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

1-PART 1: PLANT GROWTH AND PRODUCTIVITY

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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 using potato (Cara cv.) in sandy soil in the two successive winter seasons of 2019/2020 and 2020/2021. Results showed that inoculating potato plants with Biofert (as a N-fixing bacteria) in the presence of "half of the recommended doses of organic manures" (as Farmyard Manure, FYM + Poultry Manure, PM) gave the highest mean values of all studied growth (emergnce %, plant height, number of branches, fresh and dry weight of potato plant foliage) and yield characters (number of tuber/plant, total yield ton/fed, average weight of tuber g/plant and average weight of marketable tubers >45g (ton/fed)). The highest mean values of those characters were obtained from potato plants treated with the combination of FYM + PM + Biofert + 100% of NPK dose comparing with the control treatment. 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

Interest in maintaining and improving soil fertility through sensible land use and management practices has increased in recent years due to concerns over the production of healthy foods, particularly vegetables and fruits, environmental concerns, and a focus on preserving the productive capacity of soils. According to Mlaviwa and Missanjo (2019), potatoes are a significant crop with yields comparable to those of corn, rice, and wheat. In certain nations, potato production is year-round due to its quick maturation (Assa, 2012). It is an inexpensive source of energy, has high amounts of minerals, vitamins B and C, and carbohydrates. According to Muthoni and Nyamango (2009), it is regarded as moderately rich in certain free amino acids, fibers, and very minor levels of fat. It is one of the most widely grown tuber crops worldwide, with 4325478 tons of potatoes produced globally in 2017 (FAO STAT, 2017).(area and productivity of potato in Egypt is preferred) In Egypt, potatoes are both a valuable commercial crop and a staple aliment as Egyptian potatoes are exported to many countries (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 inadequate 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 Reliance on mineral fertilization led to an increase in yield and plant biomass (Guo *et al*., 2010) (Guo *et al*., 2010). According to Han and Zhao, 2009 and Sierra *et al*., 2015, the heavy use of chemical (mineral) fertilizers can, however, result in the accumulation of fertilizer residue, a rise in nutrient toxicity, greenhouse gas emissions, metal pollution, soil acidification and groundwater contamination. In addition, Mózner *et al*., (2012) indicated that crops only use 30–50% of chemical fertilizers, with the remainder being lost to the environment.

A balance between the requirement to optimize yield and profit and proper fertilization rate is thus needed to reduce the impact of crop production on the environment. Environmental protection is one of the new agriculture policy's top concerns. Because of the superior nutritional value and potential health advantages associated with these methods of farming, focus is increasingly shifting globally toward the use of organic fertilization. This study examines the impacts of adopting organic farming methods to reduce the detrimental impacts of mineral fertilization on potato tuber productivity and quality indicators. According to several studies by Stephen *et al*. (2014), Abdel-Moneim *et al*. (2015), and Mitran *et al*. (2017), the use of organic fertilization, such as farmyard manure and poultry manure or other sources, has been shown to improve the biological, chemical, and physical properties of the

soil and invariably increase plant growth and yield. Also, Zeinab *et al.* (2013) reported that organic manure increases plant levels of secondary metabolites such as phenolic, flavonoid, and antioxidant activities.

An excessive of chemical fertilizers and pesticides in today's world has resulted in soil degradation and contamination, which is one of the main issues. In theory, bio-fertilizers are more affordable and eco-friendly than chemical fertilizers (Abdel-Moneim *et al*., 2015b). Biological nitrogen, potassium and phosphorus, such as fungi, bacteria, and cyanobacteria may be considered the key word for solving such problem adding with organic fertilization. According to Farag *et al*. (2013), soil microorganisms play a critical role in the transformation of fertilizer for plant use. In the unlikely event that the microorganisms in the soil are sufficiently lacking, bio fertilizers must be used to vaccine them. There are primarily three types of bio-fertilizers: bacteria that fix nitrogen, bacteria that fix phosphorus, and bacteria that fix potassium. While phosphatic and potassic bio-fertilizers are able to solubilize the phosphates and potassium bound in soil and increase their accessibility in plants, nitrogen settling bio-fertilizers contribute nitrogen to the soil by reducing ambient nitrogen. Using a balanced combination of organic and biofertilizers with natural supplement sources will improve the development and nature of the potato (*Azotobactor*, phosphorus and potassium bacteria) get great reaction (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 in order to determine the most appropriate integration for suitable kind of bio-fertilization with organic manure. Mitigating the negative impact of mineral fertilization and produce a good vegetative growth of potato plants, obtaining the optimum potato yield with good quality of tubers suitable for local consumption and for exportation to international markets is also ,considered.

MATERIALS AND METHODS

Two field studies were conducted in a private farm in Egypt's New Valley Governorate's Ezab Al Qasr Village, Al-Wahat Al-Dakhla. in the two successive winter- of 2019–2020 and 2020–21. The goal of the study was to determine how different combinations of organic manures, bio-fertilizers, and mineral fertilizers affected the yield of safe and affordable potato tubers (Cara cv.).

2.1.1 Experimental design and treatments

Sixty treatments represented the simplest feasible combination of four rates of NPK as mineral fertilization and fifteen treatments of organic, bio-fertilizations defined—were grouped in a factorial design with three replications as follows:

- **Mineral fertilization:**

1. Zero (without fertilization).
2. 50 % NPK from recommended dose (RD;150 kg N-60 kg P_2O_5- 96 kg K_2O/fed).
3. 75% NPK RD.
4. 100 NPK RD.

