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The Effect of Different Rates of Farm Yard Manure Application on the Growth of Irish Potato (*Solanum tuberosum* L.) Production in Offa District, Southern Ethiopia

Yitbarek Abrham[1], Abrham Shumbulo[1], Elias Bojago[2]

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ABSTRACT

Background: The highlands of North America are where the potato (*Solanum tuberosum* L.) first appeared. Potato is the most important vegetable crop. Farm Yard Manure undoubtedly boosts crop output because it contains large amounts of plant-growth-critical nutrients that aren't always available in appropriate levels in the soil and the investigation is aimed to establish the ideal level of farmyard manure for increasing potato tuber production.

Methods: During the 2019-2020 agricultural season, the experiment was conducted in the Offa District W/Dekeya kebele Irrigation site under irrigation and rainfall circumstances for ten months. The experiment was created on the spot using the randomized complete block design. There were three replications and four treatments (0 t/ha^{-1}, 2.5 t/ha^{-1}, 5 t/ha^{-1} and 7.5 t/ha^{-1}).

Result: The data analysis of variance showed that varying FYM nutrient rates had significant effects on potato tuber spread and stem diameter. But the effect of FYM nutrient showed a non-significant difference ($P<0.05$) on plant height, leaf area and number of stems. The longest plant height (45.187 cm), wider leaf area (45.417 cm^2) and maximum plant spread (42.317) were recorded by the application of 5 t/ha^{-1} FYM nutrient-applied plot. Whereas the maximum stem number (3.4333) obtained by control plot and stem diameter (3.667 cm) were obtained by the application of 7.5 t/ha^{-1} FYM nutrient.

Key words: Farmyard manure, Irish potatoes, Organic matter, Rate, Sustainable agriculture.

INTRODUCTION

The potato (*Solanum tuberosum* L.), which is native to the mountains of North America, was initially grown close to Lake Titicaca, close to the boundaries of Bolivia and Peru today (Horton, 1987).

It is one of the most significant food crops in the worldwide, in terms of production, consumption rates, nutrients amount and also coming in fourth place in worldwide behind maize (*Zea mays* L.), rice (*Oryza sativa* L.) and wheat (*Triticum asstivum* L.). It comes in first place among root and tuber crops, ahead of yams, cassava and sweet potatoes (FAO, 2008). As a fat-free food crop with high mineral content, potatoes provide more energy and protein per unit of area and time than the majority of other important food crops (Lutaladio and Castaldi, 2009). The nutritional value of potatoes as a single source is second only to that of eggs due to the balance of protein to calories, the balance among the most important amino acids in a protein and the composition of minerals (Bayata, 2019). The Solanaceae family includes potatoes (*Solanum tubersom* L.).

In 1858, German botanist Schemper brought potatoes to Ethiopia. Since then, potatoes have gained popularity as a garden crop across the nation. With an annual rainfall range of 600 to 1200 mm and altitudes ranging from 1500 to 3000 meters above sea level, over 70% of Ethiopia's agricultural area is suitable for potato production (Woldegiorgis *et al.,* 2008).

[1]Department of Horticulture, College of Agriculture, Wolaita Sodo University, PO Box 138, Wolaita Sodo, Ethiopia.
[2]Department of Environmental Science, College of Natural and Computational Sciences, Wolaita Sodo University, PO Box 138, Wolaita Sodo, Ethiopia.

Corresponding Author: Abrham Shumbulo, Department of Horticulture, College of Agriculture, Wolaita Sodo University, PO Box 138, Wolaita Sodo, Ethiopia.
Email: abrhamshumbulo@gmail.com

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Low soil fertility is one of the main factors preventing Ethiopia from producing enough potatoes (Dersseh *et al.*, 2016). The majority of Ethiopia's soil fertility has already decreased as a result of crop rotation, continuous cropping, abandoning following and reduced usage of manure. The most important factor affecting crop production, as demonstrated by national yield and variety trial data from numerous locations in Ethiopia on a variety of crop species, is soil nutrient stress (Zewide *et al.,* 2012). The potato tuber has an incredibly high yield per hectare and is utilized for a wide range of industrial, livestock and processed table uses, as well as supplying nutrient-rich food in a number of situations.

In addition to vitamins, thiamine, riboflavin, niacin, calcium, iron and magnesium, potato tubers also include 19 g of carbohydrates, 0.1 g of fat, 2 g of protein and 75 g of water.

There are over 5000 a variety of kinds of which 3000 are grown in Colombia, China, Peru, Bolivia and Ecuador. Awash, Menagesha, Genet, Wechecha, Tolecha, Sisay, *etc*. are examples of world verities (Robert and Walker, 1989).

