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EFFECT OF REDUCING N, P MINERAL FERTILIZATION LEVELS COMBINED WITH BIOFERTILIZER ON GROWTH, YIELD AND TUBER QUALITY OF POTATO PLANTS

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ABSTRACT

This work was carried out at private farm (loamy soil), in Shobramant village, Giza governorate., during 2005 and 2006 summer planting seasons, to evaluate effect of reducing the recommended dose of nitrogen and phosphorus mineral fertilizers combined with seed potato tubers and plant inoculation with bio-fertilizers on plant growth, productivity, tuber quality expressed as nitrate and nitrite accumulation, specific gravity, dry matter and total carbohydrate of two potato cultivars and bacterial densities (total count of microbes, number of *Azotobacter spp.,* number of *Azospirillum spp.* in the rhizosphere. The results showed that Diamant and Spunta cultivars differed significantly in their responses to growth, yield and tuber quality characteristics, Spunta cultivar recorded the best growth with highest mean tuber weight, nitrate and nitrite tuber content. Reducing mineral N, P levels to 90, 80 and 70 % of the recommended rates combined with bio-fertilizer gave equal yield to that obtained by recommended doses. Moreover, reducing mineral N, P levels to 60 and 50% of the recommended rates significantly increased tuber specific gravity and reduced nitrate and nitrite accumulation in potato tubers. The most promising treatment is bio-fertilizer combined with 70% of recommended mineral N, P dose which satisfy the objective of producing high quality tuber with low nitrate and nitrite level and save about 30% of the cost of nitrogen and phosphorus fertilizers. On the other hand, microbial of densities of bacterial counts, *azotobacter, azospirilla* and bacillus in the rizosphere increased gradually with advanced reducing mineral fertilizers. Reducing mineral NP rates to the half and biofertilizer produced high quality tubers with low nitrate and nitrite content and also increased microbial densities in potato root rhizosphere.

Keywords: Potato, *Solanum tuberosum* L., N, P Mineral fertilizers, Bio-fertilizer, Nitrate, Specific gravity, Tuber quality, Yield.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is a crop of major significance in human nutrition, ranking fourth in food production, after wheat, corn (maize), and rice. It is the first in energy production, and second in carbohydrate and protein production (Nieder, 1992). Some of the world's largest and smallest, richest and poorest, and most progressive and most backward farmers grow potatoes (Horton and Anderson, 1992). Current systems of potato growing use large amounts of fertilizers and pesticides which are costly and cause environmental problems. The presence of sufficient potassium, phosphorus and nitrogen markedly increases the size of plant vegetative growth and leaf area (Burton, 1989). The need for phosphorus like nitrogen is critical during the early stage of plant growth where normal meristem development and rapid plant growth are necessary for high yield (Burton, 1989). Hence, it is rather important to insure adequate phosphorus availability to fulfill plant requirements, in order to accomplish high seed yield and quality. A strategy for integrated low-input potato production has been developed by Vereijken *et al* (1991) with the aim of reducing cost, improving product quality and reducing environmental damage. The strategy involved suitable crop rotation, and modest fertilizer use. In this regard, several trials have been preformed to minimize the use of inorganic fertilizers using organic and bio-fertilization (Abed-Allah, 1999), mineral N, P and bio-fertilizers (Ghosh *et al*., 2000; Hegazi and Awad, 2002) and using organic manures (El-Banna and Abed-El-Salam, 2000). The utilization of bio fertilizers is considered as a promising alternative, particularly for developing countries, bio-fertilizers mainly comprise nitrogen fixers, phosphate dissolvers (El-Hadad *et al.*, 1993). Soil reaction may affect the proportion of various elements absorbed by the plant. In Egypt, phosphate fixation is one of the reactions that occur in the alkaline high pH soils, that reaction transforms soluble phosphate to unavailable calcium forms. As a result, phosphate absorption is reduced with corresponding negative effects on the development of the plant (Burton, 1989). Therefore, there is an increasing tendency to use *Azotobacter* and *Azospirillum* strains as bio-fertilizer fixing atmospheric nitrogen. The role of N2-fixing bacteria in increasing yields and improving nutrient uptake by field crops wheat and potato with or without mineral N, P application were emphasized by (Rabie *et al*. (1995). Moreover, Ashour (1998) indicated that applying phosphorein bio-fertilizer to seed potato tubers significantly increased foliage fresh weight/plant, tuber yield/fed. and tuber dry weight compared to untreated tubers. In addition, Awad *et al*. (2002) have been reported that treating seed potato tubers with microbein (bio-fertilizer) at rate of 10.6 kg/ton before planting in addition to 75 % of the recommended mineral N, P dose, produced maximum yield and improved tuber quality. Also, Ghosh *et al*. (2000) found that using half dose of mineral N, P combined with bio-fertilizer increased potato yield approximately to that obtained using full dose of mineral N, P Nitrate ion is a well known environmental pollutant because of its potential role in infant methemoglobinemia associated with the consumption of nitrate-rich vegetables (Alexander, 1977). The formed nitrite presents a toxic hazard both because of the direct toxicity of nitrite and by the formation of carcinogenic N-nitroso compound. In addition, the nitrate concentration in potato was recorded in the range between 75- 1000 mg / kg of tuber fresh weight (US National Academy of Science, 1981). Accordingly, active researches must be conducted to find out ways of reducing nitrate accumulation in vegetable crops.

