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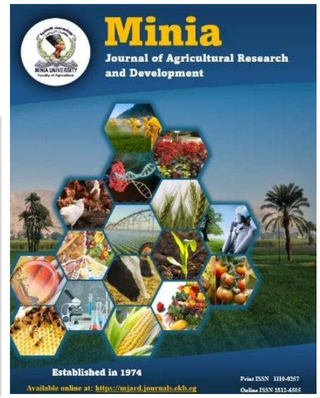


# Synergistic effects of mycorrhiza, effective microorganisms, compost tea, and mineral fertilizers on potato growth and disease management

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## ABSTRACT

Potato, a vital crop for human consumption worldwide, necessitates sustainable agricultural practices to ensure safe and high-quality tuber production. This study aimed to investigate the effects of combining mineral fertilizers with organic and biofertilizers, alongside a reduced dose of NPK (75% of the recommended rate), on the growth and yield of the potato cultivar Cara. Conducted in Isna (Upper Egypt), the experiment evaluated five fertilization treatments: Mycorrhiza + 75% NPK, EM + 75% NPK, Compost Tea + 75% NPK, 75% NPK, and 100% NPK. The results demonstrated that combining reduced doses of mineral fertilizers with organic or biofertilizers significantly enhanced potato growth and increased total yield. The produced tubers exhibited lower nitrate and nitrite levels and higher protein content. Additionally, the Mycorrhiza + 75% NPK treatment effectively reduced natural infection rates of brown rot and early blight compared to treatments using mineral fertilizers alone. This fertilization strategy presents a promising approach for implementing good agricultural practices in potato production, encouraging farmers in Upper Egypt to adopt sustainable methods to meet both local and international market demands.

**Keywords:** Potao, Bio and Organic Fertilizers, Safe Production, Early Blight, Brown Rot**.**

## 1. INTRODUCTION

Potato (*Solanum tubrosum* L.) is a very important crop for all people all over the world (Mlaviwa and Missanjo, 2019) and can be produced almost all year round in some countries (Assa, 2012). It is cheap, high in minerals, high in vitamins C and B, and high in carbohydrates. It is also a fantastic source of energy. large levels of fiber, unbound amino acids, and minimal fat (Muthoni and Nyamango, 2009). It is the world's most widely used tuber crop.

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The FAO anticipated in late December 2023 that the globe would produce 375 million tons of potatoes in 2022, with China and India producing the majority of the crop at 95.5 million and 56 million tons, respectively.

Germany produced 10.6 million tons, France produced 8 million tons, the Netherlands produced 6.9 million tons, the United Kingdom produced 4.80 million tons, and Belgium produced 3.6 million tons. In contrast, 18.5 million tons were generated in Russia, 20.9 million tons in the Ukraine, 17.8 million tons in the US, and 6.2 million tons in Canada. Argentina produced two million tons, whereas Australia produced just one million. Egypt produced 6.1 million tons, whereas South Africa produced 2.5 million tons. Global harvesting in 2022 was 17,788,408 hectares, somewhat less than in 2021 (FAO, 2023). Egypt grows potatoes for both domestic use and export to other Arab and European nations (Abdel -Aal et al, 2023). The Minia governorate, located in Middle Egypt, is well-known for producing premium potatoes throughout the fall and winter seasons, spanning from December to May (Abdelmoneim et al., 2015 and Abdel-Mageed et al., 2023) and serving as the primary supplier of potatoes to Esna and neighboring markets. Additionally, the governorate is the closest location to Esna city, the site of the experiment.

One of the biggest problems in the modern world is soil contamination and pollution brought on by over use of chemical pesticides and fertilizers. Conversely, because they are less expensive and have a smaller environmental impact than mineral fertilizers, organic and biofertilizers are preferred. According to Farag et al. (2013), biological nitrogen, potassium, and phosphorus—found in bacteria, fungus, and cyanobacteria—might be the key to solving this kind of issue.

Plant roots and other arbuscular vascular fungus (AMF) develop symbiotic connections. In order to participate in this collaboration, the fungus implants itself into the root system of the host plant, either externally (ecto mycorrhizal fungi) or inside the cells (arbuscular mycorrhizal fungi). They are essential to soil chemistry and soil microorganisms. Arbuscular mycorrhiza, which naturally occurs between plants and fungi belonging to the Glomeromycota family, is the most prevalent type of plant-fungal symbiosis. Pteridophyte, bryophyte, angiosperm, and gymnosperm roots are colonized by these fungi, which are found in a wide range of habitats, including woodlands, grasslands, agricultural regions, and many stressful situations. According to many experts (e.g., Lone et al., 2015 and Abdel-Aal et al., 2023), endomycorrhizae are mycorrhizae that do not penetrate individual root cells, while entomycorrhizae are mycorrhizae that invade the cell membrane and hyphae. Mycorrhizal plants are more capable of photosynthesizing. Due to these benefits, AMFs are thought to be very significant because, because of their capacity to draw nutrients from less fertile soils, they can significantly improve crop growth, production, and quality while also reducing the need for phosphate-based fertilizers (Roy-Bolduc 2011). When referring to a collection of various beneficial soil microbes that are extracted from naturally rich soils and utilized in agricultural production, the term "effective microorganisms" (EM) is used (Mohan, 2008). It appears that EM mostly serves to increase soil microbial diversity, which in turn increases agricultural productivity. According to research, photosynthetic bacteria, which account for most EM, work with other microorganisms to feed plants and reduce the number of pathogenic bacteria (Condor et al., 2007).

Compost teas are an organic solution made by fermenting compost in a liquid phase for a few days, either with or without aeration. Numerous studies, including Al-Dahmani et al. (2003), claim that these extracts are combined with tap water in a range of ratios from 1:5 to 1:10 (v/v) of mature compost. In view of the increased concern for the safety of food and the environment in farming, compost teas are therefore being investigated as a potential replacement for widely used synthetic fungicides (Pane et al., 2012). The effectiveness of compost can be affected by differences in the types of compost, management techniques, and preparation techniques (Egwunatum and Lane, 2009; Pant et al., 2012). Recently, compost tea has become more and more well-liked as an alternative nutritional supplement for improved plant yields (Naidu et al., 2013). Compost tea application enhances field vegetable (potato) health and disease resistance (Larkin, 2008). According to Siddiqui et al. (2011) and Moursy (2013), compost tea decreased soil fertilizer levels while simultaneously increasing crop use efficiency with mineral N fertilizer. This resulted in a decrease in environmental pollution. The objectives of this study are to evaluate the cultivation of potatoes in Upper Egypt, where farmers have limited experience with potato production, and to educate them on the application of organic and biofertilizers combined with a partial dose of recommended mineral fertilizers (NPK). The goal is to achieve a significant yield of high-quality and safe potato tubers by integrating sustainable agricultural practices.

