested in tomato production more than any other vegetables for its multiple harvests, which result in high profit per unit area (Lemma, 2002). In Ethiopia, tomato is produced mainly as a source of income and food both under rainfed as well as irrigated conditions (Lemma, 2002).

Tomatoes are heavy feeders because of their rapid growth and long production season. Tomatoes need about 84 to 112 kg of nitrogen (N) per ha and moderate to high levels of phosphorus (P) and potassium (K) for maximum yields (Dobson et al., 2002). Commercial tomato production requires optimal fertilizer and better growing management for high yield and maximum profits. In many cases, N is the element that most limits tomato crop growth, especially on coarse-textured, low organic-matter soils **(Scholberg et al., 2000)**. The three major plant nutrients, nitrogen is known to exert most noticeable effect on plant, as it is required in the greatest quantity by most crops **(Reilely and Shry, 1979)**.Both over and under application of fertilizers rates could adversely affect the growth, yield and yield components of the crop. Oversupply application of phosphorus limit in plant nodulation, acetylene, reduced the emergence of seedling by 23% and also create weak (higher plant height and thinner stem diameter) that is easier to lodging, which resulted in the lower component of yield and seed yield (Da-Bing et al., 2012).Nitrogen Fertilizer deficiency decreases the whole plant fresh and dry mass, fruit weight, number and functioning of branches, fruits, fruit number and fruit size (Ligaba et al., 2004).Most of Ethiopian lowland soils are deficient in available nitrogen and phosphorus however; studies on different rates of nitrogen and phosphorus on tomatoes have not yet been conducted in the study area (Mamo et al., 2002).

Staking tomatoes is an important growing method that will keep the plants up right from the ground and will increase the quality and quantity of the production as well as decreases the susceptibility of the plants to the pest and rotting of the fruits **(John G. 1982)**.The staking or up roping the tomato plants enable farmers to have their plants free from diseases and easily contaminating, as the crops are raised up with stakes, they experience better air circulation which reduces the incidence and spread of diseases **(Gupta M J and Shrivastav R. 2003)**.In fafen center, fafen zone, area of irrigable land is increasing every year through the efforts of government, Rural and Agricultural Bureau, NGOs and the farmers themselves. A lot of water facility activities such as wells and bore holes were being undertaken over the last few years, which are mainly used for production of high value vegetables.

In this area tomato is one of the main crops that are being cultivated and the production of tomato is normally done without fertilizer application or improper use of nitrogen fertilizer and without staking as there is no enough knowledge, technic and experience of growing this type of crops which is the standard growing techniques used in parts of the country and elsewhere around the world.The amount of fertilizer especially nitrogen (urea), which the farmers use is often less than the blanket recommendation in the region which hinders potential productivity of the crop. As a result the quality, quantity and size of the fruit as well

as the total yield of the crop is very low. Hence, it was felt relevant to assess the productivity of the crop under the farmers practices vis a vis the modern practice used around the world. Therefore, the objective of the study was: To determine the effect of plant staking and nitrogen fertilizer rates on the yield quality and quantity of tomato cultivars, To determine optimum nitrogen fertilizer rate for two tomatoes cultivars in fafen center, gursum district and To identify the highest performing nitrogen fertilizer dose for cherry tomatoes in fafen center.

2. Materials and Methods

2.1. Description of Experimental Site

The study was conducted at fafen center, Gursum district, Fafen zone, Somali Regional State of Ethiopia. It is 600 km from Addis Ababa, the study area lies between 9°35'N latitude and 42°8' E longitude and has an elevation of 1,609 m above sea level (Wudie, 2006). It receives annual rainfall that varies from 500 to 600 mm. The mean monthly minimum temperature varies from 5.8 °C in November to 14 °C from July to September and the mean monthly maximum temperature varies from 25 °C in July to 29 °C from March to April (Wudie, 2006). Unlike other parts of the region, the rainy season (GU) in the Jigjiga district has Dira' three sub seasons: (April - May), Hagaa (June - July), and Karan (August - September) all of which are equally important for cultivation of crops; availability water and pasture for livestock. Furthermore, the dr y season, Jilaal (October - March) isdivided into two sub seasons: Deyr (October - November) and Kalil (December-March) (Devereux et al., 2006).Topographically, the area is at an altitude of 1044 meters above sea level. Vegetation cover consists of various acacia species, bush trees and grasses which form the life-sustaining resources for local Somali pastoralists and agro pastoralists. The area receives an annual average of 350mm of rainfall in two seasons. First main rainy season starts April and ends June while the second rainy season starts October and ends December. The average annual temperature of the area is 35.10 C0 and 12.20 C0 maximum and minimum respectively. The farming system in the study area is agro pastoral system (SCF-UK and DPPB, 2001). The prevailing agricultural system is the pastoral farming system.