- **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. 50 %of FYM+50% of Biofert.
8. 50% of FYM+50% of Biopotass.
9. 50% of FYM+50% of Biophos.
10. 50% of PM+50% of Biofert.
11. 50% of PM+50% of Biopotass.
12. 50% of PM+50% of Biophos.
13. 50% of FYM + 50% of PM + 50% of Biofert.
14. 50% of FYM + 50% of PM + 50% of Biopotass.
15. 50% of FYM + 50% of PM +50% of Biophos.

Additionally, the suggested dosages of 100% N, P, and K fertilizers for potato production were put in consideration as a comparable control treatment. So, the total number of treatments were 180 plots.

2.1.2 Preparation of the experimental soil

The experimental field's soil had a sandy texture and poor fertility. Table 1 listed the physical and chemical characteristics of soil samples that were taken from the experimental field's top layer (0–30 cm).

The experimental field was ploughed, compacted and each plot area was 10.5 m^2 (3 m length and 3.5 m width). Each plot included 5 rows (70 cm width of each ridge).

2.1.3 Preparation of organic manures

Ripe farmyard and pigeon manure were taken from a private station of animals and birds production. Chemical analyses of the used organic manures are presented in Table (2). Organic manures were added to the soil before sowing in a single application at the rate of 5 ton fed^{-1} for FYM and 2 ton fed^{-1} for pigeon manure i.e. 12.5 and 5 kg $plot^{-1}$ for FYM and PM, 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 in order to elucidate the potential impacts of the heat from manure decomposition on potato tuber-seeds and their roots.

2.1.4 Bio-fertilization

Products made from a combination of *Azotobacter chroococcum* and *Azospirillum brasilense* nitrogen-fixing bacteria were prepared. *Bacillus megaterium and Bacillus circulans* strains that release potassium and dissolve phosphate, respectively, were employed. The Microbiology Department, Faculty of Agriculture, Minia University, Egypt, generously provided all of the bio fertilizers. Using liquid cultures (1 ml contains 10^8 cells), all bio fertilizers were applied to the soil's surface with irrigation water at a rate of 5 L/fed in two equal doses after 15 and 40 days from the planting date.

2.1.5. Mineral fertilization

NPK (100%) as control treatments for potatoes as recommended doses was used according to the Egyptian Ministry of Agriculture. and Soil Reclamation (EMASL). Also, the three treatments of 50, 75 and 100% from recommended doses for potato crop was calculated and added. Full dose of P (60 kg P_2O_5/fed (as calcium super phosphate ; 15.5% P_2O_5 in amounts of 387 kg) was added to the soil before planting while; N and K (150 kg N/fed (as ammonium nitrate; 33.5% N) and 96 kg K_2O/fed (as potassium sulphate; 48% K_2O) in amounts of 448 and 200 kg, respectively) were added in two equal doses; one after 30 days from planting and the rests were 20 days later.

2.1.6 Potato planting

Potato tubers cv. Cara (obtained from some local sellers) were used in this study. Whole tubers were planted on the 10th and 19th of October 2019 and 2020, respectively for both seasons at 20 cm apart between each other and on one side of ridges. Watering every 5-7 days ensured that the soil moisture remained at field capacity throughout the trial. All other agricultural practices were carried out as recommended by (EMASL) for potato crop.

2.1.7 Experimental procedures

Following 45 days from planting, the emergence % were counted, and the following formulae were used to estimate:

$$Emergence\,\% = \frac{Number\ of\ germinated\ hills\ per\ plot}{Total\ number\ of\ planted\ tuber\ cuttings\ per\ plot} \times 100$$

Five plant samples were randomly selected from each plot after 70 days following planting and transported right away to the lab. Plant growth characteristics, including plant height (cm), number of branches per plant, foliage fresh weight of plant (g/plant), were measured. 100 g samples of leaves from each sample were dried in an oven at 70 °C until a consistent weight. Total tuber yield was measured at full maturity (125 days after planting) and estimated as tons/fed. A random sample of 20 tubers from each experimental plot were taken for determination of tuber measurement i.e.:

1. Number of tubers per plant.
2. Average tuber weight (g).
3. Total yield ton /fed..
4. Average weight of marketable tubers (>45g) ton/fed.

2.2.3 Statistical analysis

According to the procedures outlined by Gomez and Gomez (1984), all data were statistically evaluated using the analysis of variance (ANOVA) technique. Revised least significant difference (L.S.D.) method was utilized to examine variations in mean values. Version II of the CoSTAT computer program was employed.

RESULTS AND DISCUSSION

3.1 Vegetative growth parameters of potato plants

Data presented in Tables (3 to 7) indicate the impact of various combinations of organic manure and Biofertilization under mineral fertilization as compared with 100% NPK from recommended dose on vegetative growth parameters i.e., Emergence %, plant height, number of

branches, fresh and dry weight of potato plant foliage.