The present investigation aimed to use the bio fertilizers as a cheap, safe and simple method to reduce mineral N, P. fertilizers application and reduce nitrate and nitrite accumulation in the edible part of potato under our loamy Egyptian soil condition.

MATERIALS AND METHODS

The present work was carried out at a private farm in Shobrament village, Sakkara road, Giza, during planting summer seasons of 2005 and 2006. Physical and chemical analyses of the experimental soil as well as organic chicken manure used in this experiment are presented in Tables (1 a & b and 2), respectively.

Table (1a) Chemical analysis of soil used during 2005 and 2006 seasons

Year	pH	EC ($\mu S\ cm^{-1}$)	$Caco_3$ %	Cation meq / L				Anion meq / L				ppm.		
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Co_3^{--2}	HCO_3^{-}	CL^{-}	SO_4^{--2}	N	P	K
2005	8.4	0.62	3.84	1.6	0.4	2.7	0.6	0	1	2.5	1.8	60	19	580
2006	8.5	0.67	3.81	1.5	0.3	2.9	0.5	0	2	3	1.7	75	21	571

Table(1b) Mechanical analysis of soil used during 2005 and 2006 season .

Year	Sand %	Silte %	Clay %	Soil texture
2005	53.12	12	34.88	Loamy
2006	54.49	12	33.51	Loamy

Table (2) Analysis of chicken manure used during 2005 and 2006 seasons.

Year	Macro Elements (%)				Micro Elements (ppm)				C/N Ratio	O.M %	C %
	N	P_2O_5	K_2O	Ca	Mg	Fe	Zn	Mn			
2005	4.31	3.76	2.63	1.22	0.46	409	240	214	4.56	37.45	18.31
2006	4.16	3.19	2.57	1.19	0.49	450	218	213	4.49	38.78	19.51

Two potato (*Solanum tuberosum* L.) cultivars, namely Spunta (table variety) and Diamont (table and processing variety), were selected among potato cultivars widely grown in Egypt. The two cultivars were imported from the Netherlands. Pre-sprouted cuted seed tubers were planted in 6 rows of 4 m length and 5 width at 0.75 m apart and 0.25 m within the row on January 25, in both years, therefore , the area of each experimental plot was 20 m^2. All experimental units received identical amounts of chicken manure at rate of 15 m^3 /fed., and the sulphate of potash (50 % K_2O) at a rate of 96 kg K_2O Fed^{-1} where 50 % of the total was added before planting and the rest was added after 45 days from planting. The experimental design was a split plot with three replications, in both years. The cultivars were assigned for the main plots whereas the fertilization treatments were distributed in the sub-plots. Fertilization treatments included the recommended rate of nitrogen and phosphorus fertilizers and inoculation of seed potato tubers with bio-fertilizer combined with reducing the recommended rate of mineral N, P fertilizers.

The fertilization treatments were designed as follows:

A. = Check treatment: The recommended dose of mineral N, P fertilizers without tuber inoculation with bio-fertilizer. The added phosphorus rate was 75 kg P_2O_5 Fed^{-1} provided from single super-phosphate (15 % P_2O_5) banded on rows before planting. Nitrogen fertilizer (150 kg N Fed^{-1}) was added at three equal doses, the first was base-dressed before planting as ammonium sulphate (20.6 % N). The second and third amounts were applied at 45 day after planting and two weeks later, respectively, in the form of ammonium nitrate (33.5 % N).

