Minia J. of Agric. Res. & Develop.
Vol. (43), No.3, pp 415- 441, 2023

FACULTY OF AGRICULTURE

IMPACT OF MINERAL, ORGANIC, AND BIO FERTILIZATION ON POTATO IN EGYPTIAN SANDY SOIL

2-PART 2: CHEMICAL COMPOSITION OF PLANTS AND TUBERS

Yousry T. Abdel Mageed[1]- Yasser M. M. Moustafa[1]- Maisa Lotfy Abd El-Moniem[2]- Osama M. Hafez[1]

[1] Faculty of Agriculture, Minia University, Minia 6111, Egypt.

[2] Central Laboratory of Organic Agriculture- Agric. Res. Center Giza, Egypt

Received: 1 August 2023 Accepted: 17 Sept. 2023

ABSTRACT

Prices of mineral fertilizers are getting higher nowadays, so that this experiment was designed. In a private farm in the New Vally governorate, different fertilizer combinations; organic, bio and mineral sources were used in this study to grow potato (Cara cv.) in sand soil in the two following winters of the years 2019/2020 and 2020/2021. Results showed that inoculating potato plants with Biofert (as N-fixing bacteria) in the presence of organic manures “half of the recommended doses” (as FYM + PM) gave the highest mean values of all studied growth and yield characters. When compared to plants grown with the control treatment, potato plants treated with FYM + PM + Biofert + 100% NPK dosage had the greatest mean values for those features. The increased amount of soluble nutritional components in mineral fertilization made it more impactive than organic manures or biofertilization in terms of improving soil fertility. The yield and quality indicators of potato tubers increased as a result of this impact. From the obtained results, it could be recommended that inoculating potato plants with the Biofert (as N-fixing bacteria) and Biopotass (as K-solubilizing bacteria) combined with compost (FYM) + (PM) and 75% of the recommended doses of mineral fertilization (NPK) is the best for potato production to get the highest economic yield of potato with the best qualities of marketable tubers.

Keywords: : Potato (*Solanum tuberosum* L.), NPK, Farmyard Manure (FYM), Poultry manure (PM), Bio Fertilizers.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is a very crucial crop, followed by corn, rice and wheat (Mlaviwa and Missanjo, 2019). Potao can be planted and get yield all year round in some countries (Assa, 2012). It is an inexpensive source of energy, has significant amounts of minerals, carbohydrates, vitamins B and C. It is regarded as being relatively high in several free amino acids, fibers, and very small amounts of fats (Muthoni and Nyamango, 2009). It is the most popular tuber crops in the world where, the world production of potatoes in 2021 was 376 million tons (FAO STAT, 2021). Because Egyptian potatoes are sold to many nations, they serve a significant economic role in Egypt as both a food crop and a cash crop (Abdel-Moneim *et al*., 2015a). Fertilization has an important impact on quality and yield of potato tubers. Mineral fertilization with high doses had negative impacts on quality of potato tubers. In an effort to address the problem of low fertile agricultural soil fertility that contributes to worldwide food insecurity, chemical fertilizer application has become a common and widespread practice. In order to restore soil nutrients and always increase the amount and quality of agricultural output, a dependency on these chemical fertilizers has become required. Due to increased reliance on mineral fertilizer due to high crop output and plant biomass following application of mineral fertilizer (Guo et al., 2010). A heavy reliance on chemical (mineral) fertilizers, however, has been linked to an increase in nutrient toxicity, metal pollution, greenhouse gas emissions, soil acidification and groundwater contamination, (Han and Zhao, 2009; Sierra et al., 2015). According to (Mózner et al., 2012), crops only use 30–50% of chemical fertilizers, with the remainder being lost to the environment.

Environmental protection is one of the new agriculture policy's top concerns. A balance between the requirement to increase yieldو profit and the appropriate use of fertilization rate is thus necessary to lessen the impact of crop production on the environment. Organic fertilizing has become more popular around the world due to the superior nutritional value and potential health advantages of foods obtained from these forms of farming. This study examines the effects of adopting organic farming methods to reduce the detrimental effects of mineral fertilization on potato tuber productivity and quality indicators. Due to its high organic matter content and high microbial activity, the use of organic fertilization, such as farmyard and poultry manure or other sources, has been shown to improve biological, chemical, and physical properties of the soil and invariably increase plant growth and yield (Stephen et al., 2014; Abdel-Moneim et al., 2015; Mitran et al., 2017). According to by Zeinab et al. (2013) reported that organic manure increases plant levels of secondary metabolites such as phenolic, flavonoid, and antioxidant activities.

The over use of chemical fertilizers and pesticides in today's world has resulted in soil degradation and contamination, which is one of the main issues. According to Abdel-Moneim et al. (2015), bio-fertilizers are, in theory, less costly and more environmentally benign than chemical fertilizers. The key to resolving this issue with organic fertilization may include biological nitrogen, potassium, and phosphorus sources including bacteria, fungus, and cyanobacteria. In the process of changing the supplement that plants use, soil microbes play a crucial role (Farag et.al.2013). In the unlikely event that the microorganisms in the soil are sufficiently lacking, bio fertilizers must be used to vaccine them. In general, there are three types of bio-fertilizers: bacteria that fix nitrogen, bacteria that solubilize phosphorus, and bacteria that solubilize potassium. Nitrogen settling bio-fertilizers contribute nitrogen to the soil by reducing ambient nitrogen. While phosphatic and potassic bio-fertilizers are able to solubilize the phosphates and potassium bound in soil and increase their accessibility in plants. A good combination of organic and biofertilizers (Azotobacter, phosphorus and potassium bacteria) with natural supplement sources can greatly enhance the formation and nature of potatoes (Nag, 2006).

The goal of this research is to study the impact of inoculation with different bio-fertilization under organic fertilization as (farmyard manure and poultry manure) comparing with chemical (mineral) fertilization on potato. This was to determine the most appropriate integration for suitable kind of bio-fertilization with organic manure. Also, to decrease the negative impact of mineral fertilization and produce high quality of potato tubers suitable for local consumption and for exportation to international markets.

MATERIALS AND METHODS

In a private farm at Ezab Al Qasr Village, Al-Wahat Al-Dakhla, New Valley Governorate, Egypt. Two field experiments were undertaken during the two successive winter seasons of 2019-2020 and 2020-2021. The study was conducted to investigate the impacts of using various combinations of organic manures, bio-fertilizers, and mineral fertilizers on production of safe and economic potato yield of tubers (Cara cv.).

2.1.1. Experimental design and treatments

Sixty treatments were set up in a factorial design with three replications, and they represented the simplest conceivable combination of 15 treatments of organic+bio-fertilizations and 4 rates of NPK as mineral fertilization described as follow:

- Mineral fertilization:

1. Zero (without fertilization).
2. 50 % from recommended dose (RD) NPK.
3. 75% RD. NPK.
4. 100 RD. NPK.

- Organic and bio-fertilization:

1. Farmyard manure (FYM).
2. Poultry manure (Pigeon manure “PM”).
3. 50% of FYM + 50% of PM.
4. Biofert (N- fixing bacteria).
5. Biopotass (K- releasing bacteria).
6. Biophos (P- dissolving bacteria).
7. FYM+Biofert.
8. FYM+Biopotass.

9. FYM+Biophos.
10. PM+Biofert.
11. PM+Biopotass.
12. PM+Biophos.
13. 50% of FYM + 50% of PM + Biofert.
14. 50% of FYM + 50% of PM + Biopotass.
15. 50% of FYM + 50% of PM + Biophos.

Also, 00% N, P, and K fertilizers for potato production were taken into account as a comparable control treatment. So, the total number of treatments were 180 plots.

2.1.2. Preparation of the experimental soil

The soil of the experimental field was sandy in texture and poor fertile soil. The experimental field was ploughed, compacted and each plot area was 10.5 m^2 (3 × 3.5 m length and width, receptively), with 5 rows in each plot (70 cm width of each ridge).

2.1.3. Preparation of organic manures

A private station of animal and bird production provided the ripe farmyard and pigeon manure. Table (1) provides chemical analyses of the utilized organic manures. Before planting, a single application of organic manures was added to the soil at a rate of 5 tons fed-1 for FYM and 2 tons fed-1 for pigeon manure, i.e. 12.5 and 5 kg per plot, respectively. Each experimental plot received an equal mixture of FYM and PM, and it was watered until saturation was reached. Plots were then left for two weeks to avoid the impacts of the heat from manure decomposition on potato tuber-seeds and their roots.

2.1.4. Bio-fertilization

Azotobacter chroococcum and Azospirillum brasilense were combined to create products that fix nitrogen. Bacillus megaterium and Bacillus circulans strains were substituted with bacteria that released potassium and dissolved phosphate, respectively. The Microbiology Department of Minia University in Egypt's Faculty of Agriculture generously provided all of the bio fertilizers. Using liquid cultures, all bio fertilizers were applied to the soil's surface at a rate of 5 L/fed in two equal doses after 15 and 40 days from the planting date. (1 ml has 10^8 cells).