3.1.1. Emergence of tuber-seeds

Data in Table 3 revealed that the average values of germination % for potato seed-tubers showed a significant superiority when these tubers were treated with the different organic manures and bio-fertilization in single forms in combinations. All organic fertilization forms and bio-fertilization increased germination %, while plots treated with combined organic and bio fertilizers recorded high values of this trait. Moreover, organic manures as (FYM + PM) combined with Biofert (as N-fixation) resulted in the highest mean values of germination% comparing with the other treatments whether single or combined forms during both growing seasons. Treating potato plants with the studied mineral fertilization NPK (50, 75 and 100% from the recommended dose), significantly, exhibited the highest mean values of potato germination % than those obtained from the untreated plants (zero NPK%). In this respect; with increasing NPK fertilization an increase in germination % up to 100% was found, the highest values of germination % (94.11 and 90.64%, respectively) for both seasons were recorded for the plants treated only with 100% NPK, while the lowest mean value (82.90 and 81.23%) were obtained from the control plots (Zero NPK).

The interaction impact between organic manure and/or bio fertilization and mineral fertilization comparing with 100% NPK presented in Table 3 showed that the mean values of germination % was significantly affected by addition of all investigated treatments. Such impact was more pronounced for the treatment of (FYM + PM +Biofert) with mineral fertilization, whereas the mean values of such trait was increased to be approximately around the same levels of control treatment (100% NPK as a single treatment). In this respect, the highest mean values (91.33 and 94.58% in 2019-2020 and 2020-2021 were recorded respectively for potato plants treated with the combination of (FYM + PM +Biofert) and 100% of NPK.

3.1.4. Average foliage fresh weight (g)

Data in table 4 illustrated that addition of both organic manure and bio-fertilizers in solo forms or combined together, significantly, affected the foliage fresh weight of potato plants and the treatment of FYM + foliage fresh weight during both seasons (407.42 and 435.70 g, respectively). All dose rates of mineral fertilization (0, 50, 75 and 100% NPK) significantly affected plants fresh weight as illustrated in Table 4 and with increasing the dose rates of NPK fertilizers an increase in foliage fresh weight of potato plants was noticed. Furthermore, the highest mean values of foliage fresh weight were recorded with 100% of NPK (437.22 and 396.02 g in the two seasons, respectively). On the other hand, the interaction impact between organic manure, bio-fertilizers and NPK fertilization showed significant increases of foliage fresh weight of plants due to the application all treatments combinations. Additionally, the best combination treatment was obtained from (FYM + PM + Biofert + (100%) of NPK (505.21 and 470.15 g, respectively in both seasons).

3.1.5. Average foliage dry weight of plants (g).

The average dry weight of whole potato plants were significantly affected by these investigated treatments (table 5). The highest mean value was recorded with plants treated with FYM + PM + Biofert (54.45 and 61.58 g in the first and second seasons, respectively. Regarding the impact of mineral fertilization on foliage dry weight of potato plants, results showed that with increasing the rate of NPK doses a significant increase in average foliage dry weight of plants was obtained. The highest mean values were obtained from plants treated with 100% of NPK (58.41 and 54.42 g for both seasons, respectively). Moreover, the interaction among the studied treatments resulted in increases in dry weight due to the application of organic, bio and mineral fertilizations. The highest mean values were recorded with plots treated with FYM + PM + Biofert in absence of NPK fertilization (67.54 and 66.63 g) in the two seasons, respectively.

3.2 Yield and its components

3.2.1. Number of tubers/plants

It is evident from data presented in table (6) that the addition of organic manures or bio-fertilizers in either solo or mixed applications, significantly, affected number of potato tubers per plant. Moreover, with combination of different forms of organic manure and bio-fertilization, the number of tubers was increased, and the highest values were recorded with the treatments of FYM + PM + Biofert (6.58 and 9.17), respectively in the two seasons. However, the lowest value was obtained with bio-fertilizer treatment in form of potassium releasing bacteria. Additionally, data indicated that using 100% NPK was preferable for achieving the greatest values of all the aforementioned features, followed by using 75%, 50%, and finally 0% NPK, among the various rates of NPK fertilization tested. For example, the average values for the number of tubers/plant were (7.67 and 7.64), (6.29, 6.93), (5.36 and 5.89) and (3.98 and 4.04), respectively in both seasons, respectively. Comparing with the control treatment (100% NPK), the highest mean values recorded with application of FYM + PM + Biofert in presence of 100% NPK (9.67 and 10.67) comparing with the 100% NPK alone (5.33 and 8.33), respectively during the two seasons.

3.2.2. Average weight of tuber g/plant:

As compared to the full dose of NPK over the two growing seasons of the experiment, the mean values of tubers weight/plant as impacted by various organic manures and bio-fertilizers with or without mineral fertilization are shown in table 7. Data shown in Table 9 indicated that the highest significant value was recorded with the combination of FYM + PM + Biofert as (120.26 and 133.06 g/plant). While the lowest value was recorded for the bio-fertilizer in form of potassium releasing bacteria (115.04 and 120.06 g/plant), respectively. Moreover, the illustrated data showed that with increasing rates of mineral fertilization, the average weight of potato tubers was increased.Results ,clearly, showed that the highest significant values were recorded with plants received 100% NPK ,followed by 75%, 50 then 0% NPK in the two

growing seasons. Regarding the interaction application of treatments comparing with 100% NPK, all treatments were significantly affected by the used fertilization combinations. All application of organic with bio-fertilization increased the weights of potato tubers under all addition of mineral fertilization and the highest mean values were recorded with the application of FYM + PM + Biofert with 100% NPK, in both growing seasons.