B. = A–10 % of recommended mineral N, P plus inoculation of seed tubers with bio-fertilizer.

C. = A – 20 % recommended mineral N, P plus inoculation of seed tubers with bio-fertilizer.

D. = A – 30 % recommended mineral N, P plus inoculation of seed tubers with bio-fertilizer.

E. = A – 40 % recommended mineral N, P plus inoculation of seed tubers with bio-fertilizer.

F. = A – 50 % recommended mineral N, P plus inoculation of seed tubers with bio-fertilizer.

Cultural management, disease and pest control programs were followed according to the recommendations of the Egyptian Ministry of Agriculture, for potato production (Tawfik *et al*., 1998).

Microorganisms (bio-fertilizer):

Asymbiotic nitrogen-fixing bacteria such as (*Azotobacter chroococcum Azospirillum lipoferum)* , *Bacillus megaterium* var *Phosphaticum* (Phosphate dissolver) the strains were used as suspension mixture from biofertilizers using (1:1: 1) rate which were obtained from unit of Bio-fertilizers, Fac. Agric. Ain-Shams Univ., Cairo, Egypt. The homogenous sized tubers inoculation were carried out before planting using a bacterial suspension of tested organisms containing 10^8 cell / ml $^{-1}$ from each strain and after 20 days from planting, plants were subjected to inoculation using a bacterial suspension of tested organisms containing 10^8 cell / mL^{-1} from each strain.

Data recorded:

I. Vegetative characteristics

Plant samples were randomly collected from each treatment at 75 days after planting (DAP) and the following data were recorded:

a. **Plant height:** was determined for 12 plants from each treatment.
b. **Number of leaves per plant:** was determined for 12 plants from each treatment.
c. **Number of branches per plant:** was determined for 12 plants from each treatment.
d. **Stem diameter:** was determined for 12 plants from each treatment.
e. **Average leaf area per plant:** was determined using the fourth expanded upper leaf of 15 plants from each treatment according to the method described by **Koller (1972).**
f. **Foliage dry weight per plant:** foliage of 9 plants was dried at 70 ^{o}C until a constant weight, and then the temperature was raised to 105 ^{o}C for 24 hours, then weight and recorded.

II. Chemical Analyses:

Leaf chlorophyll reading (SPAD): Leaf chlorophyll was determined at 75 days after planting (DAP) using the fourth expanded upper leaf of 12 plants per treatment. A digital chlorophyll meter, model Minolta chlorophyll meter SPAD-502, manufactured by Minolta Company was used.

The youngest full expanded thirty mature leaves (the fifth leaf from the top of the plant) of each treatment were randomly collected at 75 days after planting (DAP) to **determine leaf N,P,K** and **total carbohydrate concentration**. Leaf samples were washed with distilled water and dried at 70 ^oC for 48 h in air-forced ventilated oven. **Nitrogen** was determined colorimetrically following acid digestion according to the procedure described by Kock and McMeekin (1942). **Potassium** was estimated by flame photometer due the procedures described by Brown and Lilliland (1946). **Phosphorous** was determined colorimetrically following acid digestion according to the procedure described by Troug and Meyer (1939).

III. Tuber quality and yield components:

Each experimental plot was harvested individually after 120 days from planting and these parameters were recorded:

- **a. Average number of tubers per plant:** averaged from 18 plants per treatment.
- **b. Total tuber yield per plant:** averaged from 18 plants per treatment.
- **c. Mean tuber weight.**
- **d. Total tuber yield per feddan.**
- **e. Tubers specific gravity (S.G.):** was determined immediately after harvest using the following formula: S.G. = Tubers weight in air (g) / (Tubers weight in air – tubers weight in water) **(**Nissen, 1955).
- **f. Dry matter percentage of potato tubers (DM%):** To calculate the percentage of dry matter, weight pieces of tubers was oven-dried at 105 ^oC till constant weight in air-forced ventilated oven according to Dogras *et al* (1991) .
- **g. Tuber total carbohydrate percentage:** in the dry matter of the tubers of 9 plants per treatment. Samples were measured colorimetrically according to A.O.A.C. (1990).
- **h. Tuber nitrate and nitrite content:** were determined in dry matter of tuber according to the method of Nristna and Donaldson (1978).