2.1.5. Mineral fertilization

According to the Egyptian Ministry of Agriculture and Soil Reclamation (EMASL), 100% NPK as control treatments for potatoes were applied as control, additionally, the three treatments—50%, 75%, and 100%— from the advised dosages for potato crop were computed and applied in amounts of 448, 387, and 200 kg for ammonium nitrate (150 kg N/fed), 60 kg P2O5/fed (for calcium super phosphate; 15.5% P2O5), and 96 kg K2O/fed (for potassium sulphate; 48% K2O). P was fully incorporated into the soil before to seeding, but N and K were supplied in two equal dosages, one after 30 days and the other after 20 days.

2.1.6. Potato plantation

In this investigation, potato tubers (cv. Cara) were utilized. For both seasons, tubers were planted on the 10th and 19th of October 2019 and 2020, respectively, 20 cm apart from one another and on the ridge side. irrigated every 5-7 days ensured that the soil's moisture level remained at field capacity throughout the trial. All additional agricultural procedures for the potato crop were carried out as advised by (EMASL).

2.1.7. Experimental procedures

Five plant samples were randomly selected from each plot after 70 days following seeding and transported right away to the lab. The amounts of chlorophyll (a, b, and total mg/g dry weight F.W.) were measured. Additionally, 100 g samples of plants and tubers from every treatment duplicate were oven dried at 70 °C until consistent weight was achieved. The dried components were then completely powdered and kept for chemical N, P, and K% analyses.

2.2.3. Statistical analysis

The least significant difference (L.S.D.) approach was utilized to examine differences between mean values in accordance with the procedures outlined by Gomez and Gomez (1984). All data were statistically evaluated using the analysis of variance (ANOVA) by Version II of CoSTAT computer software.

RESULTS AND DISCUSSION

3.1. Specific gravity/tubers:

Data in table 2 demonstrated how different combinations of organic manure and bio-fertilization under mineral fertilization influenced the specific gravity of potato tubers when compared to 100% NPK from the prescribed dose over both seasons of the study. Data revealed that the specific gravity of potato tubers was strongly impacted by the addition of organic manure and bio-fertilization, whether in a combined form or separately. Plants treated with FYM + PM + Biofert realized the highest mean values of this attribute in the two seasons (1.085 & 1.093, respectively). Table (2) results on the effects of various NPK fertilization rates showed that, in comparison to the control treatment, the application of NPK fertilization considerably enhanced the mean values of potato tuber specific gravity. In other words, 100% NPK fertilization produced the greatest values (1.077 & 1.087, respectively) in both seasons, while the control treatment produced the lowest values (1.053 & 1.058) for this feature. The impact of interaction between organic manure, bio-fertilizers and mineral fertilization comparing with full dose of NPK-fertilizer are presented in table 2. All treatment significantly increased specific gravity. In this respect the highest values were observed with plants fertilized with FYM + PM + Biofert plus 100% NPK (1.099 and 1.107) comparing with 100% NPK alone (1.078 & 1.085), respectively in the two seasons.

3.2. Dry matter %

Impact of different forms of organic manure, bi-fertilizers, and mineral fertilization as well as their interactions on the percentage of tuber content of dry matter during both seasons of the experiments as presented in table 2 observed that a stimulation impact was happened on the mean values of the tuber dry matter % due to an application of the studied forms of organic manures and bio-fertilizers in single forms or combined. Such impact was more pronounced for plants fertilized with FYM + PM + Biofert, which recorded the highest values of dry matter % in both seasons of the experiments as compared to the other organic manures or bio-fertilizers forms. The effects of mineral fertilization at various NPK rates are shown in table 3. At all rates, the mean values of dry matter % in potato tubers considerably increased as compared to the untreated plants. In other words, in the two seasons, the plants treated with NPK fertilization at a rate of 100% had the highest values measured (21.58 & 20.98%) in comparison to the other treatments. Table 3 compares the mean values of dry matter% as influenced by the combination of various sources of organic manures and bio-fertilization, either alone or in combination with mineral fertilization at various rates under consideration. Data clearly shown that the combination of FYM + PM as organic manures together with the biofertilization of Biofert under all rates of mineral fertilization as soil application stimulated the average values of dry matter% in potato tubers more than plants treated with 100% NPK alone. The most desirable treatment, which resulted in the highest mean values of dry matter % of tubers related to plants treated with FYM + PM + Biofert with 100% NPK as (24.14 & 25.27%), while the values associated with lowest 100% NPK alone was (18.24 & 22.08%), while the lowest values were recorded with Biopotass (19.75 & 16.27), respectively in the two seasons.

Because organic manure not only boosted crop output by providing all the necessary plant nutrients, but also organic matter to the soil, all yield metrics and their constituents may have grown as a result of using organic manure. Additionally, it promoted cell growth, cell division, and increased photosynthetic activity for greater output. Any soil's structure, texture, aeration, humus, buffer effect, capacity to store water and conduct cations, and microbial activity are all improved by organic manures, which helps to maintain and boost soil productivity. This agreed with the results of Asghari and Fard (2015) on potato plant indicated that using the treatment of 40 t/ha of FYM was significantly increased the total dry weight, average tuber weight and average yield. Furthermore, study by Monroy et.al. (2019) showed that utilizing 4 t ha-1 of chicken manure, generated the maximum tuber yields of cv. Rosita (24.38 t ha-1) and Gata (23.85 t ha-1), and more stems and larger tuber weights, fresh foliage, and tuber production.

As for the impact of bio-fertilizers found that addition of N-fixing bacteria was more superiority increasing yield and its components. Utilizing bio-fertilizers like *Azotobacter* and *Azospirillium* has the potential to increase yield and its constituent parts by supporting vegetative growth in the potato plant and increasing leaf area, which improves photosynthetic rate and leads to increased carbohydrate formation and translocation to the tuber as described by (AbdEl-Nabi et.al.2016) on potato. The results of this study with the results are consistent of Singh et.al.

(2017) revealed that the biofertilizers have stimulatory impact on yield parameter of potato, the utilization of bio-fertilizer as seed treatment and foliar application recorded the maximum number of large size tubers (5) and yield (844.85 gm). In addition, Baddour and Sakara (2020) reported that a positive impact was noticed due to the addition of Azotobacter inoculation and recorded the highest mean values of No. of tubers per plant, average tuber weight/ g, fresh weight of potato tubers (g plant^{-1}), and dry matter of tubers (%) as well as total yield; (Mg fed^{-1}) comparing with the un-inoculated plants.

The availability and solubility of the minerals, which make them easily absorbed by plants, may be the cause of the increase in potato production brought on by mineral fertilization (NPK). Additionally, the addition of NPK to the soil increases the amount of nutrients that are available in the rooting zone and increases the capacity of plant roots to absorb additional nutrients into plant tissues. These results support those of Irungbam et.al. (2018) who indicated that the better yield parameters were dry weight of the tuber, tuber bulking rate, number of tubers per hill, and maximum tuber yield. Statistically, these parameters were statistically comparable to those of integrated nutrient management, which received 50% RDF + 50% N as farmyard manure and had a tuber yield of 21.72 t ha^{-1}.

3.3. Chemical composition of potato leaves and tubers

3.31. Total chlorophyll b mg/ g-1

Data presented in table 4, showed the average values of total chlorophyll as affected by different sources of organic manures, bio-fertilizer in solo forms or combined and rates of mineral fertilization as well as their interactions comparing with the full dose of NPK fertilization during the two seasons. From data in table 4, it can be concluded that the application of organic manures, i.e., FYM and PM in single forms or combined with bio-fertilizers, i.e., Biofert, biophoss and biopotass had significant impacts on total chlorophyll of potato leaves. Moreover, within the different organic manures and bio-fertilizer the best total chlorophyll was obtained by potato plants received FYM+PM+Biofert followed in a descending order by that supplied with FYM+PM+Biophoss and lately those fertilized with FYM+PM+Biopotass comparing with the single forms from organic manures and bio-fertilizer. The data were statistically analyzed, and the results showed that there were significant differences between the organic treatments at the 5% level.

Table 3 resulted the effects of mineral fertilization showed that applying varied amounts of NPK to potato plants resulted in considerably higher mean values of total chlorophyll than those obtained for the untreated ones. In addition, When it came to raising the mean values of total chlorophyll in potato plants, 100% NPK treatment performed better than 75%, 50%, and untreated plants. Table 3 data showed that the highest values of total chlorophyll (1.434 & 1.534 mg/g dry weight), respectively, in two seasons were recorded with plants treated with FYM + PM + Biofert and 100% NPK fertilization. This was in regards to the impact of the combination among the sources of organic manures, bio-fertilizers, and the different rates of mineral fertilization compared with the full dose of 100% NPK fertilization. In addition, plants given the full dose of NPK produced, in the two seasons, 1.268 & 1.397 mg/g dry weight, respectively.

The fact that nitrogen is a component of the chlorophyll molecule and is the primary component of all amino acids in protein and lipids, which act as a structural component of chloroplasts, may be the cause of the promotion impact of organic manures treatments on chlorophyll contents due to the addition of FYM + PM (Arisha and Bradisi, 1999). The similar results was reported by Baddour (2014), who discovered that the addition of various sources of organic manures led to a considerable increase in chlorophyll (a, b, and total chlorophyll). According to AbdEl-Nabi et al. (2016), combination between FYM and compost (15 tons fed-1) had a substantial impact on the chlorophyll content of potato plant leaves after 70 days.