3.2.3. Total yield (ton/fed)

Data illustrated in table 8 indicated that organic manures and bio-fertilization in combination with mineral fertilization had a significant impact on mean values of potato total yield during the two studied growing seasons. The addition of FYM + PM + Biofert was shown to be related with the greatest mean values of total yield, whereas plants treated just with Biopotass recorded the lowest mean values. The rate of increases for average total yield was calculated to be 38.62, 66.01, and 108.83% for the rate of 50, 75, and 100% in the two growing seasons, respectively, as compared to the control treatment (without fertilization).

3.2.4. Average weight of marketable tubers >45g (ton/fed)

Data in Table 9, showed the average weight of marketable tubers (>45 g) was affected by various organic manure and/or bio-fertilizers with mineral fertilization and their interactions during the two growing seasons and the highest mean values were recorded with the combination of FYM , PM and Biofert (37.21, 62.18 and 106.11 %) for 50, 75 and 100% in the first season, respectively. The same trend was observed, in the second season. The interaction impact of the treatments under study showed that the average values of marketable weight of tubers were significantly affected by the addition of all investigated treatments. Such impact was more pronounced for all forms of fertilizers (FYM + PM + Biofert) with mineral fertilization and the highest mean values were 20.068 and 26.672 ton/fed, respectively were recorded for the plants treated with FYM + PM + Biofert with using 100% NPK dose.

DISCUSSION

In order to produce high yields of good nutritious potatoes, this experiment was carried out to examine the individual and combined effects of applying organic, bio, and mineral fertilizers as distinct sources of nutrients to potato plants. In addition to providing N, P, and K, organic manure also converts inaccessible forms of nutrients into accessible forms to improve plants' ability to absorb nutrients. It plays a part in enhancing the physical and chemical characteristics of the soil by producing humus, which enhances these features. By increasing the amount of CO_2 that forms H_2CO_3 in the soil solution, the integration of organic materials into soils can also enhance NPK availability. These boosts yield and its constituents, such as single tuber weight and diameters, which represent its quality criteria. Application of bio fertilizers coupled with organic manures promotes the development and activity of beneficial soil microbes, as well as aids in reducing the rising incidence of micronutrients, allowing for good crop yield and soil health. If plants are growing healthily, there may be an increase in the

rate of photosynthesis, a decrease in the buildup of No3-N and carbohydrates, and a consequent rise in the size of the tubers as measured by their average weight and diameter, which will ultimately boost potato yields overall. 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 AbdEl-Nabi *et al*. (2016) cleared that decrease Nitrite (No2-N), Nitrate (No3-N) were significantly affected due to adding FYM (20ton fed^{-1}) and compost (15ton fed^{-1}). Also, Salem (2019) and Abdel-Moneim *et al*. (2015) demonstrated that All compost treatments with the Lady Rosetta cultivar produced tubers with the largest amounts of dry matter, starch, and carbohydrates. On the other hand, they remark that Lady Balfour provides the greatest nitrate concentration in tubers for all mineral N treatments.

In addition to the previously mentioned information, the use of *Azotobacter* and *Azosbrillum* bacteria as an inoculum with a variety of beneficial properties that promote plant growth, including its capacity to stabilize the nitrogen and then increase the plant concentration of nitrogen, can be credited for the increase in N% and all other treatments. The ability of the local bio-fertilizer's components to increase soil element uptake is linked to their capacity to secrete certain plant hormones, such as gibberellins, auxins, 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 increases nutrient absorption. Results of this study, also, revealed that most soil nitrogen under mineral fertilization (control) will be in the form of nitrate, and plants can absorb large amounts of nitrogen due to their capacity for assimilation. However, there may be a significant difference between N-absorption and assimilation, and the utilized nitrogen will 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 for weakly ingesting nitrate (15.5mg.kg-1 of body weight for No3-N) set by Who (1999) may be attributed to the role played by these substances in relation to the enzymatic system responsible for the biosynthesis of amino acids, protein, and other N-compounds and subsequently. This result is consistent with the result of Amany *et al.* (2013), who studied the impact of compost type and rate as well as biofertilizers (consisted of *Bacillus megatherium* + *Bacillus cerculium* + *Azotobacter. Bacillus sitlus*) and results indicated that using bio-fertilizers plus bacillus with animal or plant compost to reduce the high levels of NO_2 and NO_3 than mineral fertilization to enhance the tuber quality. Also, their results showed that using animal compost, significantly, increased nitrogen, phosphorus and potassium contents in potato leaves and 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. Phosphorous as a nutrient helps the root system develop better, which increases the root's ability to absorb more nutrients. While, the role of K in nutrient uptake and nutritional balance may be due to an increase in

photosynthesis, as well as because K_2SO_4 in the soil may be attributed to the role of sulfur, which played a part in lowering the soil pH values and subsequently made it easier for potato plants to absorb nutrients, which is reflected in the quality of the potatoes. These results are in a good agreement with those obtained by Abd El-Nabi *et al*. (2016), on potato plant, found that due to the application of NPK fertilization, nitrite (NO_2-N) and nitrate (NO_3-N) levels were considerably influenced, and these levels rose when NPK was raised from 50% to 75% of the advised dose. However, Bokovi-Rakoevi *et al*., (2018) found that the maximum nutritional concentrations were found in potato tubers at the highest NPK fertilizer rate.