## 2. MATERIALS AND METHODS

### 2.1. Experiment location and the used potato cultivar

Two consecutive field experiments were conducted during the two fall seasons of 2021 and 2022 on a private farm in the village of Al-Nawaser, Esna city, Luxor Governorate, Egypt (Longitude: 32.5146439; Latitude: 25.3678101; Elevation: 80m / 262feet; Barometric Pressure: 100Kpa). Local tuber-seeds of Cara potato variety were obtained from Minia Governorate and were selected for this study as a variety for both manufacturing and cooking purposes. The geographic map of Esna city is presented here:


**Figure 1: Geographical location of the experiment.**

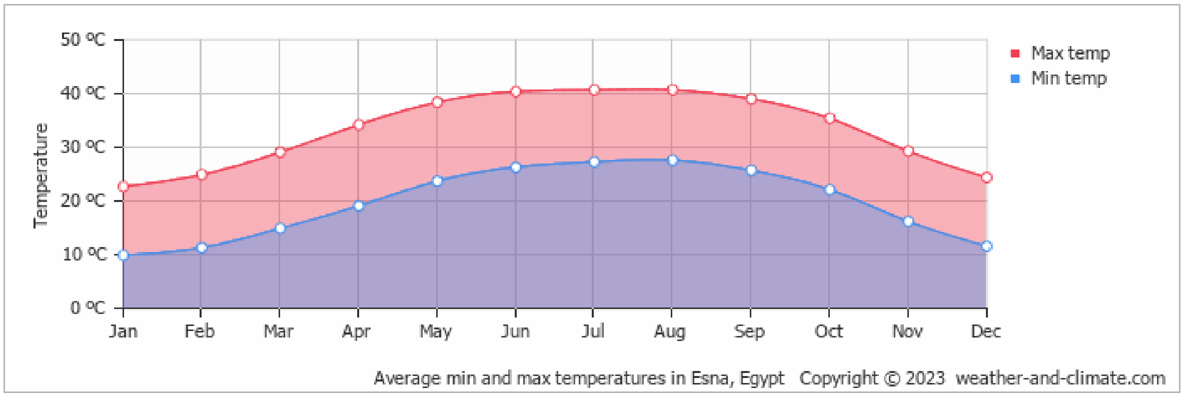


**Figure 2. The mean minimum and maximum temperatures over the year (Source: https://weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine,esna-eg,Egypt).**

### 3.3. Average humidity

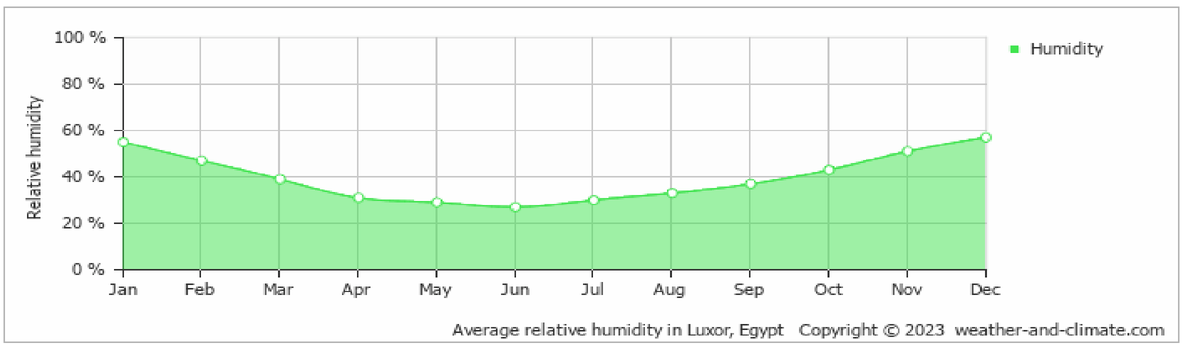


**Figure 3. The mean monthly relative humidity over the year (Source: https://weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine,esna-eg,Egypt)**

### 2.2. Soil properties

To determine the physio-chemical characteristics of the experiments soil, 10 soil samples were randomly taken from the soil surface (depths of 5-15-30 cm) and were mixed well before analysis. Laboratory soil analyses were performed before planting the tuber-seeds in the winter seasons of 2021 and 2022 according to the standard methods mentioned by Wilde et al. (1985) and data are offered in table (1).

The analyses were carried out at the Soil, Water, and Plant Materials Analysis Laboratory, Minia University, Egypt and included physical soil properties such as acidity, alkalinity, electrical conductivity, calcium carbonate content, and soil texture. Chemical soil properties were also analyzed, including water-soluble substances such as sodium, potassium, calcium, magnesium, chloride, carbonates, bicarbonates, Total of carbon and organic matter, nitrogen, available phosphorus, and available potassium.

**Table 1: Physio-chemical characteristics of the soil samples taken in the winters of 2021 and 2022 prior to planting.**

| Particle size distribution | 2021 | 2022 |
|---|---|---|
| Texture | Sandy loam | Sandy loam |
| pH (1 : 2.5) soil water ratio ) | 8.0 | 8.1 |
| E.C. (ds/m) | 1.65 | 1.66 |
| Total carbonate - C % | 0.66 | 0.65 |
| Organic matter % | 1.13 | 1.12 |
| Available N % | 0.17 | 0.18 |
| Available P (mg/kg) | 18.0 | 20.0 |
| Available K (mg/kg) | 430.0 | 434.0 |

### 2.3. Aims of research

This research aims to promote potato cultivation and production in Upper Egypt in general and in Luxor in particular; increase potato productivity and improve product quality. The study also aims to investigate the effect of EM biofertilizer, Mycorrhizae, and compost tea on potato growth and productivity along with soil properties by using a combination of 75% of nitrogen, phosphorus, and potassium (NPK) as mineral fertilizers plus these bio and organic fertilizers.

### 2.4. Experimental design

The Complete Randomized Block Design (RCBD) was used as all treatments were randomly distributed in 15 plots (5 treatments were used, and three times were each treatment duplicated in three plots). Each plot area was 10.5 $m^2$ (3 meters wide and 3.5 meters length) to present a one of 400 of one feddan. Each plot consisted of 5 lines and each line was 3.5 meters long and 70 cm wide. The potato seed-tubers were planted inside the third top of the previously irrigated lines (after 5 days from the irrigation time). The five treatments used were as follow:

1. EM + 75% of NPK
2. Mycorrhiza + 75% of NPK
3. Compost tea + 75% of NPK
4. 75% of NPK
5. 100% of NPK

These recommended doses of NPK were 180 unit of nitrogen, 120 unit of potassium, and 96 unit of phosphorus from different mineral sources containing these elements. These recommended doses were utilized during soil preparation and irrigation water usage during the growing season, in addition to other suggested dosages of mineral fertilizers, as prescribed by the Egyptian Ministry of Agriculture and Soil Reclamation for potato cultivation and production e.g., calcium nitrate and micro elements. All other good agricultural practices recommended for potato production in Egypt in these growing environmental and soil conditions were followed. The EM biofertilizer and Mycorrhizae were obtained from the Microbiology Department at the Faculty of Agriculture, Minia University, and Compost Tea was obtained from the Nile company for compost production in New Minia city, Minia Governorate and this compost was prepared to be used as a solution mixed with the irrigation water.