The function of nitrogen in promoting the growth of potato plants with accessible N and the role of nitrogen in growing the leaf area, which enhances the photosynthetic rate, might be linked to the enhancing influence of employing the biofertilizer such as *Azotobacter* and *Azosbrilum* in increment of chlorophyll. Bio-fertilizers enhanced the content of photosynthetic pigments, according to conflicting evidence on the link between growth and chlorophyll content of leaves (Malgorzata and Georgios, 2008). The result agreed with Baddour (2014), *Azotobacter chroccoccum*, *Bacillus megatherium*, and *Bacillus circulans* supplied the greatest values for chlorophyll (a, b, & a+b mg g^{-1} F.W) as compared to the un-inoculated plants before seeding with the mixture of biofertilizers. Additionally, according to AbdEl-Nabi et al. (2016), spraying plants with a mixture of bio-fertilizers (*Azotobacter chroccoccum*, *Bacillus megatherium*, and *Bacillus circulans* (2 ml/L.) followed by EM (2 ml/plant) resulted in the highest significant values of chlorophyll content in potato plant leaves after 70 days. Baddour and Sakara (2020) resulted that compared to un-inoculated plants, Azotobacter sp. addition enhanced chlorophyll concentration. Mineral application's positive effects on chlorophyll content can be linked to either the mineral's important function in the production of chlorophyll pigment or the presence of the chlorophyll molecule in plant tissues. These findings are corresponding to those reported by AbdEl-Nabi et.al. (2016) on potato plants found that application of NPK fertilization had a substantial impact on the chlorophyll content of potato plant leaves after 70 days, and it increased with increasing NPK from 50% to 75% of the required dose during two subsequent seasons.

3.4. Nitrogen percentage in leaves

Table 5 shows the nitrogen percentage of potato levels at 70 days after planting as influenced by different sources of organic manures and bio-fertilizers under mineral fertilization during two growth seasons. Table 4's data were statistically analyzed to reveal that among the organic manures and bio-fertilizers investigated, FYM + PM with Biofert was best for recording the highest nitrogen percentage values, followed by FYM + PM + Biophos, and finally FYM + PM + Biopotass when compared to the single forms. For instance, during the 2019–2020 and 2020–2021 growing seasons, the average values for the treatments of FYM + PM with Biofert, Biophos, and Biopotass were 2.31, 2.23, and 2.16 percent, respectively. Comparing with the other treatment, the average value of N% for the plants treated with any of the studied organic manures or bio-fertilizers in single forms were less than those obtained from the combination. Concerning the impact of mineral fertilization on the mean values of N% of potato leaves, data of table 5 showed a significant increase in parameter of this study for plants treated with any rates over that obtained from the untreated plants. In this respect, the highest values (2.47 & 2.53%) were obtained from the treatment of 100% NPK, while the lowest one (1.50 & 1.67%) were recorded for the untreated plants in both seasons.

Table 4 displays the interactions between mineral fertilization, bio-fertilization, and organic manures. Results showed that, when compared to the full dosage of NPK fertilization, the treatment that produced the greatest values of N% of plants treated with FYM + PM + Biofert under 100% NPK was the most effective.

3.4. Phosphorus percentage in leaves

Data illustrated in table 6, showed the impact of organic manures, bio-fertilizer, and mineral fertilization as well as their interactions on P% of potato leaves comparing with the full dose of NPK fertilization during 2019-2020 and 2020-2021 seasons. Data in table 5, also detected that the potato plants fertilized with different sources of organic manures and bio-fertilizers in a single way or combined had a pronounced positive impact on the mean values of P%. The highest value of mentioned trait was observed with plants treated with FYM + PM + Biophos comparing with the other treatments. The same trend was the same during both seasons. Regarding the investigation's focus on the effects of mineral fertilization, data from the same table showed that increasing the rate of NPK fertilization led to an increase in P% over both seasons. Data in this regard showed that, as compared to untreated plants, the greatest results were obtained with 100% of NPK. Data in table 5 makes it evident that inoculating potato plants with the mixture of microorganisms together with various organic manures at varied rates of mineral fertilization resulted in higher P% values than those obtained for the control (100% NPK). The treatments using FYM + PM + Biophos and 100% NPK produced the greatest mean values, however it was discovered that the identical treatments using 75% NPK looked to be quite close to the control treatment in the two seasons.

3.5. Potassium percentage in leaves

The comparison of the average values of K concentrations in the leaves of potato plants 70 days after planting revealed notable variations between the various combination treatments using organic manures, biofertilization, and mineral fertilization, as indicated in table 7. Data in the same table, the effects of organic manures and bio-fertilizers showed that when applied together, they considerably raised the mean values of K (%) in potato leaves when compared to the solitary forms. In other words, the FYM + PM + Biopotass treatment yielded the greatest values (2.63 & 3.39%), respectively, over both seasons, whereas plants treated with biophoss alone yielded the lowest values (1.89 & 2.04%) for this feature. As seen in table 6, it can be seen that applying the researched mineral fertilizer had a stimulating effect on the mean values of the characteristic when compared to untreated plants. Table 7 shows the various comparisons between the mean values of K (%) as influenced by the mixture of organic manure and the mixture of multi-strain inoculants under mineral fertilization. Data clearly showed that that inoculating potato tubers with Biopotass in conjunction with organic manure (FYM + PM) had a stimulating effect on the average values of K%. Additionally, the treatment of FYM + PM + Biopotass had the highest mean values (3.35 & 3.61%). Both seasons showed the same pattern.

3.6. NO3-N ppm in potato tubers

NO_3-N content of potato tubers as affected by the treatments under investigations are presented in table 8 during both seasons. Results showed that adding of organic manures and bio-fertilizers in single forms or combined significantly affected the mean values of NO_3-N content. In this respect, all traits under investigation found sharply and significantly decreases in the mean values of NO_3-N in potato tubers due to the addition of various organic manures and bio-fertilizers. The lowest values were recorded with the treatment of Biofert alone as (42.64 & 44.55 ppm) comparing with the other treatments. With respect to the impact of mineral fertilization studied on NO_3-N content in potato tubers, a stimulation impact was observed in the mean values of NO_3-N content of potato tubers, whereas the mean values of NO_3-N tended to increase with increasing the rate of mineral fertilization up to 100% NPK than those obtained from the untreated plants. The highest values realized with plants treated with 100% NPK in both seasons.

The average levels of nitrate accumulation in potato tubers as influenced by combinations of the various treatments under consideration were revealed by statistical analysis of the data in table 8. It could be concluded that a positive impact was observed in the mean values under study due to using the combination between the studied parameters. In this respect, with increasing rates of mineral fertilization found an increase in nitrate accumulation, but with addition of organic manures or bio-fertilization this accumulation decreased comparing with the highest values of nitrate accumulation, which was recorded with the full dose of mineral fertilization alone (100% NPK). This trend was true for both seasons of the experiment.

3.7. NO_2-N ppm in potato tubers

The mean values of NO_2-N content of potato tubers as influenced by organic manures, bio-fertilizers, and mineral fertilization as well as their interactions are presented in table 8 during 2019-2020 and 2020-2021 growing seasons. Regarding the impact of organic manures and bio-fertilizers sources in single forms or combined data in table 8 indicated that NO_2-N content of potato tubers was significantly affected by the addition of treatments. All treatments of organic manures and bio-fertilizer decreased the accumulation of NO_2-N in potato tubers; single application of Biofert significantly recorded the lowest values. Data in table 9, also indicated that an addition of mineral fertilization significantly increased the mean values of NO_2-N content of potato tubers than those obtained from the untreated plants. In this respect, the increase in accumulation of nitrite was obtained from the addition of 100% NPK followed by 75% and lately 50% comparing with the untreated plants. The same trend was obtained in the seasons.

Data presented in table 9 showed that single forms of organic manures or bio-fertilizer in the presence of the combination treatments between them significantly decreased the mean values of NO_2-N accumulation. On the contrary, application of the mineral fertilization increased the accumulation of nitrite. Generally, the best treatment which gave the lowest value of nitrite (0.70 & 0.98 ppm) was related to the treatment of Biopotass alone. Comparing with the full dose of the recommended dose (100% NPK), which gave the highest values of NO_2-N accumulation.

3.8. Starch % in potato tubers

Data presented in table 10 showed the concentration of starch in potato tubers as affected by the investigated organic manures, bio fertilizer in a single way and the mixtures under mineral fertilization as well as their interactions comparing with full dose of NPK fertilization during both seasons of the experiments. Such data of table 9 reflected higher values of starch % in potato tubers due to an addition of different organic manures sources and bio-fertilizers. In this respect, the highest mean values for potato tubers related to the FYM + PM + Biofrt, while the lowest values were obtained from the treatment of Biopotass alone. The data also showed that applying any level of mineral fertilization to potato plants significantly increased the average values of the aforementioned trait compared to the values obtained from the control treatment. The impact of this was greatest for plants applied with 100% NPK, followed by 75%, and then 50%. For the treatments of 50, 75, and 100% NPK over the 2019-2020 and 2020-2021 seasons, the rates of growth in the content of starch were (6.13, 6.29, and 14.63%), respectively.