CONCLUSION

Different fertilizer combinations e.g., organic, bio and mineral sources were used in this study to grow potato (Cara cv.) in sandy soil in the two successive winter seasons of the years 2019/2020 and 2020/2021. Results showed that inoculating potato plants with Biofert (as a N-fixing bacteria) in the presence of organic manures (as Farmyard Manure, FYM + Poultry Manure, PM) recorded the highest mean values of all studied growth and yield characters. The highest mean values of those characters were obtained from potato plants treated with the combination of FYM + PM + Biofert + 100% of NPK dose comparing with the plants obtained from the control treatment. The superiority impact of mineral fertilization referred to the increasing of its content from the soluble nutritional elements than those obtained for organic manures or Biofertilization. The production and quality metrics of potato tubers increased as a result of this impact. In order to achieve the highest economic yield of high-quality potato tubers, it may be concluded to inoculate potato plants with Biofert (as N-fixing bacteria) and Bio-potass (as a K-solubilizing bacteria) in addition to compost (FYM) + (PM) and 75% of the recommended doses of mineral fertilization (NPK).

Table 1: Some physical and chemical properties of the experimental soil

Soil characters		Average two seasons
Particle size distribution (%)	Coarse sand	6.03
	Fine sand	71.92
	Silt	12.30
	Clay	9.75
	Texture class	Sandy
EC dS m^{-1}(1:5)		0.87
pH (1:2.5)*		8.05
S.P %		45.7
Organic matter %		0.63
T. $CaCO_3$ %		5.49
Available nutrients (mg kg^{-1})	N	43.7
	P	5.94
	K	87.2

Table 2: 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 (3) Effect of organic manures (FYM and pigeon) plus bio-fertilization (Nitrogen fixing, Phosphate dissolving bacteria and potassium releasing bacteria) on emergence % after 45 days from cultivation of potato Cv. " Cara " in the two winter seasons of 2019-2020 and 2020-2021.

Treatments	Emergence (%)											
	2019-2020						2020-2021					
NPK100%	89.65						93.23					
	Zero	50% NPK	75% NPK	100% NPK	Mean for B	LSD at 5% for B	Zero	50% NPK	75% NPK	100% NPK	Mean for B	LSD at 5% for B
FYM	79.56	84.04	86.96	96.33	86.72	0.08	78.07	81.64	84.85	85.94	82.62	0.09
PM	78.25	90.43	91.05	92.16	87.97		78.33	81.96	85.11	86.24	82.91	
FYM+PM	79.96	84.36	87.06	96.46	86.96		78.65	82.25	85.55	86.53	83.24	
Bofert	80.36	84.83	87.25	96.73	87.29		77.60	79.55	83.36	84.54	81.26	
Biopotass	76.96	81.26	86.12	90.04	83.60		76.84	78.97	82.65	83.75	80.55	
Biophos	77.25	81.84	86.25	90.35	83.92		77.24	79.34	83.04	84.15	80.94	
FYM+Biofert	89.97	83.47	91.52	95.95	90.23		81.14	88.45	91.45	93.53	88.64	
FYM+Biopotass	79.06	82.73	89.75	95.63	86.79		79.75	86.86	89.96	92.12	87.17	
FYM+Biophos	89.86	83.06	91.05	95.74	89.93		80.55	87.66	90.75	92.75	87.93	
PM+Biofert	89.16	90.74	86.75	95.24	90.47		81.36	88.75	91.85	93.74	88.93	
PM+Biopotass	78.64	82.16	85.66	94.75	85.30		80.12	87.23	90.36	92.42	87.53	
PM+Biophos	88.75	90.74	85.84	95.06	90.10		80.86	88.05	91.04	93.17	88.28	
FYM+PM+Biofert	89.66	90.55	90.87	94.25	91.33		89.66	94.85	96.65	97.15	94.58	
FYM+PM+Biopotass	77.77	89.55	86.57	91.15	86.26		89.05	94.15	95.34	96.45	93.75	
FYM+PM+Biophos	88.35	90.14	90.24	91.76	90.12		89.26	94.47	95.65	96.82	94.05	
Mean for A	82.90	85.99	88.20	94.11			81.23	86.28	89.17	90.62		
LSD at 5% for A	0.06						0.04					
LSD for A*B	0.16						0.17					

Table (4) Effect of organic manures (FYM and pigeon) plus bio-fertilization (Nitrogen fixing, Phosphate dissolving bacteria and potassium releasing bacteria) on fresh weight g/plant after 70 days from cultivation of potato Cv. " Cara " in the two winter seasons of 2019-2020 and 2020-2021.