**2.5. Determination of the degree of mycorrhizal colonization**

The samples of potato roots were mixed to make approximately 1 g FW, rinsed with tap water, and preserved in 70% alcohol before the VAM (Vesicular-Arbuscular Mycorrhiza) colonization test. After storing the root samples, they were cut into pieces that were 1 cm in diameter. Following a 40-minute boil in 15% KOH, the samples were treated with aniline blue and then fixed in 40% lactic acid (Philips & Hayman, 1970). After suspending the stained roots in a few drops of lactic acid, they were placed on glass slides and examined under a microscope. The infection % in 100 pieces was calculated as follow:

$$\text{Root colonization \%} = \frac{\text{Number of VAM positive pieces}}{\text{Number of scored pieces}} \; x\,100$$

**2.6. Experiment preparation and tuber-seeds plantation**

Potato seeds were planted on October $10^{th}$ and $11^{th}$ in two fall seasons of 2021 and 2022, respectively. The above mentioned five treatments were applied twice; first after the complete emergence and the second time was applied two weeks after the first treatment. The application method was as follows: for EM and Mycorrhizae biofertilizers, 2 kg of black honey was added to 50 liters of water, then 4 liters of the treatment (EM or Mycorrhizae) were added, and 200 ml of the fertilizer was added to each plant near around the roots. For organic fertilizer, the compost was soaked in water for 24 hours with stirring every 4 hours, and 5 liters of Compost Tea were taken and diluted in 50 liters of water, and 200 ml of the solution was added to each plant near around the roots. Other recommended agricultural practices for commercial potato production under Luxor conditions were also implemented according to the instructions of the Egyptian Ministry of Agriculture. Data were recorded for the following plant characteristics:

**2.7 Growth characteristics**

**A. Emergence % after 30 days from planting**

After counting the emerging tubers, the following formulas were used to estimate the emergence percentage:

$$\text{Emergence \%} = \frac{\text{Number of emergence pieces per plot}}{\text{Total number of planted pieces per plot}} \; x\,100$$

**B. Vegetative growth characteristics**

Samples of 10 plants were randomly taken from each experimental plot to measure average fresh weight of the whole plant (kg), average number of main stems/plant average plant fresh weight (g), and average plant dry weight (g)

**C. Yield characteristics**

1. Tubers number /plant
2. Tubers fresh weight/plant (kg)
3. Total yield (ton/fed)

**D. Chemical characteristics analyses**

Each sample of dried plants was grinded and was prepared (about 100 g of dried leaves powder) to determine the following:

1. In accordance with Jackson (1973), the Spectro-Photometer was utilized to measure the N% across the entire plant and % in whole plant, was measured by the Molybdenum Blue method, while K% was measured using the Flame Photometer
2. Plant nitrogen, phosphorus uptake was determined by multiplying the average dry weight of the entire plant (g) X mineral% present in the whole plant.

3. The average protein content was calculated by, the average N% in the whole plant x 6.25.

### 2.8. Early blight and roots rot infections determination

To know the effect of the used fertilizers (organic, bio, and mineral) on the infection with roots rot in tubers and early blight in shoots, the infection percentages of these diseases were determined in all plants in each replicate of all treatments using the following equation:

$$\text{Infection \%} = \frac{\text{Number of infected plants per plot}}{\text{Total number of plants per plot}} \times 100$$

### 2.9. Statistical analysis

Software version 4.0 of MSTAT-C was used to conduct the statistical analysis. Applying the standard deviation, we compared the mean values of the disease infection characteristics. Following the methodology outlined by Gomez and Gomez (1984), all data were analyzed using analysis of variance (ANOVA) techniques. The means of the treatments were compared using the LSD.

## 3. RESULTS

In general, all treatments of the used organic, and biological fertilizers when were used in combination with the mineral fertilizers significantly affected the studied characteristics. The used treatments changed the obtained potato tubers shape and other phenotypic characteristics (Figure 4).

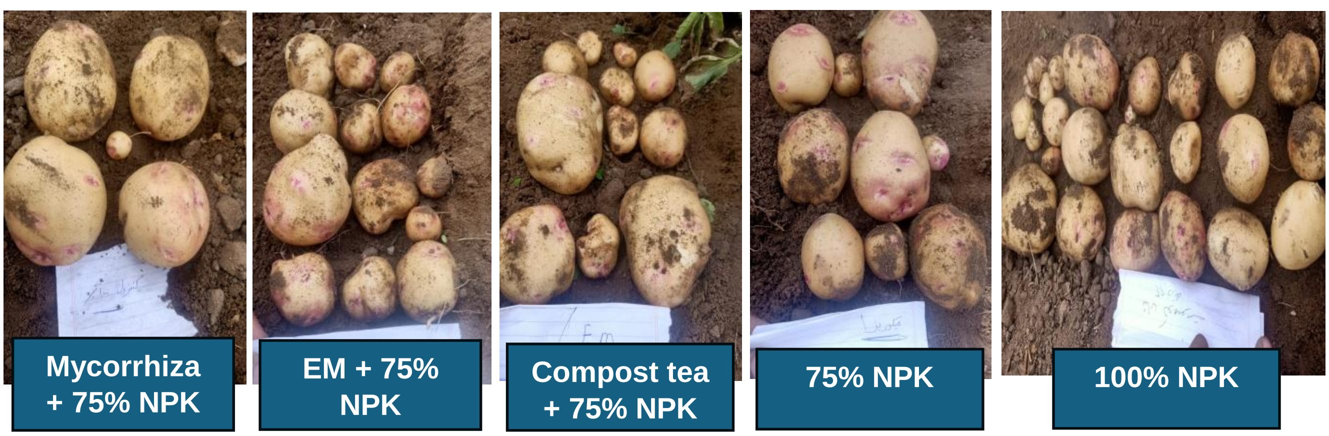


**Figure 4. Effect of mycorrhiza, EM, compost tea and mineral fertilizers on tubers photos showing shapes and number/plant of potato (cv. Cara) grown in newly reclaimed lands.**

### 3.1. Potato growth characters

#### 3.1.1. Plant fresh weight (g)

Data in table 2 showed that this characteristic was affected by the fertilization treatments as the obtained mean values were 1400.4 g in the 1st season, and 1406 in the 2nd season.3 g and the full dose of NPK (T5) gave the heaviest value of plant fresh weight (1607.3 g and 1603.3 g) in the first and second seasons, respectively. Also, using compost tea + 75% of NPK (T3) almost gave similar results to T5 (1507.3g and 1590.0 g) during two seasons, respectively with insignificant differences in the second season only followed by the other combinations of the used fertilizers (table 2).

### 3.1.2. Plant dry weight (g)

Table 2 is also showing the potato plant dry weight values and showed the differences in these values as affected by the fertilization treatments. The mean values of this characteristic were 178.7 g and 159.5 g and plants fertilized with only the full dose of NPK (T5) reached their peak in the first season at 176.0 g and in the second season at 159.5 g followed by T1 and T3. T4 (75% NPK) gave the lowest values (142.3 g and 143.3 g) with significant differences with all other fertilization combinations.

**Table 2: Effect of organic, bio and mineral fertilizers on plant fresh and dry weights of potato grown in two successive seasons; 2020/2021 and 2021/2022.**

| Treatment | Plant fresh weight (g) | | | | Plant dry weight (g) | | | |
|---|---|---|---|---|---|---|---|---|
| | First season | | Second season | | First season | | Second season | |
| Mycorrhiza + 75% NPK | 1458.0 | c | 1466.7 | b | 157.3 | bc | 162.3 | b |
| EM + 75% NPK | 1336.0 | d | 1313.3 | c | 153.3 | c | 152.3 | c |
| Compost Tea + 75% NPK | 1507.3 | b | 1590.0 | a | 164.7 | b | 163.0 | b |
| Control 75% NPK | 1093.3 | e | 1058.3 | d | 142.3 | d | 143.3 | d |
| Control 100% NPK | 1607.3 | a | 1603.3 | a | 176.0 | a | 176.3 | a |
| Mean | 1400.4 | | 1406.3 | | 158.7 | | 159.5 | |
| LSD | 39.54 | | 72.30 | | 7.80 | | 5.09 | |

## 3.2. Potato yield components

### 3.2.1. Total number of tubers/plant

The mean values of this characteristic as described in table 3 were 11.9 and 11.6 in the two seasons, respectively and plants fertilized with T5 significantly gave the highest values (14.7 and 14.8) in the two seasons. Treatment T2 and T4 gave the lowest values (only 09.5, 10.0 and 110, 09.8, respectively). T3 (compost tea + 75% of NPK) came in the middle of the other fertilization treatments.