The data in table 10 clearly showed that inoculating potato plants with a combination of the investigated microorganisms along with the different organic manures investigated at various rates of mineral fertilization resulted in higher starch% values than those obtained for the control treatment (100% NPK). Comparing the treatment with FYM + PM + Biofert and 100% NPK to the control therapy (100% NPK), the greatest mean values were found. Both seasons revealed the same pattern. In addition to N, P, and K additions, adding organic manure makes nutrients available in an available form to facilitate absorption of these nutrients in the soil that produces humus substances and improves the physical and chemical properties of the soil, increasing the availability of nutrients. Additionally, adding organic materials to soils can boost NPK availability by increasing the amount of CO2 that forms H2CO3 in the soil solution. This boosts yield and its constituents, such as tuber weight and diameters, which are reflected in quality parameters. The use of organic sources promoted the development and activity of advantageous microorganisms in the soil, assisted in reducing the occurrence of micronutrients, and might support high crop yield and soil health. Foods cultivated organically are thought to be higher quality, healthier, and more nutrient-rich than their conventional counterparts. These results are confirmed with those of Abd El-Nabi et.al. (2016) cleared that the addition of FYM (20 tons fed-1) and compost (15 tons fed-1) had a substantial impact on the reductions in nitrite (NO_2-N) and nitrate (NO_3-N). Also, Salem (2019) demonstrated that all compost treatments with potatoes (Lady Rosetta cultivar) yielded the greatest dry matter, starch, and carbohydrate contents in tubers. On other hand, all mineral N treatments with potato (Lady Balfour cultivar) give the highest nitrate content in tubers. The use of Azotobacter and Azosbrillum bacteria as an inoculum with a variety of beneficial properties that promote plant growth, including their capacity to stabilize nitrogen and then increase the plant concentration of nitrogen, can also be credited for the increase in N% and all other treatments. Additionally, increase the nutrient content and quality parameters due to the fact that the local bio-fertilizer's components' capacity to boost soil element uptake is correlated with their capacity to secrete certain plant hormones, such as auxins, gibberellins, and cytokines. These hormones play a crucial role in increasing the surface area of the roots by lengthening the main roots and their branches, which boosts nutrient absorption. Additionally, the findings of this study demonstrated that, under mineral fertilization (control), the majority of soil nitrogen was in the form of nitrate, and plants could absorb large amounts of nitrogen due to their capacity for assimilation. The results also suggested that the difference between N-absorption and assimilation could be significant, and that the utilized nitrogen would be stored as nitrate in potato tissues. The beneficial effect of the combination of microorganisms on reducing the rate of nitrate accumulation in the tissues of potato tubers to be less than the permissible limits weakly intake (15.5mg.kg-1 of body weight for NO3-N) that were provided by Who (1999) may be attributed to the role played by these substances in pertinent to the enzymatic system responsible for biosynthesis of amino acids, protein, and the other N-compounds and subsequently reduce the nitrate. This result is consistent with the results of Amany et.al. (2013) who studied influence of biofertilizers (consisting of *Bacillus megatherium* + *Bacillus cerculium* + *Azotobacter*+*Bacillus sitlus*) and compost forms and rates, and their findings showed that, as compared to mineral fertilization, combining bio-fertilizers combined bacillus with animal or plant compost reduced the high levels of NO_2 and NO_3 and improved potato tuber quality. Additionally, their findings demonstrated that employing animal compost considerably raised the amounts of nitrogen, phosphate, and potassium in leaves and tubers. Baddour and Sakara (2020) reported that with the exception of NO3-N contents, which were decreased, Azotobacter sp. inoculation had an impact on N, P, K, and Fe contents in potato plant leaves and tubers. It also sharply and significantly increased total carbohydrates, starch (%), and vitamin C (mg 100g-1) in potato tubers.

Due to its potential for absorption, the majority of soil nitrogen produced by mineral fertilizer will take the form of nitrate and be readily accessible to plants in large quantities. As a nutrient, phosphorus is crucial for boosting root system development and increasing roots' ability to absorb additional nutrients. While the role of K in nutrient uptake and nutritional balance may be due to increasing photosynthesis, K2SO4 in the soil also attributed to the role of S, which played a part in lowering the values of soil pH and subsequently made it easier for the roots of potato plants to absorb nutrients, which is reflected in the quality of potato tubers. These results are in a good agreement with those obtained by Abd El-Nabi et.al. (2016) on potato plant who found that Application of NPK fertilization had a substantial impact on nitrite (NO_2-N) and nitrate (NO_3-N), which rose when NPK was raised from 50% to 75% of the recommended amount. However, Bošković-Rakočević et.al. (2018) reported that the concentrations of determined nutrients in potato tubers were the highest at the highest NPK fertilizer rates. Data obtained in this study are very promising and highly valuable to produce high yield of potato tubers with the best qualities free from undesirable concentrations of NPK, Nitrate and nitrite (as safe products) which are very suitable for foreign markets.

CONCLUSION

Inoculating potato tubers with Biofert (as N-fixation) of microorganisms in the presence of organic manures (as FYM + PM) under investigation produced the highest values of all study parameters, and this impact was more pronounced for the treatment of FYM + PM+Biofert, according to the same conditions of this investigation. The greater increase in its content of soluble nutritional components than that found for organic manures or biofertilization was the superiority effect of mineral fertilization. This impact was reflected on increasing the yield and quality parameters of potato tubers.

Thus, it could be suggested that inoculating potato tubers with biofert as N-fixation combined with compost FYM+PM be used as the most effective treatment for achieving the highest safe and economical yield of potato tubers under mineral fertilization (100% NPK), which is approximately 75% from NPK. In this study, safe and clean products of potato tubers were obtained which is good for local markets and for exportation to foreign markets as well.

Table 1: Chemical analysis of the organic manures used

Organic manure properties	FYM	PM
pH 1:5	6.59	6.08
EC (1:10)(dSm^{-1})	4.13	3.75
Organic matter (%)	43.25	51.12
Organic carbon (%)	25.15	29.72
Total nitrogen (%)	1.30	2.04
C/N ratio	19.3	14.6
Total Phosphorus (%)	0.43	0.55
Total Potassium (%)	0.59	0.88
SP%	95.2	99.6

Table (2). Effect of organic manures (FYM and pigeon) plus bio-fertilization (Nitrogen fixing, phosphate dissolving bacteria and potassium releasing bacteria) on specific gravity of potato tuber cv. " Cara " in the two winter seasons of 2019-2020 and 2020-2021.

Treatments	Specific gravity					
	2019-2020					
NPK100%	**1.078**					
A / B	**Zero**	**50%NPK**	**75%NPK**	**100%NPK**	**Mean for B**	**LSD at 5% for B**
FYM	1.036	1.050	1.056	1.060	**1.051**	**0.002**
PM	1.042	1.067	1.075	1.090	**1.069**	
FYM+PM	1.048	1.072	1.084	1.093	**1.074**	
Bofert	1.053	1.072	1.081	1.088	**1.073**	
Biopotass	1.035	1.043	1.039	1.053	**1.043**	
Biophos	1.046	1.069	1.076	1.084	**1.069**	
FYM+Biofert	1.048	1.050	1.050	1.065	**1.053**	
FYM+Biopotass	1.044	1.057	1.060	1.063	**1.056**	
FYM+Biophos	1.043	1.045	1.045	1.057	**1.048**	
PM+Biofert	1.066	1.065	1.067	1.081	**1.069**	
PM+Biopotass	1.055	1.053	1.058	1.068	**1.059**	
PM+Biophos	1.062	1.060	1.060	1.077	**1.065**	
FYM+PM+Biofert	1.079	1.079	1.084	1.099	**1.085**	
FYM+PM+Biopotass	1.071	1.069	1.073	1.088	**1.075**	
FYM+PM+Biophos	1.074	1.075	1.076	1.092	**1.079**	
Mean for A	**1.053**	**1.062**	**1.066**	**1.077**		
LSD at 5% for A	**0.001**					
LSD for A*B	**0.004**					
	2020-2021					
NPK100%	**1.085**					
A / B	**Zero**	**50%NPK**	**75%NPK**	**100%NPK**	**Mean for B**	**LSD at 5% for B**
FYM	1.044	1.047	1.061	1.064	**1.054**	**0.002**
PM	1.048	1.051	1.063	1.071	**1.058**	
FYM+PM	1.052	1.053	1.066	1.074	**1.061**	
Bofert	1.041	1.043	1.058	1.061	**1.051**	
Biopotass	1.032	1.034	1.049	1.051	**1.042**	
Biophos	1.036	1.040	1.053	1.055	**1.046**	
FYM+Biofert	1.060	1.063	1.073	1.088	**1.071**	
FYM+Biopotass	1.056	1.059	1.070	1.078	**1.066**	
FYM+Biophos	1.057	1.061	1.073	1.083	**1.069**	
PM+Biofert	1.072	1.075	1.085	1.098	**1.083**	
PM+Biopotass	1.065	1.069	1.078	1.090	**1.076**	
PM+Biophos	1.064	1.073	1.083	1.090	**1.078**	
FYM+PM+Biofert	1.085	1.086	1.093	1.107	**1.093**	
FYM+PM+Biopotass	1.076	1.078	1.088	1.100	**1.086**	
FYM+PM+Biophos	1.080	1.083	1.092	1.105	**1.090**	
Mean for A	**1.058**	**1.061**	**1.072**	**1.081**		
LSD at 5% for A	**0.001**					
LSD for A*B	**0.005**					

Table (3). Effect of organic manures (FYM and pigeon) plus bio-fertilization (Nitrogen fixing, Phosphate dissolving bacteria and potassium releasing bacteria) on dry matter% of potato tuber cv. " Cara " in the two winter seasons of 2019-2020 and 2020-2021.