Early in its development, the above-ground stems of the potato plant are upright; subsequently, they stretch out and become prostrate or semi-prostrate. A swollen underground stem is what the tuber is. Tuber buds or eyes are present. Under specific circumstances, a sprout develops from this. The majority of the roots on the surface of the potato's 0.3-meter fibrous root system are relatively shallow (Aselsoa, 2003). Potatoes are regarded as a wintertime vegetable. Most cultivars initiate tubers more quickly on short days, but under ideal temperature circumstances, tuberization can happen even on lengthy days. Although potatoes may handle a variety of soil types, deep soil is preferable. H 5.5-6.09 well-drained sandy or silt loam (Willians *et al.,* 1991).

Since propagating potatoes from true potato seed has many issues, such as sensitivity to disease, poor germination, weak seedlings, *etc*., sprouts generate a daughter plant and the subsequent crop and unless the growing sprout is harmed, the other does not resume growth (Morris, 1966). By delivering large quantities of plant growth-essential elements that are frequently lacking in the soil, FYM increases crop output. It adds organic matter to the soil, boosts the amount of beneficial bacteria in the soil, promotes the physical properties of the soil (such as water retention, infiltration and percolation), maintains adequate soil aeration and also maintains good drainage (Fageria, 2012). The study's objective is to establish the ideal rate of animal manure for a larger portion of potato output.

MATERIALS AND METHODS

Description of the study area

During the 2019-2020 agricultural season, the experiment was conducted in the Offa District W/Dekeya kebele irrigation site under irrigation and rainfall circumstances for ten months. The location of the area is in Ethiopia's southern Wolaita zone. Gesuba, the Capital City of Offa District, is located 414 kilometers from Ethiopia's capital Addis Abeba and 29 kilometers from Wolaita Sodo. Kindo Koysha Woreda, Gamo Gofa Zone, Humbo and Sodo Zuriya and Kindo Didaye District all form the northern, southern, eastern and western boundaries of the District. According to the National Census, District was expected to have a total population of 132,054 in 2017, of which 65,765 were men and 66,291 were women. In District, there are 2 urban and 21 rural kebeles. The District spans 38,557 hectares in total. According to data from the District Agriculture Office, 22,912 hectares, or (59.4%) of the land was under cultivation. The District is situated between latitudes 6°37′07.63′N and 6°50′07.10′N, longitudes 37°24′18.06′E and 37°89′13.27′E and an altitude between 1200 and 2800 meters above sea level, according to the Central Statistical Agency (CSA). Kola, Weynadega and Dega make for 22, 62 and 16% of Offa Districts geoecology, respectively. According to the Offa District Agriculture Office, The District receives 800-1400 mm of rainfall on average each year and experiences typical temperatures ranging from 14 to 34°C. This experiment involved the use of numerous materials. These are a particular type of local potato tuber. Equipment such as spade, meter, hoe, rake, shovel, string and farm manure.

Three replications and four treatments were used in the field experiment, which was carried out in RCBD. Each replication featured a full set of treatments that were randomly assigned to plots within each small, homogenous block in the experimental region. Since the gradient's concentration runs perpendicularly (North to South), our block was arranged against it. Each plot comprised four rows with five plants in each row. Per plot, there were 20 plants. There were 240 plants in total. As a therapy, four levels of FYM were applied. 0 kg/ha was utilized as the control in Treatment 1 (T1). Treatments (T2) use 2,500 kg per hectare, Treatment (T3) uses 5,000 kg and Treatment (T4) uses 7,500 kg.

The impact of various rates of FYM on potato tuber was measured for the following significant growth performance parameters: Plant height, leaf area, plant spread, stem diameter and the number of stems. Six plants in the two middle rows of each plot were determined to be in the vegetative growth stage and six of the aforementioned parameters were measured and collected from them. The trial site was selected and all unwanted components including weeds, stone straw and other substances were cleared away. By excavating four or more holes rather than using draught animals and our men, the ground was very effectively prepared. The total area of the land was 8.5 m × 11 m, or 93.5 m^2, with a plot size of 1.5 m × 3.0 m, or 4.5 m^2. Plot and block distances were each 0.5 meters apart. Water makes the levels of the land's surface softer, allowing us to create a raised seedbed. Various amounts of FYM were dispersed and integrated with the soil according to its level in each experimental plot before two weeks' worth of sprouted potato tuber was planted on a well-prepared seedbed. As a control group, an experimental plot with no animal dung was used. There were four rows in each plot with twenty plants in each, with a distance of 75 cm between rows and 30 cm between plants. There have been 240 plants sown in all. All agronomic procedures, including watering, weeding, soiling, cultivating, *etc*., were carried out in accordance with local recommendations.