Treatments	Fresh weight (g/plant)											
	2019-2020						2020-2021					
NPK100%	478.46						389.66					
	Zero	50% NPK	75% NPK	100% NPK	Mean for B	LSD at 5% for B	Zero	50% NPK	75% NPK	100% NPK	Mean for B	LSD at 5% for B
FYM	232.37	289.57	349.75	365.70	309.35		254.23	308.15	340.88	343.89	311.79	
PM	282.82	388.47	414.97	470.22	389.12		260.20	312.71	342.31	345.85	315.27	
FYM+PM	305.08	394.45	428.48	495.73	405.94		265.41	317.25	344.80	349.42	319.22	
Bofert	273.40	379.74	423.46	465.61	385.55		250.48	277.93	327.73	337.33	298.37	
Biopotass	232.59	293.36	316.55	336.31	294.70		242.08	268.73	319.38	330.96	290.29	
Biophos	252.49	359.85	400.27	446.42	364.76		245.93	274.69	324.01	333.93	294.64	
FYM+Biofert	262.02	327.56	355.97	411.79	339.34		296.80	368.12	400.02	422.80	371.93	
FYM+Biopotass	220.58	275.60	330.19	378.58	301.24	2.60	280.93	351.63	385.81	406.92	356.32	1.52
FYM+Biophos	240.94	302.74	344.99	392.95	320.41		288.27	360.33	390.36	414.23	363.30	
PM+Biofert	272.95	339.42	400.19	456.67	367.31		302.88	372.20	404.89	427.43	376.85	
PM+Biopotass	253.54	313.53	372.90	427.18	341.79		285.28	356.73	394.09	411.45	361.89	
PM+Biophos	261.47	326.48	386.64	442.67	354.32		293.73	363.09	396.63	419.88	368.33	
FYM+PM+Biofert	305.02	375.46	443.97	505.21	407.42		375.97	440.27	456.39	470.15	435.70	
FYM+PM+Biopotass	283.49	350.70	415.50	474.98	381.17		382.09	432.05	446.65	460.81	430.40	
FYM+PM+Biophos	293.76	364.03	429.44	488.33	393.89		378.10	436.85	451.73	465.26	432.99	
Mean for A	264.84	338.73	387.55	437.22			293.49	349.38	381.71	396.02		
LSD at 5% for A	1.30						1.28					
LSD for A*B	5.21						3.05					

Table (5) Effect of organic manures (FYM and pigeon) plus bio-fertilization (Nitrogen fixing, Phosphate dissolving bacteria and potassium releasing bacteria) on Average dry weight of single after 70 days from cultivation of potato Cv. " Cara " in the two winter seasons of 2019-2020 and 2020-2021.

Treatments	Average dry weight of single (g)											
	2019-2020						2020-2021					
NPK100%	53.73						60.94					
	Zero	50% NPK	75% NPK	100% NPK	Mean for B	LSD at 5% for B	Zero	50% NPK	75% NPK	100% NPK	Mean for B	LSD at 5% for B
FYM	30.90	38.73	46.02	48.84	41.12		31.10	38.44	43.77	45.52	39.71	
PM	37.76	51.91	55.51	62.77	51.99		31.69	38.82	44.22	46.07	40.20	
FYM+PM	40.75	52.72	59.05	66.22	54.69		33.32	39.47	44.89	46.62	41.08	
Bofert	36.53	50.65	56.56	62.24	51.50		30.55	34.34	41.33	43.18	37.35	
Biopotass	30.96	39.24	42.23	45.01	39.36		28.86	32.94	40.17	41.88	35.96	
Biophos	33.64	47.97	53.48	59.64	48.68		29.78	33.62	40.69	42.63	36.68	
FYM+Biofert	32.15	40.43	47.86	54.94	43.85		37.23	50.07	55.94	59.80	50.76	
FYM+Biopotass	29.28	36.85	44.13	50.52	40.20	0.11	34.90	47.29	53.33	57.07	48.15	0.53
FYM+Biophos	34.94	43.73	46.75	52.64	44.52		35.84	48.77	54.58	58.41	49.40	
PM+Biofert	36.56	45.37	53.43	61.05	49.10		37.89	50.61	56.52	60.38	51.35	
PM+Biopotass	33.84	41.93	49.85	57.04	45.67		35.38	47.94	53.92	57.78	48.75	
PM+Biophos	34.95	43.55	51.64	59.05	47.30		36.52	49.45	55.28	59.10	50.09	
FYM+PM+Biofert	40.75	50.18	59.33	67.54	54.45		52.59	62.48	64.61	66.63	61.58	
FYM+PM+Biopotass	37.83	46.86	55.64	63.34	50.92		51.18	58.29	63.36	65.21	59.51	
FYM+PM+Biophos	39.25	48.66	57.43	65.27	52.65		51.84	61.85	63.95	65.98	60.90	
Mean for A	35.34	45.25	51.93	58.41			37.24	46.29	51.77	54.42		
LSD at 5% for A	0.05						0.33					
LSD for A*B	0.21						1.06					