Treatments	Dry matter %					
	2019-2020					
NPK100%	18.24					
A / B	Zero	50%NPK	75%NPK	100%NPK	Mean for B	LSD at 5% for B
FYM	15.23	17.14	18.11	19.84	17.58	
PM	14.75	16.76	17.64	22.66	17.95	
FYM+PM	15.83	17.71	18.63	22.20	18.59	
Bofert	14.05	16.36	17.22	20.88	17.13	
Biopotass	12.85	15.44	16.08	19.75	16.03	
Biophos	13.55	15.84	16.71	20.35	16.61	
FYM+Biofert	16.45	19.43	20.62	21.87	19.59	
FYM+Biopotass	15.14	16.73	17.65	18.25	16.94	0.79
FYM+Biophos	15.88	18.76	19.85	21.16	18.91	
PM+Biofert	18.07	20.33	21.24	22.57	20.55	
PM+Biopotass	18.34	19.34	20.06	21.44	19.80	
PM+Biophos	17.65	18.86	19.34	22.04	19.47	
FYM+PM+Biofert	18.35	20.84	21.66	24.14	21.25	
FYM+PM+Biopotass	17.15	18.34	19.14	23.05	19.42	
FYM+PM+Biophos	17.65	18.75	19.65	23.47	19.88	
Mean for A	16.06	18.04	18.91	21.58		
LSD at 5% for A	0.45					
LSD for A*B	1.60					
	2020-2021					
NPK100%	22.08					
A / B	Zero	50%NPK	75%NPK	100%NPK	Mean for B	LSD at 5% for B
FYM	12.59	15.09	17.22	17.72	15.66	
PM	12.60	15.26	17.34	17.84	15.76	
FYM+PM	12.93	15.42	17.51	18.27	16.03	
Bofert	12.29	13.57	16.22	16.96	14.76	
Biopotass	11.81	13.10	15.73	16.57	14.30	
Biophos	12.15	13.35	16.08	16.77	14.59	
FYM+Biofert	14.60	19.34	21.60	22.94	19.62	
FYM+Biopotass	13.64	18.44	20.45	21.92	18.61	0.61
FYM+Biophos	14.23	18.91	21.08	22.45	19.17	
PM+Biofert	14.78	19.59	21.77	23.18	19.83	
PM+Biopotass	13.96	18.66	20.72	22.30	18.91	
PM+Biophos	14.42	19.20	21.35	22.75	19.43	
FYM+PM+Biofert	20.25	23.86	24.54	25.27	23.48	
FYM+PM+Biopotass	19.77	23.42	24.20	24.79	23.05	
FYM+PM+Biophos	20.09	23.54	24.30	24.92	23.21	
Mean for A	14.67	18.05	20.01	20.98		
LSD at 5% for A	0.29					
LSD for A*B	1.22					

Table (4). Effect of organic manures (FYM and pigeon) plus bio-fertilization (Nitrogen fixing, Phosphate dissolving bacteria and potassium releasing bacteria) on total chlorophyll mg. g-1 of potato leaves cv. " Cara " in the two winter seasons of 2019-2020 and 2020-2021.

Treatments	Total chlorophyll mg/g FW					
	2019-2020					
NPK100%	1.268					
A B	Zero	50%NPK	75%NPK	100%NPK	Mean for B	LSD at 5% for B
FYM	1.109	1.187	1.211	1.234	**1.186**	
PM	1.139	1.256	1.301	1.345	**1.260**	
FYM+PM	1.162	1.281	1.319	1.368	**1.283**	
Bofert	1.094	1.203	1.247	1.299	**1.210**	
Biopotass	1.051	1.116	1.135	1.160	**1.115**	
Biophos	1.072	1.182	1.224	1.273	**1.188**	
FYM+Biofert	1.067	1.152	1.227	1.322	**1.192**	
FYM+Biopotass	1.042	1.126	1.196	1.283	**1.162**	**0.004**
FYM+Biophos	1.054	1.138	1.205	1.302	**1.175**	
PM+Biofert	1.111	1.198	1.275	1.378	**1.241**	
PM+Biopotass	1.089	1.168	1.243	1.311	**1.203**	
PM+Biophos	1.099	1.181	1.258	1.359	**1.224**	
FYM+PM+Biofert	1.149	1.241	1.322	1.434	**1.287**	
FYM+PM+Biopotass	1.123	1.212	1.280	1.398	**1.253**	
FYM+PM+Biophos	1.136	1.226	1.307	1.415	**1.271**	
Mean for A	**1.100**	**1.191**	**1.250**	**1.325**		
LSD at 5% for A	**0.002**					
LSD for A*B	**0.008**					
	2020-2021					
NPK100%	1.397					
A B	Zero	50%NPK	75%NPK	100%NPK	Mean for B	LSD at 5% for B
FYM	1.128	1.210	1.271	1.294	**1.226**	
PM	1.131	1.218	1.284	1.303	**1.234**	
FYM+PM	1.141	1.225	1.291	1.312	**1.242**	
Bofert	1.120	1.160	1.247	1.269	**1.199**	
Biopotass	1.105	1.147	1.231	1.254	**1.184**	
Biophos	1.113	1.153	1.241	1.262	**1.192**	
FYM+Biofert	1.196	1.346	1.414	1.457	**1.353**	
FYM+Biopotass	1.165	1.318	1.383	1.426	**1.323**	**0.004**
FYM+Biophos	1.180	1.332	1.399	1.443	**1.339**	
PM+Biofert	1.201	1.354	1.420	1.464	**1.360**	
PM+Biopotass	1.174	1.324	1.390	1.436	**1.331**	
PM+Biophos	1.188	1.340	1.406	1.452	**1.347**	
FYM+PM+Biofert	1.374	1.483	1.516	1.534	**1.477**	
FYM+PM+Biopotass	1.360	1.471	1.498	1.523	**1.463**	
FYM+PM+Biophos	1.367	1.477	1.506	1.529	**1.470**	
Mean for A	**1.192**	**1.301**	**1.353**	**1.397**		
LSD at 5% for A	**0.002**					
LSD for A*B	**0.007**					

Table (5). Effect of organic manures (FYM and pigeon) plus bio-fertilization (Nitrogen fixing, Phosphate dissolving bacteria and potassium releasing bacteria) on N% of potato leaves cv. " Cara " in the two winter seasons of 2019-2020 and 2020-2021.

Treatments	N%					
	2019-2020					
NPK100%	**2.19**					
A / B	**Zero**	**50%NPK**	**75%NPK**	**100%NPK**	**Mean for B**	**LSD at 5% for B**
FYM	1.48	1.85	1.98	2.07	**1.85**	
PM	1.60	2.20	2.35	2.66	**2.20**	
FYM+PM	1.73	2.23	2.50	2.81	**2.32**	
Bofert	1.55	2.15	2.40	2.64	**2.18**	
Biopotass	1.31	1.66	1.80	1.91	**1.67**	
Biophos	1.43	2.03	2.27	2.53	**2.06**	
FYM+Biofert	1.36	1.71	2.03	2.33	**1.86**	
FYM+Biopotass	1.25	1.56	1.87	2.14	**1.70**	**0.02**
FYM+Biophos	1.31	1.64	1.95	2.23	**1.78**	
PM+Biofert	1.55	1.92	2.26	2.59	**2.08**	
PM+Biopotass	1.43	1.78	2.11	2.42	**1.93**	
PM+Biophos	1.48	1.85	2.19	2.50	**2.00**	
FYM+PM+Biofert	1.73	2.13	2.51	2.86	**2.31**	
FYM+PM+Biopotass	1.60	1.99	2.35	2.68	**2.16**	
FYM+PM+Biophos	1.66	2.06	2.43	2.77	**2.23**	
Mean for A	**1.50**	**1.92**	**2.20**	**2.47**		
LSD at 5% for A			**0.01**			
LSD for A*B			**0.04**			
	2020-2021					
NPK100%	**2.83**					
A / B	**Zero**	**50%NPK**	**75%NPK**	**100%NPK**	**Mean for B**	**LSD at 5% for B**
FYM	1.33	1.75	2.04	2.12	**1.81**	
PM	1.38	1.78	2.06	2.17	**1.85**	
FYM+PM	1.42	1.82	2.10	2.19	**1.88**	
Biofert	1.31	1.52	1.93	2.00	**1.69**	
Biopotass	1.22	1.45	1.85	1.93	**1.61**	
Biophos	1.28	1.47	1.86	1.96	**1.64**	
FYM+Biofert	1.68	2.34	2.61	2.77	**2.35**	
FYM+Biopotass	1.55	2.22	2.52	2.66	**2.24**	**0.02**
FYM+Biophos	1.62	2.29	2.56	2.71	**2.29**	
PM+Biofert	1.73	2.40	2.63	2.81	**2.39**	
PM+Biopotass	1.58	2.26	2.54	2.69	**2.27**	
PM+Biophos	1.65	2.33	2.58	2.73	**2.32**	
FYM+PM+Biofert	2.48	2.91	3.02	3.12	**2.88**	
FYM+PM+Biopotass	2.43	2.84	2.95	3.05	**2.82**	
FYM+PM+Biophos	2.44	2.89	2.98	3.09	**2.85**	
Mean for A	**1.67**	**2.15**	**2.42**	**2.53**		
LSD at 5% for A			**0.01**			
LSD for A*B			**0.05**			

Table (6). Effect of organic manures (FYM and pigeon) plus bio-fertilization (Nitrogen fixing, Phosphate dissolving bacteria and potassium releasing bacteria) on P% of potato leaves cv. " Cara " in the two winter seasons of 2019-2020 and 2020-2021.