The following procedure was followed in detail to gather information on the potato tuber's growth characteristics and yield factors. Six randomly chosen plants from the two middle rows of each experimental plot were used to measure and record various growth performance metrics. The it with data

was collected 48 days after the tuber's appearance. Plant height (cm): After the plants achieved their peak vegetative growth stage, the height was measured from the ground up to the highest growth point above the ground. The Intelligent Leaf Area Metre was used to measure the leaf area (in cm) from six plants randomly selected from the two middle rows. Plant spread: Using the meter (which encompasses the plant's canopy cover), it was measured from 6 plants in the two center rows of the plot. The number of stems was hand counted. Stem diameter: For the chosen plants, it was measured with a veneer caliper. The SAS analysis software was used to perform an analysis of variance on the data gathered from the impact of various rates of animal manure. At a probability level of 5%, the least significant difference test (LSD) would be used to calculate the mean separation.

RESULTS AND DISCUSSION

The performance of Irish potato tuber growth was influenced by various rates of FYM nutrients. The research data reveals that FYM significantly affects some plant growth performance metrics, such as plant spread and stem diameter, but does not affect parameters like plant height, leaf area and stem number of potato tuber crop plants. The table below (Appendix Table 1) displays this. Means with the same letter in front of them are not statistically different at alpha = 5%; NS stands for non-significant, CV for the coefficient of variance and LSD for the least significant difference. PH stands for plant height, LA for leaf area, NS for stem number, SP for plant spread and SD for stem diameter (Table 1).

Growth parameters

Plant height

According to the analysis of variance in Appendix Table 1, there were no significant differences ($p<0.05$) in the plant height of Irish potato at the various FYM nutrient rates (0, 2500, 5000 and 7500 kg FYM/ha^{-1}). The longest plant height (41.897 cm) was recorded on an unfertilized plot. While the shortest plant height (38.500 cm) was recorded by the application of 2.5 t/ha^{-1} FYM nutrient applied plots, which are statistically similar to 5 and 7.5 t/ha^{-1} FMY applications (Table 1). The result showed that the plant height increased from control up to the optimum level and decreased in over-dose-applied plots. This is due to the fact that plants require the optimum amount of nutrients for their normal growth and over-dosage applications can result in stress for plants. The result was agreed upon by Koireng *et al.* (2018), who reported that their field experiment with the combination of organic manure and micronutrient applications in potatoes did not show a significant difference in plant height.

Leaf area

According to the result of the ANOVA, there was no significant difference ($p<0.05$) among the treatments on the leaf area of Irish potatoes (Appendix Table 1). The wider leaf area (45.417 cm^2) was recorded by the application of a 5 t/ha^{-1} FYM applied plot, whereas the narrower leaf area (38.533 cm^2) was recorded from the control plot; however, the rest of the 2.5 and 7.5 t/ha^{-1} FYM applied plots are statistically similar (Table 1). The finding reveals that the

Table 1: Effect of different rates of FYMs nutrient on, plant height, leaf area, number of the stem, the spread of the plant and steam diameter.

Treatment	PH (cm)	LA (cm^2)	NS	SP	SD (cm)
0 (Control)	41.897^{a}	38.533^{b}	3.4333^{a}	38.383^{d}	2.5833^{c}
2500	38.500^{a}	39.433^{ab}	3.1100^{b}	40.200^{b}	2.7700^{b}
5000	45.187^{a}	45.417^{a}	3.1533^{b}	42.317^{a}	3.5333^{ab}
7500	38.583^{a}	41.283^{ab}	3.0533^{b}	40.467^{b}	3.667^{a}
LSD (5%)	14.979	6.2764	1.1486	1.6949	0.8259
CV (%)	18.27	7.63	18.04	2.10	13.61

Means within a column followed by the same letter (s) are not significantly different at a 5% level of significance; PH= Plant height; LA= Leaf area; NS= Number of stems; SP= Spread of plant; SD= Stem diameter; LSD (0.05)= Least Significant Difference at 5% level; and CV= Coefficient of variation.

Appendix Table 1: Mean square and significant levels for plant height, leaf area, number of stems, spread of plants and stem diameter after 48 days the tuber emerged of Irish potato in Offa District, Southern Ethiopia.