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

Treatments	No. of tuber/plant											
	2019-2020						2020-2021					
NPK100%	5.33						8.33					
	Zero	50% NPK	75% NPK	100% NPK	Mean for B	LSD at 5% for B	Zero	50% NPK	75% NPK	100% NPK	Mean for B	LSD at 5% for B
FYM	3.00	4.67	7.00	7.33	5.50		2.67	4.33	5.33	5.67	4.50	
PM	3.33	5.33	7.67	7.67	6.00		3.00	4.67	5.67	6.00	4.83	
FYM+PM	3.33	6.00	8.00	8.00	6.33		3.33	4.67	5.67	6.00	4.92	
Bofert	4.33	4.67	6.67	6.33	5.50		2.67	3.67	5.00	5.33	4.17	
Biopotass	3.67	5.00	3.67	4.67	4.25		2.00	3.33	3.67	5.00	3.50	
Biophos	4.33	6.33	4.00	5.33	5.00		2.33	3.67	5.00	5.33	4.08	
FYM+Biofert	4.67	5.67	7.00	9.33	6.67		4.33	6.67	7.67	8.67	6.83	
FYM+Biopotass	4.00	5.33	5.00	8.67	5.75	0.62	3.67	6.00	7.00	8.00	6.17	0.58
FYM+Biophos	4.33	5.67	6.67	8.67	6.34		4.00	6.33	7.00	8.33	6.42	
PM+Biofert	5.00	5.00	7.33	8.00	6.33		4.33	6.67	8.00	8.67	6.92	
PM+Biopotass	4.00	4.33	6.00	6.67	5.25		3.67	6.00	7.33	8.00	6.25	
PM+Biophos	4.67	4.67	7.00	7.33	5.92		4.00	6.33	7.67	8.33	6.58	
FYM+PM+Biofert	4.00	6.33	6.33	9.67	6.58		7.00	9.00	10.00	10.67	9.17	
FYM+PM+Biopotass	3.33	5.67	6.00	8.33	5.83		6.67	8.33	9.33	10.33	8.67	
FYM+PM+Biophos	3.67	5.67	6.00	9.00	6.08		7.00	8.67	9.67	10.33	8.92	
Mean for A	3.98	5.36	6.29	7.67			4.04	5.89	6.93	7.64		
LSD at 5% for A	0.36						0.40					
LSD for A*B	1.25						1.16					

Table (7) Effect of organic manures (FYM and pigeon) plus bio-fertilization (Nitrogen fixing, Phosphate dissolving bacteria and potassium releasing bacteria) on average weight of potato tuber Cv. " Cara " in the two winter seasons of 2019-2020 and 2020-2021.

Treatments	Average tuber weight (g/plant)											
	2019-2020						2020-2021					
NPK100%	117.93						131.36					
	Zero	50% NPK	75% NPK	100% NPK	Mean for B	LSD at 5% for B	Zero	50% NPK	75% NPK	100% NPK	Mean for B	LSD at 5% for B
FYM	112.19	114.63	118.73	121.12	116.67		117.46	121.52	124.08	125.04	122.02	
PM	115.32	113.82	115.1	120.19	116.11		117.79	121.76	124.32	125.33	122.30	
FYM+PM	114.78	115.52	119.21	121.88	117.85		117.91	122.09	124.73	125.78	122.63	
Bofert	111.36	118.54	120.82	120.06	117.70		117.06	119.23	123.07	123.88	120.81	
Biopotass	109.67	114.38	117.55	118.55	115.04		116.26	118.39	122.24	123.35	120.06	
Biophos	110.56	116.64	118.02	119.32	116.14		116.64	118.85	122.67	123.50	120.42	
FYM+Biofert	117.26	121.64	118.06	122.01	119.74		120.65	127.49	130.14	132.15	127.61	
FYM+Biopotass	112.87	115.82	115.99	120.1	116.20	0.73	119.55	125.95	128.99	130.67	126.29	0.50
FYM+Biophos	116.07	116.74	119.44	121.2	118.36		120.18	126.94	129.43	131.49	127.01	
PM+Biofert	115.19	120.62	122.39	124.89	120.77		121.08	127.58	130.51	132.41	127.90	
PM+Biopotass	113.69	117.7	116.22	123.73	117.84		119.55	126.42	129.27	131.09	126.58	
PM+Biophos	113.57	114.67	116.83	123.95	117.26		120.32	127.04	129.87	131.72	127.24	
FYM+PM+Biofert	112.96	117.24	123.06	127.79	120.26		128.76	133.35	134.61	135.51	133.06	
FYM+PM+Biopotass	111.42	115.67	122.92	125.90	118.98		127.86	132.77	133.83	134.85	132.33	
FYM+PM+Biophos	112.23	116.52	119.9	126.82	118.87		128.22	132.96	134.25	135.25	132.67	
Mean for A	113.28	116.68	118.95	122.50			120.62	125.49	128.13	129.47		
LSD at 5% for A	0.48						0.11					
LSD for A*B	1.47						0.99					

Table (8) Effect of organic manures (FYM and pigeon) plus bio-fertilization (Nitrogen fixing, Phosphate dissolving bacteria and potassium releasing bacteria) on average total yield ton.fed-1 of potato tuber Cv. " Cara " in the two winter seasons of 2019-2020 and 2020-2021.