### 3.2.2. Single tuber fresh weight

From potato plants fertilized with T3 and T5, the significant highest single tuber fresh weight values were 194.0 and 196.7 g in the first season, and 206.7and 200.0g in the second season, respectively in comparison to the other treatment, the mean values were 184.3 and 1190.8g, respectively, according to table 3.

### 3.2.3. Tubers fresh weight/plant

Table 3 is describing the fresh weight of tubers per one plant (production of single plants) and showed that in the first season, fertilization treatments; T%, T3, and T2 gave the highest values of this characteristic (1260.3 g, 1250.0 g, and 1202.3 g, respectively) but T4 (only 75% of NPK) significantly gave the lowest values (779.7 g). Regarding the second season, the same trend is almost observed for all treatments.

**Table 3: Effect of organic, bio and mineral fertilizers on single tubers fresh weight, total No. of tubers/plants, No of marketable tubers/plant and % of jumbo tubers (>4.5 cm)/plant of potato grown in two successive seasons; 2020/2021 and 2021/2022.**

| Treatment | Single tuber weight (g) | | | | Total No. of tubers/plant | | | | No of marketable tubers/plant | | | | % of jumbo tubers (>4.5 cm)/plant | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | First season | | Second season | | First season | | Second season | | First season | | Second season | | First season | | Second season | |
| Mycorrhiza + 75% NPK | 179.7 | c | 182.7 | c | 10.8 | c | 10.7 | c | 6.03 | b | 6.73 | c | 56.0 | a | 63.3 | a |
| EM + 75% NPK | 186.3 | bc | 196.3 | b | 09.5 | d | 10.0 | c | 5.70 | c | 9.53 | d | 60.0 | a | 58.7 | b |
| Compost Tea + 75% NPK | 194.0 | ab | 206.7 | a | 13.6 | b | 12.8 | b | 6.70 | a | 13.6 | b | 49.3 | b | 52.7 | c |
| Control 75% NPK | 164.7 | d | 168.3 | d | 11.0 | c | 09.8 | c | 5.63 | c | 10.97 | c | 49.7 | b | 57.0 | b |
| Control 100% NPK | 196.7 | a | 200.0 | b | 14.7 | a | 14.8 | a | 6.73 | a | 14.67 | a | 46.0 | b | 48.7 | d |
| Mean | 184.3 | | 190.8 | | 11.9 | | 11.6 | | 6.16 | | 11.91 | | 52.2 | | 56.1 | |
| LSD | 8.07 | | 6.32 | | 0.64 | | 1.16 | | 0.19 | | 0.64 | | 5.72 | | 2.40 | |

**3.2.4. Number of marketable tubers plant[1]**

This character is describing the potato plants production of tubers good for marketing and table 3 is showing that the mean values of this character are 6.16 and 11.91 tubers/plant. In general, values of marketable tubers produced from plants of the second season were higher than those of the first season. Moreover, the fertilization treatments; T4 and T3 resulted in the highest values of this characteristics (6.73, 14.67 and 6.70, 13.6 tubers/plant in the first and second season, respectively) followed by the other treatments.

**3.2.5. Number of jumbo tubers (>4.5 cm) /plant**

Tubers produced from potato plants were sorted in different diameter sizes according to markets demand and this character is showing the jumbo tubers which their diameters are more than 4.5 cm. the obtained mean values of this characteristic were 52.2 and 56.1 % during both seasons, respectively. Potato plants treated with the treatment No 1 (T1; Mycorrhiza + 75% of NPK) produced the highest values in the first and second season (56.0 and 63.3 %, respectively but the EM + 75% of NPK (T2) also gave the highest value of jumbo tubers only in the first season (60.0 %) followed by the other treatments (table 3).

**3.2.6. Tubers fresh weight/fed (total yield/fed)**

Yield per feddan was significantly affected by the applied fertilization combination mixes as described in table 4 and the mean values were 13.8 and 14.3 ton/fed. Interestingly, plants treated with compost tea + 75% of NPK produced the highest yield per feddan (16.5 and 16.7 ton /fed) in the first and second season, respectively with significant differences with all other fertilization treatments specially the full dose of NPK treatment (T5) which gave 13.7 and 13.9 ton/fed. On the other hand, T4 (75% of NPK) gave the lowest values (11.9 and 12.4 ton/fed) in the first and second season, respectively (table 4).

### 3.3. Chemical determinations in potato leaves and tubers

#### 3.3.1. Chlorophyll a, b, and carotenoids

Table 5 is showing the content of pigments in potato leaves as influenced by the fertilization treatments and data in this table revealed that the average values of the determined three pigments were 2.67, 4.20, and 1.23 mg/g fresh weight of chlorophyll a, b, and carotenoids, respectively. T1 gave the highest value of Chlorophyll a (4.78 mg/g fresh weight) and gave the highest value of carotenoids as well (2.54 mg./g fresh weight) but gave the lowest value of chlorophyll b (3.40 mg fresh weight) comparing to the other treatments.

**Table 4: Effect of organic, bio and mineral fertilizers on total yield/ fed and tubers fresh weight/plant of potato grown in two successive seasons; 2020/2021 and 2021/2022.**

| Treatment | Total yield/fed (ton) | | | | Tubers fresh weight/plant (kg) | | | |
|---|---|---|---|---|---|---|---|---|
| | First season | | Second season | | First season | | Second season | |
| Mycorrhiza + 75% NPK | 13.0 | c | 13.6 | c | 1190.3 | b | 1193.3 | c |
| EM + 75% NPK | 14.0 | b | 14.9 | b | 1202.3 | ab | 1245.0 | bc |
| Compost Tea + 75% NPK | 16.5 | a | 16.7 | a | 1250.0 | ab | 1283.3 | ab |
| Control 75% NPK | 11.9 | d | 12.4 | d | 779.7 | c | 786.7 | d |
| Control 100% NPK | 13.7 | bc | 13.9 | c | 1260.3 | a | 1320.0 | a |
| Mean | 13.8 | | 14.3 | | 1136.5 | | 1165.7 | |
| LSD | 0.73 | | 0.59 | | 65.24 | | 53.58 | |

**Table 5: Effect of organic, bio and mineral fertilizers on chlorophyll a, b, and carotenoids content in leaves of potato.**

| Treatment | Chlorophyll "a" (mg/g fresh weight) | | Chlorophyll "b" (mg/g fresh weight) | | Carotenoids (mg/g fresh weight) | |
|---|---|---|---|---|---|---|
| Mycorrhiza + 75% NPK | 4.783 | a | 3.40 | b | 2.54 | a |
| EM + 75% NPK | 2.060 | b | 4.43 | a | 0.91 | b |
| Compost Tea + 75% NPK | 2.133 | b | 4.46 | a | 0.89 | b |
| Control 75% NPK | 2.187 | b | 4.36 | a | 0.90 | b |
| Control 100% NPK | 2.167 | b | 4.36 | a | 0.90 | b |
| Mean | 2.666 | | 4.20 | | 1.229 | |
| LSD | 0.61 | | 0.5 | | 0.29 | |

### 3.3.2. Nitrogen content in leaves and tubers

Potato leaves contained a percentage of 1.82 of nitrogen but tubers contained 3.70 % as mean values as shown in table 6. Meanwhile, leaves and tubers of plants treated with the full dose of NPK significantly gave the highest values of nitrogen in leaves and tubers (2.13 and 4.23 %, respectively) comparing to the other fertilization mixes.