Treatments	P%					
	2019-2020					
NPK100%	0.154					
A / B	Zero	50%NPK	75%NPK	100%NPK	Mean for B	LSD at 5% for B
FYM	0.135	0.164	0.174	0.185	**0.165**	
PM	0.147	0.193	0.216	0.234	**0.198**	
FYM+PM	0.157	0.206	0.226	0.244	**0.208**	
Bofert	0.128	0.175	0.193	0.212	**0.177**	
Biopotass	0.119	0.145	0.156	0.164	**0.146**	
Biophos	0.136	0.185	0.203	0.221	**0.187**	
FYM+Biofert	0.134	0.166	0.200	0.231	**0.183**	
FYM+Biopotass	0.128	0.159	0.191	0.221	**0.175**	**0.002**
FYM+Biophos	0.141	0.173	0.207	0.238	**0.190**	
PM+Biofert	0.153	0.187	0.224	0.257	**0.205**	
PM+Biopotass	0.146	0.180	0.215	0.248	**0.197**	
PM+Biophos	0.157	0.194	0.231	0.266	**0.212**	
FYM+PM+Biofert	0.170	0.208	0.247	0.284	**0.227**	
FYM+PM+Biopotass	0.164	0.202	0.238	0.274	**0.219**	
FYM+PM+Biophos	0.176	0.215	0.256	0.293	**0.235**	
Mean for A	**0.146**	**0.183**	**0.212**	**0.238**		
LSD at 5% for A	**0.001**					
LSD for A*B	**0.004**					
	2020-2021					
NPK100%	2.83					
A / B	Zero	50%NPK	75%NPK	100%NPK	Mean for B	LSD at 5% for B
FYM	0.163	0.207	0.234	0.244	**0.212**	
PM	0.164	0.209	0.237	0.246	**0.214**	
FYM+PM	0.168	0.212	0.241	0.250	**0.218**	
Bofert	0.159	0.183	0.222	0.232	**0.199**	
Biopotass	0.147	0.173	0.217	0.225	**0.190**	
Biophos	0.153	0.176	0.220	0.229	**0.195**	
FYM+Biofert	0.199	0.265	0.295	0.313	**0.268**	
FYM+Biopotass	0.185	0.253	0.281	0.301	**0.255**	**0.002**
FYM+Biophos	0.192	0.257	0.288	0.306	**0.261**	
PM+Biofert	0.204	0.270	0.298	0.314	**0.271**	
PM+Biopotass	0.187	0.256	0.285	0.304	**0.258**	
PM+Biophos	0.198	0.262	0.291	0.309	**0.265**	
FYM+PM+Biofert	0.278	0.325	0.337	0.348	**0.322**	
FYM+PM+Biopotass	0.273	0.319	0.331	0.343	**0.317**	
FYM+PM+Biophos	0.274	0.323	0.333	0.345	**0.319**	
Mean for A	**0.196**	**0.246**	**0.274**	**0.287**		
LSD at 5% for A	**0.001**					
LSD for A*B	**0.005**					

Table (7). Effect of organic manures (FYM and pigeon) plus bio-fertilization (Nitrogen fixing, Phosphate dissolving bacteria and potassium releasing bacteria) on K% of potato leaves cv. " Cara " in the two winter seasons of 2019-2020 and 2020-2021.NO3-N ppm in potato tubers:

Treatments	K%					
	2019-2020					
NPK100%	**2.08**					
A / B	**Zero**	**50%NPK**	**75%NPK**	**100%NPK**	**Mean for B**	**LSD at 5% for B**
FYM	1.71	2.14	2.28	2.41	**2.14**	
PM	1.84	2.55	2.83	3.11	**2.58**	
FYM+PM	1.99	2.68	2.98	3.25	**2.73**	
Bofert	1.62	2.28	2.53	2.79	**2.31**	
Biopotass	1.74	2.39	2.66	2.92	**2.43**	
Biophos	1.49	1.91	2.02	2.15	**1.89**	
FYM+Biofert	1.61	2.01	2.26	2.60	**2.12**	
FYM+Biopotass	1.68	2.09	2.34	2.71	**2.20**	**0.02**
FYM+Biophos	1.54	1.83	2.17	2.48	**2.01**	
PM+Biofert	1.82	2.24	2.52	2.94	**2.38**	
PM+Biopotass	1.90	2.32	2.60	3.03	**2.46**	
PM+Biophos	1.75	2.17	2.43	2.82	**2.29**	
FYM+PM+Biofert	2.04	2.47	2.79	3.23	**2.63**	
FYM+PM+Biopotass	2.12	2.57	2.87	3.35	**2.73**	
FYM+PM+Biophos	1.98	2.41	2.70	3.14	**2.56**	
Mean for A	**1.79**	**2.27**	**2.53**	**2.86**		
LSD at 5% for A	**0.02**					
LSD for A*B	**0.04**					
	2020-2021					
NPK100%	**3.45**					
A / B	**Zero**	**50%NPK**	**75%NPK**	**100%NPK**	**Mean for B**	**LSD at 5% for B**
FYM	1.70	2.16	2.50	2.63	**2.25**	
PM	1.73	2.21	2.54	2.69	**2.29**	
FYM+PM	1.76	2.25	2.60	2.72	**2.33**	
Bofert	1.65	1.90	2.37	2.45	**2.09**	
Biopotass	1.51	1.80	2.30	2.41	**2.00**	
Biophos	1.59	1.84	2.32	2.42	**2.04**	
FYM+Biofert	2.07	2.87	3.14	3.30	**2.85**	
FYM+Biopotass	1.94	2.75	3.04	3.22	**2.74**	**0.03**
FYM+Biophos	2.00	2.80	3.09	3.26	**2.79**	
PM+Biofert	2.14	2.92	3.16	3.33	**2.89**	
PM+Biopotass	1.96	2.77	3.07	3.23	**2.76**	
PM+Biophos	2.07	2.85	3.13	3.27	**2.83**	
FYM+PM+Biofert	2.94	3.36	3.45	3.54	**3.32**	
FYM+PM+Biopotass	3.02	3.42	3.51	3.61	**3.39**	
FYM+PM+Biophos	2.98	3.39	3.47	3.57	**3.35**	
Mean for A	**2.07**	**2.62**	**2.91**	**3.04**		
LSD at 5% for A	**0.01**					
LSD for A*B	**0.06**					

Table (8). Effect of organic manures (FYM and pigeon) plus bio-fertilization (Nitrogen fixing, Phosphate dissolving bacteria and potassium releasing bacteria) on NO3-N ppm content of potato tubers cv. " Cara " in the two winter seasons of 2019-2020 and 2020-2021.

Treatments	NO_3-N ppm					
	2019-2020					
NPK100%	69.33					
A / B	Zero	50%NPK	75%NPK	100%NPK	Mean for B	LSD at 5% for B
FYM	43.13	46.80	50.90	54.63	**48.87**	
PM	41.73	45.27	49.60	55.73	**48.08**	
FYM+PM	44.20	48.27	52.17	53.23	**49.47**	
Bofert	36.70	40.67	44.53	48.67	**42.64**	
Biopotass	38.07	41.90	45.83	49.93	**43.93**	
Biophos	39.47	43.30	47.33	51.37	**45.37**	
FYM+Biofert	43.80	49.87	57.57	67.70	**54.73**	
FYM+Biopotass	41.30	47.10	54.60	64.90	**51.98**	**0.31**
FYM+Biophos	42.57	48.40	56.13	66.43	**53.38**	
PM+Biofert	40.03	45.87	53.10	63.27	**50.57**	
PM+Biopotass	37.63	43.17	50.40	60.13	**47.83**	
PM+Biophos	38.80	44.43	51.67	61.60	**49.13**	
FYM+PM+Biofert	36.37	41.87	48.93	58.73	**46.48**	
FYM+PM+Biopotass	33.80	39.20	47.23	55.50	**43.93**	
FYM+PM+Biophos	35.07	40.57	48.63	57.10	**45.34**	
Mean for A	**39.51**	**44.44**	**50.58**	**57.93**		
LSD at 5% for A			**0.24**			
LSD for A*B			**0.62**			
	2020-2021					
NPK100%	63.21					
A / B	Zero	50%NPK	75%NPK	100%NPK	Mean for B	LSD at 5% for B
FYM	42.81	47.87	54.19	62.77	**51.91**	
PM	41.80	47.21	53.10	61.70	**50.95**	
FYM+PM	41.21	46.31	52.13	60.39	**50.01**	
Bofert	36.40	42.59	46.47	52.75	**44.55**	
Biopotass	37.26	43.24	47.40	54.32	**45.55**	
Biophos	37.90	43.78	48.23	55.67	**46.40**	
FYM+Biofert	46.92	52.27	60.18	70.54	**57.48**	
FYM+Biopotass	45.43	50.81	58.15	67.73	**55.53**	**0.56**
FYM+Biophos	45.18	51.55	59.11	69.09	**56.23**	
PM+Biofert	44.77	49.96	56.98	66.30	**54.50**	
PM+Biopotass	43.35	48.53	55.26	63.70	**52.71**	
PM+Biophos	44.11	49.27	56.06	65.24	**53.67**	
FYM+PM+Biofert	40.39	45.63	51.36	58.81	**49.05**	
FYM+PM+Biopotass	38.79	44.22	49.34	57.09	**47.36**	
FYM+PM+Biophos	39.59	45.08	50.37	57.52	**48.14**	
Mean for A	**41.73**	**47.22**	**53.22**	**61.57**		
LSD at 5% for A			**0.20**			
LSD for A*B			**1.21**			

Table (9). Effect of organic manures (FYM and pigeon) plus bio-fertilization (Nitrogen fixing, Phosphate dissolving bacteria and potassium releasing bacteria) on NO2-N ppm content of potato tubers cv. " Cara " in the two winter seasons of 2019-2020 and 2020-2021.