Source of variation	Replication	FYM	Error	CV	Grand mean
DF	2	3	6		
PH (cm)	45.8490	30.4155^{ns}	56.2086	18.27	41.042
LA (cm^2)	7.1758	28.0150^{ns}	9.8692	7.63	41.167
NS	0.74478	0.08561^{ns}	0.33051	18.04	3.1875
SP	7.54083	7.77139*	0.71972	2.10	40.342
SD (cm)	1.57516	0.57619*	0.17088	13.61	3.0383

Where; DF= Degree of freedom, CV= Coefficient of variation, ns= Non-significant, * = Significance level and FYM= Farm yard manure.

increase in FYM from the control to the optimum rate increased leaf area compared to the higher and also control plots. This is due to the increased nutrients available in FYM increased leaf area at the optimum rate on Irish potato. This result was in agreement with the finding of Muhammad *et al.* (2017), who reported that the increase in bio fertilizer from the control to the optimum level increased leaf area in their Brinjal field experiment. But the result disagreed with Najm *et al.* (2013), who reported that the leaf area increased by decreasing the application of nitrogen and cattle manure from the higher to the control in the potato field experiment.

Number of stems

According to the analysis of variance in Appendix Table 1 below, there was no significant difference ($p<0.05$) in the number of stems between all treatments on Irish potatoes. The maximum number of stems per plant of Irish potato (3.4333) was obtained by the application of 5 t/ha^{-1} of FYM nutrient-applied plots, while the minimum (3.0533) was registered by the control plot. Again, the application of 2.5, 5 and 7.5 t/ha^{-1} applied plots showed statistical similarity with each other (Table 1). On the other hand, the number of potato stems increased 12.44% from 75 t/ha^{-1} FYM to the control plot. This result implies that the increase in FYM nutrient from the higher to the control increased the stem number in Irish potatoes. This is due to in control plots there is optimum growth-supporting nutrient in the soil compared to a higher-nutrient applied plot. This indicates plants need an adequate amount of nutrients for their normal growth and development. The result agreed with Hassanpanah and Azimi (2012), who reported that decreasing organic manure increased the number of stems in potatoes.

Spread of plant

The ANOVA indicated in Appendix Table 1 shows that the FYM nutrient had a significant ($p<0.05$) effect on the spread of the plant in Irish potatoes. The highest (42.317) were recorded by the 5 t/ha^{-1} FYM nutrient applied plot. While the lower (38.383) was recorded by the control plot. Whereas again, the 7.5 t/ha^{-1} and 2.5 t/ha^{-1} FYM nutrient-applied plots are statistically similar to each other. This result reveals that the increase in FYM increased the spread of the plant in the Irish potato. This is due to the fact that this FYM nutrient causes early leaf canopy growth on potato tuber plant spreading. The finding is in line with Mama *et al.* (2016), who reported that the spread of potatoes increased by increasing the rates of organic and inorganic nutrients.

Stem diameter

The analysis of variance indicated in Appendix Table 1 shows that the effect of FYM nutrients had a significant ($p<0.05$) effect on stem diameter in Irish potatoes. The wider stem diameter (3.667 cm) was recorded by the 7.5 t/ha^{-1} FYM nutrient applied plot. While the narrower stem diameter (2.5833 cm) was recorded from an unfertilized plot (Table 1). This result implies that the Irish potato stem diameter increased significantly by increasing the rates of FYM nutrients from the control plot to 7.5 t/ha^{-1} FYM-applied plot. This is due to the higher rate of farmyard manure application, which gives a legsury growth rate to the Irish potato compared to the control plot. The finding was agreed with by Shaaban and Kisetu (2014), who reported that the increase in compound fertilizer increased the stem diameter in their Irish potato field experiment.

CONCLUSION

Among root and tuber vegetables, the Irish potato is one of the most important root and tuber vegetable crops in the world. The crop is a rich source of starch, carbohydrates and minerals. Farmyard manure nutrient has a higher nutritional value for the Solanaceous family crops, including Irish potato. Additionally, it enriches the soil's bacterial population, adds organic matter and boosts the soil's physical properties (such as water retention, infiltration, percolation). In this study, the effect of FYM on Irish potato growth was examined using a range of factors, including plant height, leaf area, the number of stems, the spread of the plant and stem diameter. According to the current investigation, plant height, leaf area and number of stems per plant did not show a significant difference ($P<0.05$) among the means. But the spread of plants and stem diameter showed a significant difference ($P<0.05$) in the effect of FYM nutrients in Irish potatoes.

Conflict of interest

The authors declare that they have no conflict of interest.

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