**Table 6: Effect of organic, bio and mineral fertilizers on nitrogen, phosphorus, potassium, and protein content in leaves and tubers of potato.**

| Treatment | N % | | | | P % | | | K % | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Leaves | | Tubers | | Leaves | | Tubers | Leaves | | Tubers | |
| Mycorrhiza + 75% NPK | 1.66 | c | 3.50 | c | 0.218 | bc | 0.205 | 2.15 | e | 3.24 | d |
| EM + 75% NPK | 1.84 | b | 3.80 | b | 0.218 | bc | 0.242 | 2.45 | c | 3.45 | c |
| Compost Tea + 75% NPK | 1.82 | b | 3.67 | b | 0.173 | c | 0.249 | 2.51 | b | 3.56 | b |
| Control 75% NPK | 1.64 | c | 3.10 | d | 0.243 | ab | 0.203 | 2.27 | d | 3.04 | e |
| Control 100% NPK | 2.13 | a | 4.23 | a | 0.292 | a | 0.285 | 2.68 | a | 3.90 | a |
| Mean | 1.82 | | 3.70 | | 0.229 | | 0.237 | 2.41 | | 3.44 | |
| LSD | 0.124 | | 0.25 | | 0.05 | | 0.06 | 0.06 | | 0.08 | |

### 3.3.3. Phosphorus content in leaves and tubers

The mean values of phosphorus (P%) in analyzed samples of potato leaves and tubers were 0.229 and 0237 %, respectively as shown in table 6. Potato plants treated with T5 (full dose of NPK) showed that their leaves and tubers contained the significant highest values of phosphorus (0.292 and 0237 %, respectively) followed by the other treatments.

### 3.3.4. Potassium content in leaves and tubers

The average potassium level in the potato samples (leaves and tubers) was 2.41% and 3.44%, respectively, according to the data in table 6. Additionally, the highest potassium content values (2.68 and 3.90%) were seen in the potato plant's leaves and tubers after treatment with the full dose of NPK, which was followed by the other treatments.

### 3.3.5. Protein content in leaves and tubers

Data in table 7 which is describing the effect of using different fertilization mixes on the amount of protein in potato tubers and leaves and the mean values of these treatments are 11.4 and 23.1 % in leaves and tubers, respectively. Potato plants fertilized with the full dose of NPK (T5) gave leaves and tubers containing the significant highest values of protein (13.3 and 26.5%, respectively followed by the other treatments.

**Table 7: Effect of organic, bio and mineral fertilizers on protein content in leaves and tubers of potato.**

| Treatment | Protein % | | | |
|---|---|---|---|---|
| | Leaves | | Tubers | |
| Mycorrhiza + 75% NPK | 10.4 | c | 21.9 | c |
| EM + 75% NPK | 11.5 | b | 23.8 | b |
| Compost Tea + 75% NPK | 11.4 | b | 24.2 | b |
| Control 75% NPK | 10.2 | c | 19.4 | d |
| Control 100% NPK | 13.3 | a | 26.5 | a |
| Mean | 11.4 | | 23.1 | |
| LSD | 0.76 | | 1.55 | |

### 3.3.6. Nitrate and nitrite content in potato leaves and tubers

The mean value of nitrate (NO3) content in the analyzed samples of potato leaves as shown in table 8 is 386.6 mg/Kg dry weight of those leaves and potato plants treated with the treatment No 5 (T5) which shows the full dose of NPK contained the significant highest values of nitrate (353.0 mg/Kg of the dry weight followed by T1 (365.0 mg/Kg dry weight), T4 (365.0 mg/Kg dry weight) and T2 (353.0 mg/Kg dry weight). However, the mean value of nitrate percentage in potato tubers is 890.1 mg/Kg of dry weight of the analyzed samples. Also, T5 gave the significant highest value (1186.7 mg /Kg dry weight) followed by T4, T1, and both T3 and T2 (table 8). Regards the nitrite (NO2) content in leaves and tubers of potato, potato leaves contained 22.3 and 47.0 mg/Kg of the dry weight of the analyzed samples of leaves and tubers, respectively as mean values of nitrite content (table 8). Plants treated with T5 (NPK full dose) contained the significant highest values of nitrite (28.1 and 58.0 mg/Kg dry weight) in their leaves and tubers, respectively followed by the other treatment.

### 3.4. Effect of fertilizer types on soil properties

Table 9, 10 and 11 are showing the impact of the various fertilizers used in the experiments on soil characteristics comparing with the soil properties before plantation. The EC (electric conductivity) values were reduced in the soil because of the applied bio, organic and mineral fertilizers. Regards to the soil content of calcium chloride (CaCO3), this content was much decreased in the soil after the application of the fertilizers comparing with the higher content before plantation. Furthermore, the content of nutrient elements, e.g., Na, K, Ca, Mg, Cl, and N was reduced after adding the fertilizers and by the plant growth as the applied fertilizers made these nutrients available to the potato plants (table 9, 10 and 11). On the other hand, the organic fertilizers (compost tea + 75% NPK) increased the soil content of available P and the total N.

**Table 8. Effect of organic, bio and mineral fertilizers on nitrate ($NO_3$), and nitrite ($NO_2$) content in leaves and tubers of potato.**

| Treatment | Nitrate ($NO_3$, mg/kg dry weight) | | | | Nitrite ($NO_2$, mg/kg dry weight) | | | |
|---|---|---|---|---|---|---|---|---|
| | Leaves | | Tubers | | Leaves | | Tubers | |
| Mycorrhiza + 75% NPK | 365.0 | b | 843.3 | c | 20.8 | c | 45.0 | c |
| EM + 75% NPK | 353.0 | b | 723.3 | d | 20.2 | cd | 40.3 | d |
| Compost Tea + 75% NPK | 315.0 | c | 763.3 | d | 19.7 | d | 44.5 | c |
| Control 75% NPK | 365.0 | b | 933.7 | b | 22.5 | b | 48.0 | b |
| Control 100% NPK | 353.0 | a | 1186.7 | a | 28.1 | a | 58.0 | a |
| Mean | 386.6 | | 890.1 | | 22.3 | | 47.2 | |
| LSD | 13.19 | | 70.89 | | 0.96 | | 1.72 | |

**Table 9. Effect of organic, bio and mineral fertilizers on soil properties before and after potato plantation.**

| Sample | pH | EC ds/m | $CaCO_3$ | Soil samples analysis | | | |
|---|---|---|---|---|---|---|---|
| | | | | Particle size analysis | | | |
| | | | | sand % | Clay % | Silt % | Texture |
| **Mycorrhiza + 75% NPK** | 8.5 | 0.44 | 2.21 | 80.7 | 14.5 | 4.8 | Sandy loam |
| **EM + 75% NPK** | 8.1 | 0.79 | 2.03 | 82.6 | 12.4 | 5 | Sandy loam |
| **Compost Tea + 75% NPK** | 8.0 | 0.57 | 2.05 | 84.9 | 12.6 | 2.5 | Loamy sand |
| **Control 75% NPK** | 8.4 | 0.53 | 2.1 | 84.9 | 12.6 | 2.5 | Loamy sand |
| **Control 100% NPK** | 8.2 | 0.45 | 1.97 | 85.0 | 12.5 | 2.5 | Loamy sand |
| **Before planting** | 8.0 | 1.65 | 3.76 | 82.3 | 15.2 | 2.5 | Sandy loam |