Treatments	NO_2-N ppm					
	2019-2020					
NPK100%	1.86					
A B	Zero	50%NPK	75%NPK	100%NPK	Mean for B	LSD at 5% for B
FYM	0.86	1.13	1.38	1.65	**1.26**	0.05
PM	0.77	1.04	1.31	1.60	**1.18**	
FYM+PM	0.95	1.23	1.47	1.78	**1.36**	
Bofert	0.87	1.12	1.35	1.65	**1.25**	
Biopotass	0.70	0.97	1.23	1.44	**1.09**	
Biophos	0.81	1.03	1.28	1.56	**1.17**	
FYM+Biofert	1.33	1.55	1.72	1.77	**1.59**	
FYM+Biopotass	1.14	1.34	1.51	1.56	**1.39**	
FYM+Biophos	1.22	1.42	1.61	1.68	**1.48**	
PM+Biofert	1.06	1.22	1.38	1.43	**1.27**	
PM+Biopotass	0.92	1.04	1.17	1.22	**1.09**	
PM+Biophos	0.97	1.15	1.29	1.33	**1.18**	
FYM+PM+Biofert	0.82	0.96	1.06	1.12	**0.99**	
FYM+PM+Biopotass	0.67	0.77	0.84	0.88	**0.79**	
FYM+PM+Biophos	0.74	0.87	0.97	1.02	**0.90**	
Mean for A	**0.92**	**1.12**	**1.31**	**1.45**		
LSD at 5% for A	0.03					
LSD for A*B	0.10					
	2020-2021					
NPK100%	63.21					
A B	Zero	50%NPK	75%NPK	100%NPK	Mean for B	LSD at 5% for B
FYM	1.21	1.39	1.68	1.84	**1.53**	0.05
PM	1.17	1.34	1.63	1.81	**1.49**	
FYM+PM	1.15	1.31	1.58	1.75	**1.45**	
Bofert	1.05	1.03	1.34	1.54	**1.24**	
Biopotass	0.98	1.08	1.38	1.59	**1.26**	
Biophos	1.01	1.12	1.43	1.63	**1.30**	
FYM+Biofert	1.41	1.62	1.94	2.04	**1.75**	
FYM+Biopotass	1.34	1.56	1.83	1.96	**1.67**	
FYM+Biophos	1.37	1.57	1.88	2.00	**1.70**	
PM+Biofert	1.32	1.50	1.78	1.94	**1.64**	
PM+Biopotass	1.24	1.43	1.70	1.86	**1.56**	
PM+Biophos	1.27	1.45	1.76	1.91	**1.60**	
FYM+PM+Biofert	1.11	1.28	1.55	1.71	**1.41**	
FYM+PM+Biopotass	1.07	1.16	1.46	1.65	**1.34**	
FYM+PM+Biophos	1.10	1.22	1.52	1.68	**1.38**	
Mean for A	**1.19**	**1.34**	**1.63**	**1.79**		
LSD at 5% for A	0.04					
LSD for A*B	0.11					

Table (10). Effect of organic manures (FYM and pigeon) plus bio-fertilization (Nitrogen fixing, Phosphate dissolving bacteria and potassium releasing bacteria) on starch % of potato tubers cv. " Cara " in the two winter seasons of 2019-2020 and 2020-2021.

Treatments	Starch %					
	2019-2020					
NPK100%	18.79					
A / B	Zero	50%NPK	75%NPK	100%NPK	Mean for B	LSD at 5% for B
FYM	18.83	19.36	19.58	19.85	19.41	0.09
PM	18.99	19.98	20.43	20.85	20.06	
FYM+PM	19.23	20.19	20.74	21.05	20.30	
Bofert	18.92	20.57	21.44	22.15	20.77	
Biopotass	17.23	17.63	17.95	19.43	18.06	
Biophos	18.15	19.34	19.65	19.96	19.28	
FYM+Biofert	18.53	20.34	20.96	21.75	20.39	
FYM+Biopotass	17.44	18.16	18.24	19.94	18.45	
FYM+Biophos	17.77	18.76	18.55	20.52	18.90	
PM+Biofert	18.85	20.06	19.63	22.11	20.16	
PM+Biopotass	18.06	19.31	18.88	20.96	19.30	
PM+Biophos	18.42	19.63	19.16	21.53	19.69	
FYM+PM+Biofert	19.77	21.25	20.86	23.72	21.40	
FYM+PM+Biopotass	19.07	20.54	20.04	22.67	20.58	
FYM+PM+Biophos	19.55	20.87	20.36	23.16	20.98	
Mean for A	18.59	19.73	19.76	21.31		
LSD at 5% for A	0.06					
LSD for A*B	0.17					
	2020-2021					
NPK100%	26.14					
A / B	Zero	50%NPK	75%NPK	100%NPK	Mean for B	LSD at 5% for B
FYM	15.94	18.35	20.22	20.77	18.82	0.08
PM	16.13	18.53	20.36	20.98	19.00	
FYM+PM	16.35	18.63	20.61	21.22	19.20	
Bofert	15.67	16.95	19.36	19.96	17.99	
Biopotass	15.33	16.56	18.95	19.57	17.60	
Biophos	15.43	16.77	19.23	19.76	17.80	
FYM+Biofert	17.98	22.24	23.96	25.15	22.33	
FYM+Biopotass	17.17	21.43	23.14	24.43	21.54	
FYM+Biophos	17.64	21.75	23.55	24.76	21.92	
PM+Biofert	18.14	22.42	24.17	25.35	22.52	
PM+Biopotass	17.44	21.55	23.37	24.56	21.73	
PM+Biophos	17.84	21.99	23.82	24.95	22.15	
FYM+PM+Biofert	22.96	25.95	26.61	27.17	25.67	
FYM+PM+Biopotass	22.54	25.64	26.14	26.76	25.27	
FYM+PM+Biophos	22.75	25.75	26.44	26.96	25.48	
Mean for A	17.95	20.97	22.66	23.49		
LSD at 5% for A	0.09					
LSD for A*B	0.16					

REFERENCES

Abd El-Nabi, H. M. E.; El-Gamily and Nahla A. R. Keshta (2016). Response of potato plants to organic, bio and mineral fertilization. J. Plant Production, Mansoura Univ., 7 (8): 861 – 867.

Amany, A. Abd-Ellatif; Ali, B. E. and EL-Mehrat, H. G. (2013). Impact of Biofertilizers and compost type and rate on potato production under organic farming (B) Chemical composition. J. Biol. Chem. Environ. Sci., 8(3): 29-47.

Arisha H.M. and A. Bradisi, 1999. Impact of mineral fertilizers and organic fertilizerss on growth, yield and quality of potato under sandy soil conditions. Zagazig J. Agric. Res., 26: 391–405.

Asghari, M. T. and Fard, R. M. A. (2015). The impact of farmyard manure and nitrogen fertilizer on some characteristics of potato (Solanum tuberosum var. Agria). Biharean Biologist, 9 (2): 81-84.

Baddour, A. G. (2014). Ecological study on potato and onion crops grown under organic farming comparing with mineral fertilization. Ph.D. Thesis Fac. Agric. Mansoura Univ. Egypt.

Baddour, A. G. and Hanaa M. Sakara (2020). Bio-fortification of potato plants with different nitrogen rates and applied iron forms in presence and absence of Azotobacter sp. Egypt. J. Soil. Sci. 60(4): 449-467.

Bošković-Rakočević, L.; Dinić, Z.; Dugalić, G.; Dugalić, M.; Mladenović, J. and Đurić, M. (2018). Impact of different rates and methods of application of NPK-fertilizers on the quality of potato tubers. Acta Agriculturae Serbica, Vol. XXIII, 45: 101-110.

FAO (2021). https://www.potatonewstoday.com/2022/03/28/fao-updates-global-potato-statistics/

Farag, M. I.; Abdalla, M. A.; Mohamed, M. F. and Aboul-Nasr, M. H. (2013). Impact of Biofertilization on Yield and Quality of some Potato Cultivars (Solanum Tuberosum L.). International Journal of Agriculture and Food Science Technology. 4 (7): 695-702.

Farida, H. B.; M. M. El-Dsouky, H. S. Sadiek and A. A. Abo-Baker (2003). Response of tomato to inoculation with oculants of different bacterial species. Assiut J. Agric. Sci. 34(5): 275-285.