Treatments	Total yield (ton/fed)											
	2019-2020						2020-2021					
NPK100%	11.515						18.614					
	Zero	50% NPK	75% NPK	100% NPK	Mean for B	LSD at 5% for B	Zero	50% NPK	75% NPK	100% NPK	Mean for B	LSD at 5% for B
FYM	5.722	9.100	14.129	15.093	11.011		5.328	8.955	11.250	12.045	9.395	
PM	6.528	10.313	15.008	15.672	11.880		6.014	9.660	11.980	12.787	10.110	
FYM+PM	6.498	11.783	16.213	16.576	12.768		6.683	9.686	12.012	12.824	10.301	
Bofert	8.197	9.411	13.700	12.920	11.057		5.308	7.436	10.470	11.230	8.611	
Biopotass	6.842	9.722	7.334	9.412	8.328		3.951	6.709	7.619	10.480	7.190	
Biophos	8.138	12.552	8.025	10.812	9.882		4.630	7.412	10.425	11.198	8.416	
FYM+Biofert	9.309	11.725	14.049	19.352	13.609		8.886	14.451	16.965	19.471	14.943	
FYM+Biopotass	7.675	10.494	9.859	17.702	11.433	1.234	7.452	12.840	15.343	17.768	13.351	1.246
FYM+Biophos	8.544	11.253	13.543	17.864	12.801		8.169	13.666	15.399	18.624	13.964	
PM+Biofert	9.791	10.253	15.251	16.985	13.070		8.916	14.463	17.757	19.508	15.161	
PM+Biopotass	7.731	8.664	11.854	14.030	10.570		7.453	12.901	16.116	17.835	13.576	
PM+Biophos	9.016	9.104	13.903	15.445	11.867		8.189	13.675	16.930	18.657	14.363	
FYM+PM+Biofert	7.681	12.616	13.242	21.007	13.637		15.318	20.410	22.888	24.568	20.796	
FYM+PM+Biopotass	6.307	11.149	12.538	17.829	11.956		14.486	18.806	21.238	23.692	19.556	
FYM+PM+Biophos	7.002	11.231	12.230	19.403	12.467		15.265	19.589	22.062	23.764	20.170	
Mean for A	7.665	10.625	12.725	16.007			8.403	12.711	15.230	16.963		
LSD at 5% for A	0.458						0.863					
LSD for A*B	2.469						2.493					

Table (9) Effect of organic manures (FYM and pigeon) plus bio-fertilization (Nitrogen fixing, Phosphate dissolving bacteria and potassium releasing bacteria) on average weight of marketable tubers <45g (ton.fed-1) of potato Cv. " Cara " in the two winter seasons of 2019-2020 and 2020-2021.

Treatments	Weight of marketable tubers > 45g (ton/fed)											
	2019-2020						2020-2021					
NPK100%	10.063						17.791					
	Zero	50% NPK	75% NPK	100% NPK	Mean for B	LSD at 5% for B	Zero	50% NPK	75% NPK	100% NPK	Mean for B	LSD at 5% for B
	5.311	8.793	13.430	14.194	10.432		5.051	8.505	10.769	11.494	8.955	
PM	5.989	9.933	14.619	14.741	11.321		5.706	9.254	11.431	12.202	9.648	
FYM+PM	5.951	11.579	15.649	15.547	12.181		6.345	9.278	11.427	12.199	9.812	
Bofert	7.808	9.071	12.497	12.490	10.467		5.063	6.768	9.957	10.715	8.126	
Biopotass	6.835	9.301	6.766	9.140	8.010		3.741	6.364	7.270	10.034	6.852	
Biophos	7.884	11.878	7.415	10.478	9.414		4.158	7.109	9.947	10.648	7.966	
FYM+Biofert	8.758	11.211	13.309	18.430	12.927	1.188	8.446	13.822	16.225	18.543	14.259	1.188
FYM+Biopotass	7.974	10.056	9.392	16.880	11.075		7.140	12.288	14.615	16.954	12.749	
FYM+Biophos	7.891	11.007	12.669	17.003	12.143		7.762	13.070	14.693	17.733	13.315	
PM+Biofert	10.017	9.312	14.320	16.201	12.462		8.538	13.833	16.907	18.615	14.473	
PM+Biopotass	7.993	7.954	11.459	13.330	10.184		7.082	12.276	15.378	17.051	12.947	
PM+Biophos	8.627	8.710	13.582	14.747	11.417		7.844	13.014	16.117	17.802	13.694	
FYM+PM+Biofert	7.285	12.005	12.090	20.068	12.862		14.587	19.509	21.869	23.405	19.843	
FYM+PM+Biopotass	5.999	10.689	11.254	16.987	11.232		13.797	17.978	20.266	22.571	18.653	
FYM+PM+Biophos	6.646	10.765	11.391	18.485	11.822		14.530	18.658	21.019	22.705	19.228	
Mean for A	7.398	10.151	11.989	15.248			7.986	12.115	14.526	16.178		
LSD at 5% for A	0.444						0.842					
LSD for A*B	2.376						2.375					

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الملخص العربي

تأثير التسميد المعدني والعضوي والحيوي على البطاطس في أرض مصرية رملية

1- الجزء الأول: النمو الخضرى وانتاجية المحصول

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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 إستخدام التسميد العضوى مع الحيوى حسن من صفات النمو الخضرى من حيث نسبة الإنبات، ارتفاع النبات، عدد الأفرع للنبات و الوزن الطازج و الجاف لاوراق البطاطس بالإضافه الى تحسين إنتاجية المحصول من حيث (عدد الدرنات/نبات، إجمالى المحصول الكلى بالطن / فدان، متوسط وزن الدرنه و متوسط وزن الدرنات القابله للتسويق) ووجد أن خليط من السماد البلدي وزرق الحمام في وجود التسميد الحيوى لبكتريا مثبته للنيتروجين في صوره فرديه للنمو الخضرى و المحصول 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 و الحصول على إنتاج عالى ومنتج آمن من درنات البطاطس.