**Table 10. Effect of organic, bio and mineral fertilizers on soil contents of water-soluble salts before and after potato plantation.**

| Sample | Water soluble salts (1:5) me /100 g soil | | | | | |
|---|---|---|---|---|---|---|
| | Na | K | Ca | Mg | Cl | CO3+HCO3 |
| **Mycorrhiza + 75% NPK** | 0.42 | 0.15 | 0.8 | 0.4 | 1.46 | 1.63 |
| **EM + 75% NPK** | 0.28 | 0.12 | 1.6 | 0.3 | 1.36 | 1.5 |
| **Compost Tea + 75% NPK** | 0.33 | 0.12 | 1..1 | 0.3 | 1.06 | 1.3 |
| **Control 75% NPK** | 0.28 | 0.13 | 1 | 0.2 | 1.06 | 1.3 |
| **Control 100% NPK** | 0.2 | 0.11 | 0.9 | 0.4 | 0.8 | 1.07 |
| **Before planting** | 0.69 | 0.29 | 3 | 1.2 | 1.65 | 1.89 |

**Table 11: Effect of organic, bio and mineral fertilizers on soil contents of available elements (N, P, and K) before and after potato plantation.**

| **Sample** | **Water soluble salts (1:5) me /100 g soil** | | |
|---|---|---|---|
| | Total N % | Available P (mg/kg) | Available K (mg/kg) |
| **Mycorrhiza + 75% NPK** | 0.18 | 21 | 290 |
| **EM + 75% NPK** | 0.16 | 16 | 190 |
| **Compost Tea + 75% NPK** | 0.21 | 25 | 210 |
| **Control 75% NPK** | 0.19 | 23 | 220 |
| **Control 100% NPK** | 0.17 | 18 | 200 |
| **Before planting** | 0.17 | 18 | 430 |

### 3.5. Effect of EM and mycorrhiza inoculation on microbial population and mycorrhizal colonization of the soil planted with potato

As shown in table 12, data in this table is showing that adding the EM to the soil planted with potato increased the soil content of bacteria from $54x10^5$ (before inoculating the soil) to $208x10^5$. also, the mycorrhiza inoculation increased the soil content of bacteria to $130x10^5$. regarded to the soil content of fungi, inoculating the soil with EM increased the soil content of fungi from $39x10^5$ (before inoculation) to $70x10^5$ after inoculation and the mycorrhiza inoculation increased the soil content of fungi to $139x10^5$. The actinomycetes and azotobacter numbers were also increased by about 1.5 times with the inoculation of EM and mycorrhiza. The azospirillum content of the soil was almost doubled by the inoculation of EM and mycorrhiza. In regards to the mycorrhizal colonization percentages, inoculating the soil with mycorrhiza increased the mycorrhizal colonization percentage up to eight times (79%) comparing 10% colonization before the inoculation (table 12).

**Table 12. Effect of EM and mycorrhizal inoculation on microbial population and mycorrhizal colonization of potato plants grown in sandy soil.**

| Treatment | $10^5$ | $10^5$ | $10^4$ | $10^3$ | $10^3$ | Colonization (%) |
|---|---|---|---|---|---|---|
| | Bacteria | Fungi | Actinomycetes | Azotobacter | Azospirillum | |
| T1 | 54 | 39 | 31 | 86 | 40 | 10 |
| T2 | 112 | 64 | 37 | 90 | 65 | 32 |
| T3 | 208 | 70 | 28 | 105 | 90 | 37 |
| T4 | 130 | 139 | 40 | 135 | 80 | 79 |

T1: Soil without inoculation, T2: Soil with inoculation (Soil only), T3: EM+ soil, T4: Mycorrhiza + soil.

### 3.6. Early blight and brown rot infections

Natural infection with potato plants early blight and tubers brown rot were surveyed and detected. Figure 5 showed that potato plants differed in their symptoms of early blight and the treatment with mycorrhiza+75% NPK showed the lowest percentage of infection (49%), whereas the treatment with 100% of the recommended doses of NPK showed the highest percentage of infection (71%). The other treatments showed percentage of infection in between those two treatments. Regarding the infection with the brown rot in potato tubers treated with different treatments, plants treated with mycorrhiza +75% NPK showed a zero percent of infection and both EM+75% NPK (Figure 5) and compost tea+75% NPK showed the highest obtained percentages (11.7 and 11.2%, respectively). The single treatments with 75% NPK and 100% NPK gave 5.2% and 7.6%, respectively (Figure 6).

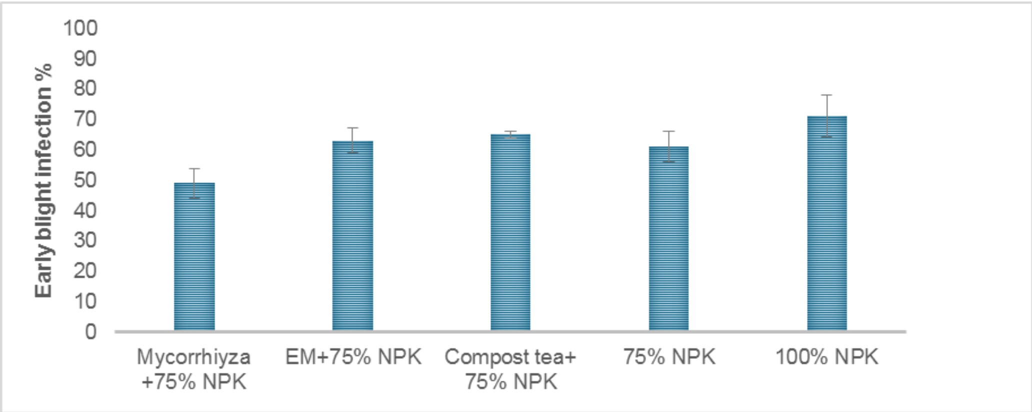


**Figure 5. Effect of mycorrhiza, EM, compost tea and mineral fertilizers on potato percentage of early blight infection.**