Gavrilenko, V. F. and T. V. Zigalova, (2003). The Laboratory Manual for the Photosynthesis. Academia, Moscow. 256 стр. (in Russian).

Gomez, K. A., and A. A. Gomez, (1984). "Statistical Procedures for Agricultural Research". John

Wiley and Sons, Inc., New York.pp:680.

Guo, J., Liu, X., Zhang, Y., Shen, J., Han, W., Zhang, W. (2010). Significant acidification in major Chinese croplands. – Science 327: 1008-1010.

Haluschak, P. (2006). Laboratory Methods of Soil Analysis. Canada-Manitoba Soil Survey. April.

Han, H. and Zhao, L. (2009). Farmers' character and behaviour of fertilizer application evidence from survey of Xinxiang County Henan Province, China. – Agricultural Sciences in China 8(10): 1238-1245.

Irungbam, P., Pramanick, M. and Devi, T. S. (2018). Growth and productivity of potato (cv. Kufri Jyoti) and soil nutrient status as influenced by different nutrient management in new alluvial zone of West Bengal. J. Environ. Biology, 39, (1): 17-22.

Małgorzata, B. and Georgios, K. (2009). Physiological response and yield of pepper plants (Capsicum annum l.) To organic fertilization. J. center European Agric., 9 (4): 715-722.

Mama, A.; Jeylan, J. and Aseffa, A. W. (2016). Impacts of different rates of organic and inorganic fertilizer on growth and yield components of potato (Solanum tuberosum l.) in Jimma are, south west Ethiopia. Intel J. Res. - Granthaalayah, 4 (11): 115-121.

Mitran, T., Mani, P. K., Bandyopadhyay, P. K. and Basak, N. (2017). Influence of organic amendments on soil physical attributes and aggregate associated phosphorus under longterm rice wheat-cropping. – https://doi.org/10.1016/S1002-0160(17)60423-5.

Mlaviwa, J. and E. Missanjo (2019). Recent trends and future directions on value addition of Irish potato (Solanum tuberosum L.) among smallholder farmers. Emer. Sci. J., 3: 0-0. DOI: 10.28991/esj-2019-01167.

Monroy, J. P.; Ramírez, A. K. R.; Huerta, A. G.; López, D. J. P. and Sangerman-Jarquín, D. (2019). Organic fertilization with three levels of chicken manure in four potato cultivars. Revista Mexicana Ciencias Agrícolas, 10 (5): 1139-1149.

Mózner, Z., Tabi, A. and Csutora, M. (2012): Modifying the yield factor based on more efficient use of fertilizer - the environmental impacts of intensive and extensive agricultural practices. – Ecological Indicators 16: 58-66.

Muthoni, J. and Nyamango, D. O. (2009). A review of constraints to ware Irish potatoes production in Kenya. J. Horticult. Forestry, 1 (7): 98-102.

Nag, G. P. (2006). Integrated nutrient management in potato for Chhattisgarh plains. M.Sc. (Ag). Thesis IGKV, Raipur. 94-95.

Ramandeep; Singh, S.; Kumari, S. and Singh, Sh. K. (2018). Impact of bio-fertilizers and fertilizers on potato (Solanum tuberosum L.) cv. Kufri Pukhraj and Kufri Jyoti cultivation. Intel. J. Chem. Stud., 6(4): 29-31.

Reeuwijk, L. P. (2002). Procedures For Soil Analysis. Inter. Soil Ref. and Info. Center. Food and Agric. Organization of the United Nations.

Rukun, L. (1999). Analytical Methods of Soil and Agricultural Chemistry. Beijing: China Agricultural Science and Technology Press.

Salem, B. A. E. (2019). Role of some bio and organic amendments to improve potato productivity and quality. Ph. D. Thesis Agric. Sci. (Hort. - Vegetables), Fac. of Agric., Minia Univ. Egypt.

Sierra, J.; Causeret, F.; Diman, J. L.; Publicol, M.; Desfonatianes, L.; Cavalier, A. and Chopin, P. (2015). Observed and predicted changes in soil carbon stocks under export and diversified agriculture in the Caribbean. The case study of Guadeloupe. – Journal of Agriculture, Ecosystem and Environment 213: 252-264.

Singh, J. P., (1988). A rapid method for fertermination of nitrate in soil and plant extracts. Plant and soil. 110: 137-139.

Singh, M.; Biswas, S. K.; Nagar, D.; Lal, K. and Singh, J. (2017). Impact of Bio-fertilizer on Growth Parameters and Yield of Potato. Int. J. Curr. Microbiol. App. Sci., 6(5): 1717-1724.

Stephen, O., David, A. A., Abdullahi, A. B. and Oludare, O. A. (2014). Impact of NPK and poultry manure on growth, yield, and Proximate composition of three amaranths. – Journal of Botany ID 828750, 6.

Thymanavan, B., and Sadasivam, S. (1984). Quality of plant and Foods for human nutrition; 34:253.

WHO/EU, (1999). WHO and EU Drinking water Quality Guidelines for Heavy Metals and Threshold Values Leading to Crop Damage.

Zeinab, A. S., Farouk, K. E., Alaa, A. G. and Mohamed, F. Z. (2013). Antioxidant activities of phenolics, flavonoids and vitamin C in two cultivars of fennel (Foeniculum vulgare) in responses to organic and bio-organic fertilizers. – Journal of Saudi Society of Agricultural Sciences 14: 91-99.

الملخص العربي

تأثير التسميد المعدني والعضوي والحيوي على البطاطس في أرض مصرية رملية

2- الجزء الثاني: التركيب الكيميائي للنباتات والدرنات

يسرى تمام عبد المجيد1، ياسر محمود محمد مصطفى1، مايسة لطفي عبد المنعم2، أسامة محمد

قسم البساتين – كلية الزراعة – جامعة المنيا – المنيا - – جمهورية مصر العربية
رئيس بحوث – المعمل المركزى للزراعة العضوية – مركز البحوث الزراعية – الجيزة – جمهورية مصر العربية
طالب دكتوراة - قسم البساتين (خضر) – كلية الزراعة – جامعة المنيا – المنيا - – جمهورية مصر العربية

أجريت تجربتين حقليتين بمزرعه خاصه بقريه عزب القصر بالواحات الداخله، محافظه الوادى الجديد خلال الموسمين الشتويين 2019-2020 و 2020-2021م لدراسه كل التفاعلات الممكنه بين الاسمده العضويه اضافة الى التسميد الحيوي في وجود التسميد المعدنى وتأثيرها على إنتاج محصول آمن من البطاطس صنف كارا. إشتملت هذه التجربة على 60 معاملة في تصميم قطع منشقة متعامدة في 3 مكررات ، والمعاملات تمثل كل التفاعلات الممكنة بين 4 معدلات من الأسمدة المعدنيه (بدون تسميد، 50، 75 و 100% تسميد معدنى من الموصى به) كقطع رئيسية – و15 معامله من التسميد العضوى والمعدنى (سماد بلدى، سماد زرق الحمام، خليط من السماد البلدى + زرق الحمام، أسمده حيويه مثبته للنيتروجين، أسمده حيويه مذيبه للبوتاسيوم، أسمده حيويه مذيبه للفوسفات، سماد بلدى + أسمده حيويه مثبته للنيتروجين، سماد بلدى + أسمده حيويه مذيبه للبوتاسيوم، سماد بلدى + أسمده حيويه مذيبه للفوسفات، سماد زرق الحمام + أسمده حيويه مثبته للنيتروجين، سماد زرق الحمام + أسمده حيويه مذيبه للبوتاسيوم، سماد زرق الحمام + أسمده حيويه مذيبه للفوسفات، سماد بلدى+ زرق الحمام + أسمده حيويه مثبته للنيتروجين، سماد بلدى +زرق الحمام+ أسمده حيويه مذيبه للبوتاسيوم، سماد بلدى + زرق الحمام+ أسمده حيويه مذيبه للفوسفات) كقطع منشقه، اضافه الى ذلك، تم مقارنة جميع المعاملات تحت الدراسه بمعامله المعدل الموصى به من NPK كمعامله كنترول. يمكن تلخيص النتائج فى أن أستخدام التسميد العضوى مع الحيوى حسن من صفات النمو الخضرى والتركيب الكيميائى للأوراق والدرنات ووجد أن خليط من السماد البلدي وزرق الحمام في وجود التسميد الحيوى لبكتريا مثبته للنيتروجين في صوره فرديه أعلى القيم من التركيب الكيميائى للأوراق والدرنات وقللت من محتوى الدرنات من النترات والنيتريت بالمقارنة بالتسميد المعدنى فقط. ولذلك فى النهايه نستطيع القول أن التفاعل المشترك بين معاملة النباتات بخليط من السماد البلدى وزرق الدواجن مع التسميد الحيوى بمثبتات النيتروجين مع إضافه 100% من NPK أعلى القيم لجميع الصفات المذكوره خلال كلا الموسمين. ويمكن التوصية لكل مزارعى ومنتجى البطاطس بإستخدام هذه التوليفة من الأسمدة العضوية والمخصبات الحيوية مع 75% من الأسمدة المعدنية لتوفير التكاليف وإنتاج إنتاج عالى ومنتج آمن من درنات البطاطس.