2.2. Planting Material

Two types of tomatoes big tomatoes (Roma vf variety) and cherry tomatoes cultivar seeds was purchased from a research or agricultural input sells inside the country (Ethiopia). Both fruit types of tomatoes are mostly preferred by consumers in the area. Nitrogen fertilizer (Urea), insecticides and all other required farm tools were used.

2.3. Treatment and Experimental Design

Factorial combination of the growing methods (staking and without staking) and four levels of nitrogen (0, 50,100 and 150 N Kg ha-1) was applied to the cultivar of Roma Vf and (0, 50, 100, 150, 200, 250, 300 and 350 kg/ha) was used for cherry tomatoes as form of urea(46% N). The experimental plots were arranged in factorial design, with three replications. The size of the plot was 3.96 m2, the distance between rows was 45 cm and between plants 25 cm for Roma vf with four rows per plot and 45 cm between rows with 25 cm between plants for cherry tomatoes with four rows per plot. A distance of 1 m and 0.5 m was maintained between replications and plots respectively, the spacing adopted for the varieties is based on local recommendations (Lemma, 2002).

2.4. Cultural Practices

The land was ploughed using a tractor; leveling, mulching and furrowing was done manually. The seedling was transplanted as the seedlings was raised in a nursery close to the experimental site for 45 days, a stage with about 15 cm height, and transplanted with one seedling per hole. Nitrogen at the treatment levels was applied using Urea (46%) once the sowing or transplanting and Other cultural practices (weeding, watering, cultivation and pest control) was applied uniformly as per the recommendation for the crop.Plots were supplemented by irrigation during the dry period followed by recommended frequency (Lemma, 2002). During the course of the study, fungicide was applied at weekly interval to control late blight disease since the incidence is usually observed.

2.5. Data Collection.

For the data collection, five plants were randomly selected from the central two rows and the following data was recorded.

2.6. Vegetative Growth.

Plant height (PH): The height (cm) of the plant was measured from the ground level to the highest point at first harvest.

2.7. Phenotypically Growth

Flowering Date (FD): recording when approximately 50 % of the plant population in each plot started flowering. Maturity Date (MD): recording when approximately 90% of plants per plot attained their first crop harvest.

2.8. Yield Assessment

Marketable and non-marketable fruit number and weight: Fruits was harvested at ¾ breaker stage. Mean number and weight of marketable and total fruits per plant was determined by using the 5- randomly taken plants from the central two rows of each plot. The fruits were grouped into marketable and non-marketable. Fruits which are cracked and damaged by diseases, insects, birds, and very small sized fruits (under sized for Roma vf variety) were considered as non-marketable while fruits which are free of such damages was considered as marketable and measured using a sensitive balance immediately after harvesting. Marketable fruit yield per hectare was calculated from plot yield taken from the central two rows. Mean weight of marketable fruit: Average weight of fruit over all harvest period from the 5- randomly

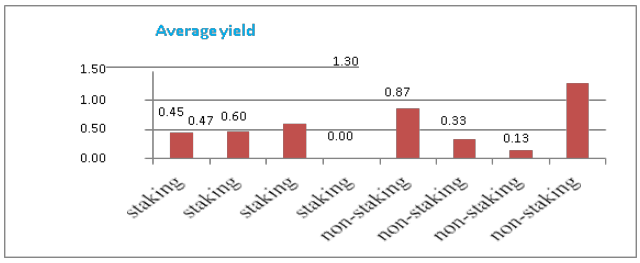

Figure 1: Average yield for non-staking and staking

selected plants was the taken from the central two rows and was recorded and calculated.

2.9. Data Analysis

Analysis of variance and correlation matrix of data collected was performed using SPSS software. The mean comparison and mean differences was separated by using least significant difference (LSD) test procedure and SPSS at probability level of 5%.