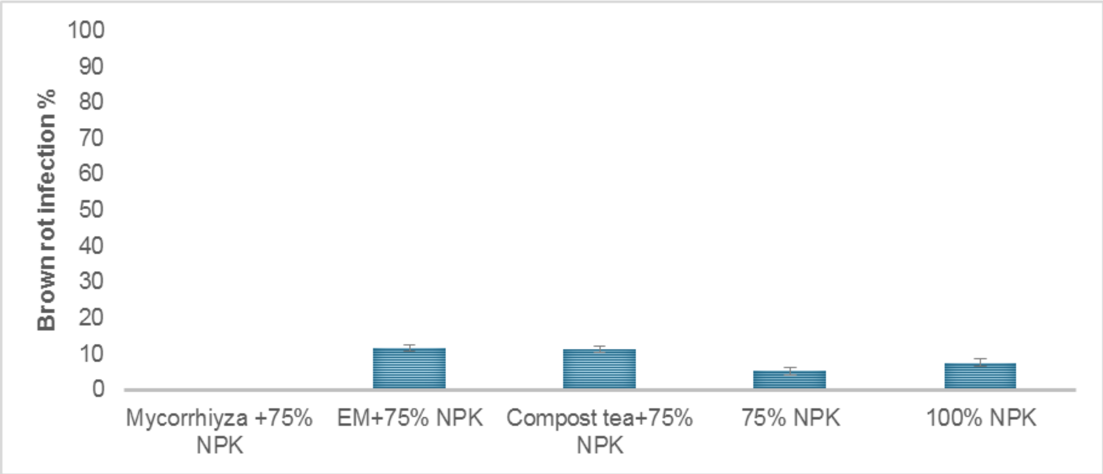


**Figure 6. Effect of mycorrhiza, EM, compost tea and mineral fertilizers on potato percentage of brown rot infection.**

## DISCUSSION

The results of this study, which make use of various mixes of mineral, organic, and biological fertilizers, are highly advantageous for agriculture, science, and the economy. Comparing these fertilizer combinations to applying solely mineral fertilizers, the development of potato plants was enhanced, the overall production of tubers increased, and the number of early blight infections decreased. Many people have turned to artificial fertilizers in an effort to increase crop yields and reduce food insecurity as a result of the global issue of infertile agricultural soil. An increasing amount of artificial fertilizers are needed due to soil nutrient replenishment and the unavoidable improvement in crop yield and quality. Because of its high crop production and high plant biomass, mineral fertilizers are becoming more and more popular (Guo et al., 2010).

However, studies have demonstrated that the usage of heavy chemical fertilizers can result in metal pollution, nutritional toxicity, soil acidification, groundwater contamination, greenhouse gas emissions, and fertilizer residue accumulation (Han and Zhao, 2009; Sierra et al., 2015).

About 30 to 50 percent of chemical fertilizers actually reach crops, with the remaining portion ending up in the environment, according to Mózner et al. (2012). Organic and bio fertilization can improve the physical, chemical, and biological properties of the soil, resulting in increased plant development and yield (Stephen et al. 2014; Mitran et al. 2017). This is due to the fact that these techniques make use of a lot of organic matter, which is produced by plenty of bacteria.

Scientists have spent decades refining microbiological techniques such as biocontrol and biofertilizer agents, which are mixtures of bacteria and fungus that improve plant health and growth. Mahanty et al. (2016) claim that biofertilizers have a number of environmentally friendly strategies to boost crop yields. By populating the rhizosphere, or the inside tissues of the plant, living bacteria found in biofertilizers, on the other hand, promote plant development whether applied to the surfaces of plants, seeds, or soil.

Verma et al. (2019) claim that biofertilizers may break down organic molecules, create plant hormones, oxidize sulfur, fix nitrogen, and dissolve phosphate. By cycling nutrients, biofertilizers frequently guarantee the best potential crop development and growth (Phadwaj et. Al., 2014). On the other hand, pesticides' harmful effects might be lessened by biocontrol agents. Biological control, an alternative to chemical pesticides, uses microorganisms and other living things to control plant diseases. Microorganisms' biocontrol powers are enhanced by the production of antibiotic enzymes and compounds by bacteria, which can deplete iron from the rhizosphere and induce systemic resistance by lysing the fungal cell wall (Parani and Saha, 2012).

Applying biofertilizers is one tactic to enhance soil microbial condition, which affects nutrient accessibility and organic matter breakdown (Chaudhary and Sharma, 2019). Because biofertilizers can improve soil microbial diversity, they may be able to help environmentally aware farmers achieve higher agricultural yields (Agri et al., 2022). This was evident in these experiments, where we observed that applying 75% of the recommended doses of NPK in conjunction with compost tea, EM, and mycorrhizae applications increased soil prosperities, the vigorous growth of potato plants, and the production of marketable tubers compared to the control treatment (100% of NPK).

Dormant or active, the microorganisms included in biofertilizers can support a wide range of biological processes that can change nutrients from an inaccessible to an accessible condition (Gaur, 2010). In order to preserve the fertility of agricultural soil, biofertilizers can be applied successfully, according to Kannaniyan (2002). Many studies have shown that biofertilizer improved agricultural productivity and plant growth when compared to the control group (Atimanew and Adholeya, 2022; Clarson, 2004; Malboobi et al., 2009; Abu El-Khair et al., 2011; El-Sayed et al., 2015). According to our findings, bacterial inoculation increased potato yield when compared to the control group.

It seems sense that beneficial bacteria like Bacillus and Azotobacter found in biofertilizers could promote plant growth. Jen-Hshuan (2006) claims that Azotobacter spp. produce antifungal compounds that help plants fight off a variety of plant diseases, thereby increasing plant output. The nitrogen-fixing bacteria Azotobacter and Azospirillium thrive best in the root zone, which raises the amount of nitrogen available in the soil. Because nitrogen is essential for the growth of the shoot system, aids in reproduction, and is the main component of chlorophyll—the pigment that gives plants their green hue and powers photosynthesis—plants depend on nitrogen as a macronutrient (Sandha et al., 2021).

A drop in abscisic acid, an increase in mineral absorption, and the production of phytohormones such cytokinin and IAA GAs could be the causes of the improved potato yield from biofertilizers (Elhakim et al., 2016). Our results demonstrate that potato tubers inoculated with Azospirillum and Azotobacter greatly enhanced growth features, which is consistent with other studies. This was explained by the creation of phytohormones such as auxin, cytokinin, gibberellins, and abscisic acid, which increase plant development and productivity (Bottini et al., 2004). Beneficial bacteria can improve the quality of the soil (Nayak et al., 2020; Ngilangil and Vilar, 2020).

The beneficial impacts of microorganisms on soil structure, namely how they can make the soil less compact, better draining, and more friable, were highlighted in a study conducted by Gang et al. (2022). This could lead to conditions that are more conducive to plant growth. The level of soil organic carbon (SOC) rose when we treated the soil with EMs and mycorrhiza. Soil organic carbon is directly impacted by the diversity of soil bacteria (Buyer et al., 2010). An increase in SOC stimulates the biological activity of the soil, improving nutrient use efficiency and increasing nutrient availability for the developing plant. In comparison to soil fertilized with mineral fertilizers, soil fertilized with biofertilizers exhibited higher levels of phosphate and potassium.

These results showed a clear correlation between the inoculation content and the available nutrients in the soil. The addition of biofertilizers may increase soil P availability because they foster a greater population of bacteria that can solubilize soil P. Biofertilizers, according to Kumar et al. (2001), boost P absorption by increasing the solubility of insoluble P in soil. Our results are in agreement with those of Ramalkashi et al. (2008). $K^+$ absorption is greatly enhanced by biofertilizers that change the ion selectivity of the soil, as noted by Hamdia et al (2005). Using biofertilizers resulted in the buildup of N, P, and K independently, which helped to maintain the nutritional balance, according to Adesete et al. (2008) and Egamberrdiveva (2007).

The findings of these investigations may represent a positive development for safe, clean agriculture and the production of nutritious, wholesome potato tubers. Additionally, as farmers in the Upper Egypt districts are unfamiliar with potato plantations, this will lower the cost of potato production and encourage them to cultivate and produce potatoes on their fields. These farmers only grow common crops like corn, wheat, and sugar cane, which are labor-intensive for the soil and not very profitable.

Since farmers in these districts do not plant potatoes in their fields and because residents of these districts spend a lot of money on potato purchases, potato tubers are transported from other Egyptian governorates, such as Minia (Middle Egypt governorate), to the Upper Egypt governorates, such as Esna, Luxor, and Aswan. Therefore, encouraging more people to cultivate potatoes in these areas will lower the cost of potato goods (both fresh and processed).