V. Densities of micro organisms:

Densities of *azotobacters, azosprilla* and *bacillus* per gram of dry rhizospheric soil counted at 30, 60, and 90 days from planting and determined on Ashby's medium (Abdel-Malek and Ishac, 1968), and semi solid malate medium, (Doberiener, 1978), respectively, by MPN technique and the numbers were calculated using cochran's table (Cochran, 1950). While *bacillus* densities were counted using plate count technique on their specific media (Yassen, 2003).

Statistical analysis

The obtained data from 2005 and 2006 seasons were statistically combined analyzed after *chi-square* test for homogeneity of *K* variance with equal degree of freedom according to the procedure described by Snedecor and Cochran, (1982). The Fishers protected least significant difference (LSD) at $P \leq 0.05$ was employed to separate the treatment means.

RESULTS AND DISCUSSION

1. Vegetative characteristics:

Data presented in Table (3) show that regardless of fertilization treatments, the studied cultivars differed significantly in their growth behavior. Spunta cultivar recorded the higher plant height, stem diameter, number of leaves per plant, leaf area and foliage dry weight compared to Diamant cultivar which recorded the lower values. Differences between Spunta and Diamant cultivars in vegetative growth might be due to differences in growth behavior and responses of these cultivars. These results were in good harmony with those reported by Gabr and Sarg (1998), who found significant plant height differences among five potato cultivars, also, with Kim *et al*. (1993) who recorded significant differences in number of leaves per plant, and with El-Kaddour (2005) who found significant differences in stem diameter, leaf area /plant and foliage dry weight /plant between Spunta and Diamant cultivars subjected to flowering induction treatments. As indicated earlier, there are genotypic differences in nutrient use efficiency at the same level of soil fertility. Better spatial exploitation of the root system, release of acidifying and/or chelating substances can explain genotypic differences in uptake efficiency (Badawy and Ahmed, 2006).

On the other hand, the tested fertilization rates regardless of the cultivars were differed significantly in their effect on plant growth where 90 % of the recommended mineral N, P dose plus bio-fertilizer recorded the highest growth values, followed by the treatment in which the recommended mineral N, P dose (check) were applied. Also, no significant differences were obtained when 80, 70 and 60 % of recommended mineral N, P dose + bio-fertilizer were applied whereas the lowest growth values were recorded when the recommended mineral N, P rate were reduced to 50 % + bio-fertilizer. Indicating that reducing the recommended dose of mineral N, P either with bio-fertilizer caused significant reeducation in plant growth. The obtained enhancing effects of mineral N, P on vegetative growth of potato may be attributed to the beneficial effects of N on stimulating for aerostatic activity for producing more tissues and organs, since N play major roles in the synthesis of structural proteins and other several macromolecules, in addition, to its vital contribution in several biochemical processes in the plant related to growth (Marschner, 1995). Besides, nitrogen is an important constituent of protoplasm and enzyme, the biological catalytic agents which speed up life processes, have N as their major constituents (Mengel and Kirkby, 1987), also, the beneficial effect of applied P on plant growth may be due through its content in nuclic acids DNA and RNA and through its role in photosynthesis and respiration (Mengel and Kirkby, 1987). Moreover, additive effect of bio-fertilizer on plant growth have been reported through the soil micro organisms known as phosphate solubilizing bacteria play fundamental role in converting P fixed form to be soluble and available for plant nutrition (Quastel, 1965; and Zayed, 1988). In addition, *Azotobacter* and *Azospirillum* nitrogen fixing bacteria not only provides the nitrogen but also produces a variety of growth promoting substances like IAA, GA and vitamin B (Becking, 1981; and Fayez *et al* 1985). Hence, the combination effect of mineral and bio-fertilizer on enhancing plant growth can be expected. The obtained enhancing effects of mineral N, P on vegetative growth of potato are in good harmony with the results recorded by Badawy and Ahmed (2006) who reported that increasing mineral N, P fertilizer levels from 60 + 30 to 180 + 90 kg N + P_2O_5 /fed significantly increased potato growth parameters expressed as plant height, foliage fresh weight and number of stems per plant. Also, the promotive effect of bio-fertilizer inoculation agree with the results obtained by El-Gamal (1996a) who found that inoculation of seed potato tubers with bio-fertilizer increased plant height.