3. Results and Discussion

Effect of plant staking and nitrogen fertilizer rates on plant's growth and crop yield has shown great impact on tomatoes cultivar particularly nitrogen fertilizer rate on cherry tomatoes cultivars' growth and yield. The nitrogen fertilizer rates of 0kg/ha, 50kg/ha, 100kg/ha and 150kh/ha for big tomato cultivar (Roma VF variety) has shown significance plant growth as shown below thought there is no high significance between the crop's yield due to environmental stress (frost). Even though the fertilizer rates of nitrogen for cherry tomatoes have shown significant difference in all aspects either plants growth or crops yield. For Roma vf The plant's response to staking is reliable system for tomato growing however crop's yield was not highly productive as there was environmental factors (frost) that hindered the production system during the production stage of the crop.

3.1. Plant Yield

As shown below Roma vf variety plants has shown significance difference between the staked and non-staked. The un-staked plants kept less growing during the early stage of the plants growth while and were less susceptible for the frost at the time of frost period however the staked plants were at their flowering stage and wilted after the frost outbreak so the plant's production become at lower level compared to the un- staked plants.

The cherry tomatoes were exposed with varied dose of nitrogen fertilizer from 0kg/ha, 50kg/ha, 100kg/ha, 150kg/ha, 200kg/ha, 250kg/ha, 300kg/ha and 350kg/ha. The crops' product and plants' were influenced by quantity of fertilization that each treatment was exposed during the experiment. Plant's response to the fertilizer doses was a varied as shown in the below graph, the highest average yield was obtained from 250kg/ha and the lowest yield was given by

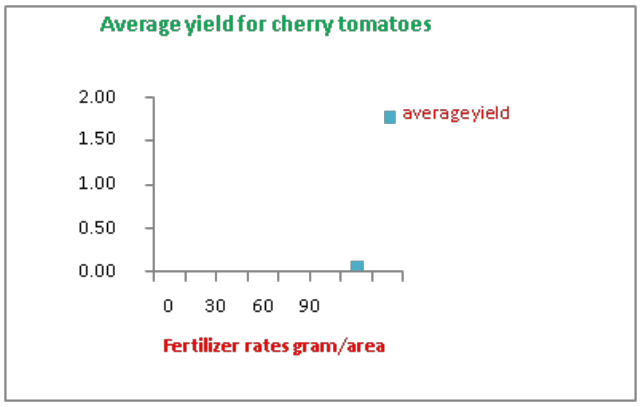

Figure 2: Average yield of cherry tomatoes

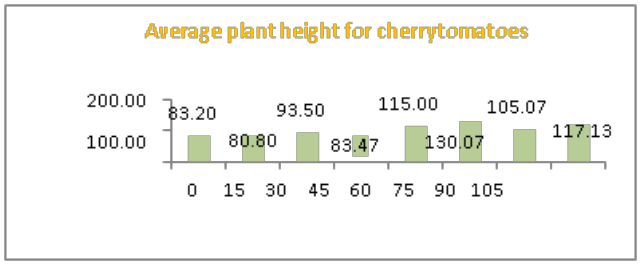

Figure 3: Average plant height of cherry tomatoes.Plant's

the 150kg/ha. However the 200kg/ha and 100kg/ha were the 2nd and 3rd most productive rates according to this experiment.

Cherry tomatoes plants' yield is enhanced by the quantity of the nutrients in the soil though under and over dose are inhibiting the production of the crop.

The effect of the fertilizer rates on the cherry tomatoes was observable as shown on the above graph as the yield of the treatments were more different even though some doses performed well, under the specified doses in this experiment. The ideal or the expected production of one hectare of cherry tomatoes is 4-14tones/ha so for reaching the potential and highest capacity of cherry tomato production in fafen center the maximum yield of 1.67kg/3.96m2 with an average production of 4.217 was obtained from 250kg/ha of nitrogen fertilizer rate . that means it's in the optimum range of the tomato production even-though it's at the lower production level statistically.

3.2. Plant Height

Cherry tomatoes Plants growth was highly significant at (P0.05) due exposure of nutrients into the plants, the maximum plant height was obtained from 250kg/ha fertilizer rate as shown below. Nutrient doses were less effective at the lower quantities than at higher levels that show the deficiency of the nitrogen element in studied area. Cherry tomato plants height were more severely affected by the under than higher doses **(Mahamud M.2021)**.