## CONCLUSION

This study investigated the impact of combining mineral fertilizers with organic and biofertilizers on potato cultivation in newly reclaimed lands of Upper Egypt. The application of partial doses of mineral fertilizers (75% of the recommended NPK) in combination with mycorrhiza, Effective Microorganisms (EM), and compost tea significantly enhanced potato plant growth and increased total yield. The resulting potato tubers were of high quality, with lower nitrate and nitrite contents, and higher protein levels. Notably, the treatment of Mycorrhiza + 75% NPK effectively inhibited natural infection by brown rot and reduced early blight incidence compared to single mineral fertilizer treatments. These findings suggest that integrating organic and biofertilizers with reduced mineral fertilizer doses can improve potato production while promoting sustainable agricultural practices. This approach holds promise for encouraging farmers in Upper Egypt to adopt potato cultivation, thereby enhancing local food security and providing economic benefits by meeting the demands of both domestic and international markets.

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**الملخص العربى**

## دراسة تأثير بعض المركبات العضوية والمخصبات الحيوية على نمو وانتاجية البطاطس في الأراضي المستصلحة حديثاً



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**قسم البساتين (خضر) – كلية الزراعة – جامعة المنيا – جمهورية مصر العربية**



لدراسة تأثير توليفات من 75% من الأسمدة المعدنية (NPK) والأسمدة العضوية والحيوية مع الأسمدة المعدنية المفردة بنسبة 75% و 100%: أجريت تجربتان حقليتان متتاليتان خلال موسمي الخريف 2021 و 2022 في مزرعة خاصة بقرية النواصر، مدينة إسنا، محافظة الأقصر، جمهورية مصر العربية.

تم الحصول على الدرنات المحلية لصنف البطاطس كارا من محافظة المنيا وتم اختيارها لهذه الدراسة كصنف لأغراض التصنيع والطهي معاً. واستخدم تصميم القطاعات العشوائية الكاملة (RCBD) حيث تم توزيع جميع المعاملات عشوائياً في 15 قطعة (تم استخدام 5 معاملات، وتم تكرار كل معاملة ثلاث مرات في ثلاث قطع). تبلغ مساحة كل قطعة أرض 10.5 مترًا مربعًا (عرض 3 أمتار وطول 3.5 مترًا) لتشكل مساحة قدرها وحدة واحدة من 400 وحدة للفدان الواحد. وتتكون كل قطعة من 5 خطوط ويبلغ طول كل خط 3.5 متر وعرضه 70 سم. تمت زراعة درنات البطاطس داخل الثلث العلوى للخطوط المروية سابقاً (بعد 5 أيام من وقت الري). وكانت المعاملات الخمسة المستخدمة على النحو التالي:

1. EM + 75% of NPK
2. Mycorrhiza + 75% of NPK
3. Compost tea + 75% of NPK
4. 75% of NPK
5. 100% of NPK

وكانت الجرعات الموصى بها من NPK (التي أوصت بها وزارة الزراعة واستصلاح التربة المصرية لزراعة وإنتاج البطاطس) هي 180 وحدة نيتروجين، و120 وحدة بوتاسيوم، و96 وحدة فوسفور من مصادر معدنية مختلفة تحتوي على هذه العناصر. تم استخدام هذه الجرعات أثناء تحضير التربة ومع مياه الري خلال موسم الإنتاج بالإضافة إلى الجرعات الأخرى الموصى بها من الأسمدة المعدنية مثل نترات الكالسيوم والعناصر . وتم الصغرى. وتم اتباع جميع الممارسات الزراعية الجيدة الأخرى الموصى بها لإنتاج البطاطس في مصر في ظل هذه الظروف البيئية والتربة حديثة الأستصلاح. وقد تم الحصول على السماد الحيوي EM والميكوريزا من قسم الميكروبيولوجيا الزراعية بكلية الزراعة جامعة المنيا، كما تم الحصول على شاي الكومبوست من شركة النيل لإنتاج السماد بمدينة المنيا الجديدة بمحافظة المنيا وتم تجهيز هذا السماد لاستخدامه كمحلول يمكن استخدامه لرى النباتات به ثم الري العادى بعده.

**تم دراسة الصفات البستانية والكيميائية والميكروبيولوجية المختلفة على النحو التالي:**

**أ) صفات النمو:**

أ- نسبة إنبات براعم البطاطس من الدرنات بعد 30 يوماً من الزراعة.

**ب. خصائص النمو الخضري**

1 .متوسط الوزن الطازج للنبات بأكمله (كجم)

2 .متوسط عدد السيقان الرئيسية/النبات

3 .متوسط وزن النبات الطازج (جم)

4 .متوسط الوزن الجاف للنبات (جم)

**ج. صفات المحصول:**

1 .متوسط عدد الدرنات / نبات

2 .متوسط وزن الدرنات الطازجة/نبات (كجم)

3 .متوسط المحصول الكلى (طن/فدان)

**د- تحليل الخصائص الكيميائية:**

تم طحن كل عينة من النباتات المجففة وتحضيرها (حوالي 100 جرام من مسحوق الأوراق المجففة) لتحديد ما يلي:

1. نسبة النيتروجين (N)

2 .نسبة الفوسفور (P)

3 .نسبة البوتاسيوم (K).

4 .نسبة البروتين الكلى.

5 .المحتوى من النترات (NO3) والنتريت (NO2) .

6 .المحتوى من صبغات الكلوروفيل والكارتونيات.

هـ- تحديد الإصابة باللفحة المبكرة على المجموع الخضرى للنباتات أثناء النمو والعفن البنى في الدرنات الناتجة.

لمعرفة تأثير الأسمدة المستخدمة (العضوية والحيوية والمعدنية) في الإصابة بمرض العفن البنى في الدرنات واللفحة المبكرة في الأفرع تم تحديد نسب الإصابة بهذه الأمراض في جميع النباتات في كل مكررة لجميع المعاملات.

أظهرت النتائج أن استخدام الأسمدة المعدنية المفردة (75% أو 100% من الـ NPK) بالجرعات الموصى بها أو توليفة من 75% من الـ NPK مع الأسمدة العضوية والحيوية (الميكوريزا، EM، وشاي الكمبوست) أعطت نتائج جيدة ومختلفة ويمكن تطبيقها في الأراضي المستصلحة حديثاً في منطقة صعيد مصر. فقد أظهرت النتائج أن استخدام جرعات جزئية من الأسمدة المعدنية مع الأسمدة العضوية أو الحيوية أدى إلى تعزيز نمو نباتات البطاطس وزيادة المحصول الكلي مع إعطاء درنات صحية جيدة تحتوي على نسبة أقل من النترات والنتريت. علاوة على ذلك، أدت معاملة الميكوريزا + 75% NPK إلى تثبيط الإصابة الطبيعية بالعفن البني في درنات البطاطس وتقليل الإصابة الطبيعية باللفحة المبكرة مقارنة بالمعاملة المنفردة بالأسمدة المعدنية. ويمكن اعتبار هذه المعاملات نهجاً واعداً نحو تطبيق الممارسات الزراعية الجيدة في إنتاج البطاطس وتشجيع المزارعين المصريين في منطقة الصعيد في مصر العليا على زراعة وإنتاج البطاطس للأسواق المحلية والخارجية.