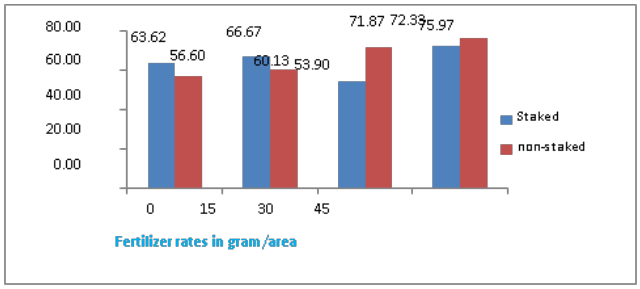

Figure 4: Average plant height in cm for staked & non-staked

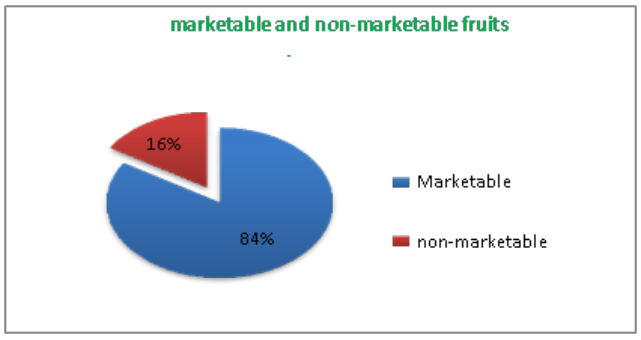

Figure 5: marketable and non-marketable.

Cherry tomatoes.Plant's height has shown its potential positive effect on the yield production as the highest average weight yield and upper plant height was harvested and produced from 250 kg/ha.

The effect of nutrient application is occasionally observed in plant's height as clearly stated in the above graphs. Plants height was lower in fewer doses as the insufficiency of nutrients or nutrient deficiency in the area was inhibiting factor of the plants growth. Plant's height was at the normal level which is close to maximum point with the more quantity dosages as described above. There was variation among the doses for the plant height of Roma vf as nutrient supply had promoted the plant growth however there was no significant difference among the treatments as the result of environmental stresses (such as frost during vegetative and flowering stage). According to this study 150kg/ha had produced and performed the highest plant height with non-staked growing system and the lowest plant height was observed from the zero fertilizer application treatment with no-staking system.

3.3. Marketable and non-marketable

Cherry tomatoes were at the peak level of marketable fruit production 99.9% and there was no variation between and among the treatments. The Roma vf had 16% of non-marketable fruits even though there was not significance difference among the treatments.

84% of the harvested fruits were marketable and the remaining 16% was non-marketable due to fruit injuries, blemishes, disease and insects (such as fruit flies)

The Roma vf cultivar was stressed by an environmental factor (frost) during the late vegetative growth and early flowering period so the field experiment was less productive than expected as there was only one main harvesting period. Roma vf had positive responsive after the application of the nutrients with the different levels even though the output of doses were varied due to the different responses of the crop for the nutrients. Though there was no significance difference between the two growing systems thoug there was a difference among the treatments and between treatments and the highest productivity was obtained from 150kg/ha.

4. Conclusion and Recommendations

The impact of nitrogen fertilizer rate on Roma vf is productive compared to zero fertilizer rates in fafen center. The fertilizer has huge significance in plants growth and crop's yield to smooth and increase crop's productivity fertilizer application is fit and productive. Plant staking is always very reliable and stable farming system for tomatoes growing though in this experiment there were environmental factors such as frost that had some setbacks for the growing system to be at its own level of productiveness.

The cherry tomatoes were tested with eight different doses and the response of the plants was significant and varied from rate to dose. The plant height performance was influenced by the different types of fertilizers though the highest plant height and the maximum yield were obtained from the 250kg/ha. The nitrogen doses' impact was more negative in this study at lower levels compared to the higher -level dosages.

The tomato production has responded and produced well under the application of nitrogen fertilizer with varied level of yield production in the fafen center, Gursum district though the doses' performance and productivity were significant different, non- significant different and highly significant difference among and between the treatments for the two cultivars and the two methods of growing systems for the Roma vf cultivar. However, the highest productivity with consistence variation from the other doses in both yield and plant height was observed and obtained from the 250kg/ha of nitrogen fertilizer for the cherry tomatoes in the studied area.

Plant staking is more convenient with the cherry tomatoes than Roma vf as plant height has reached up 1.74m and the recommended dose for cherry tomato and Roma vf are 250kg/ha and 150kg/ha respectively in fafaen center, gursum, fafen zone, SRS, Ethiopia.

Conflict of Interest

Authors declare that there is no conflict f interests involve in publishing this research paper.

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