The interaction between the two studied factors was significant, data presented in Table (3) show that the highest plant height, stem diameter, mean leaf area, number of leaves/plant and foliage dry weight were recorded by Spunta cultivar subjected to the 90% of the recommended mineral N,P rates combined with bio-fertilizer. Whereas, the highest number of branches/plant was recorded when Diamant cultivar has treated with the recommended mineral N, P dose (check treatment). On the contrary, the lowest growth values were obtained when Diamant plants was subjected to half recommended dose of mineral N, P + bio-fertilizer treatment.

2. Chemical analyses:

2.1. Leaf chlorophyll reading:

Regarding the studied cultivars, data presented in Table (4) indicate that there were no significant differences between the studied cultivars in leaf chlorophyll content during the course of study, regardless of fertilization treatments. This result is in parallel with that recorded by El-Kaddour (2005) who found no differences between Spunta and Diamant cultivars subjected to flowering induction treatments. The concentration of leaf chlorophyll in the tissues of potato leaves 75 days after planting (DAP) decreased progressively and consistently with decreasing mineral N, P fertilizer level from 100 % of the recommended levels to the half + bio-fertilizer inoculation. The depressing effect of reducing mineral N, P levels on chlorophyll content in leaves was in harmony with results reported by Gungula *et al*. (2005), who mentioned that N fertilization delayed metabolic changes associated with senescence include chlorophyll loss, also P fertilization which delay proteolysis and changes in nucleic acid DNA and RNA levels (Mengel and Kirkby, 1987). This result is in agreement with that obtained by El-Gamal (1996a) who mentioned that increasing N rate significantly increased leaf chlorophyll content of potato plants.

2.3. Leaf total nitrogen percentage

Regardless of fertilization treatments, data in Table (4) show that Spunta cultivar recorded the higher percentage of foliage total nitrogen (4.33 %). On the contrary, Diamant cultivar had the lower percentage (3.91%) foliage total N. Differences between the studied cultivars in percentage of foliage total nitrogen might be due to the genetic differences as previously demonstrated by Zrust *et al*. (1999) among four potato cultivars under their study. Also, El-Gizawey *et al* (2006) recorded significant differences in foliage total nitrogen % between Spunta and Diamant potato cultivars. As indicated

Table (3): Effect of fertilizer treatments, cultivars and their interactions on vegetative of potato plants at 75 days after planting (combined analyses of 2005 and 2006 summer seasons).

Cultivar	Fertilizer treatments	Plant height (cm)	No. of stem/ plant	Stem diameter (cm.)	No. of leaves/ plant	Average leaf area (cm^2)	Foliage dry weight (g) / plant
Spunta	A (control)	٨١,٤0	4.33	١,٨٠	142.3	27.9	127.6
	B	٩٠,٤0	5.00	١,٩٠	١٤٩,٨	29.1	159.6
	C	٧٦,٨٠	3.67	٧٨.١	١٤٣,٦	26.2	125.4
	D	٧٥,١٣	3.33	١,٧٦	1٢9.9	25.9	121.2
	E	٧٣,١٥	3.33	١,٦٣	1٢1.2	24.9	109.8
	F	٦٥,٨0	3.00	٥٦.١	١٠١.00	23.3	94.7
Mean Spunta		**77.11**	**3.78**	**1.74**	**131.3**	**26.22**	**123.1**
Diamont	A (control)	٦٤,٣٣	3.67	٨٦.١	116.7	26.0	112.0
	B	٦٨,١٠	4.33	1.70	١٣٢,٧	28.8	135.2
	C	٥٦,٠٠	3.33	1.60	١١٣,٨	25.1	103.9
	D	٥٣,٦٤	3.00	٦٤.١	١٠٦,٣	24.7	105.4
	E	٥٣,٨٨	3.33	١,٣٦	١٠٠,٧	24.1	98.9
	F	٤٩,٣٣	2.67	1.48	٨٩,٦	22.9	72.9
Mean Diamant		**57.55**	**3.33**	**1.61**	**111.8**	**25.27**	**104.72**
Mean fertilizer	A (control)	72.87	4.00	1.83	129.5	26.95	119.8
	B	79.25	4.67	1.80	141.25	28.95	147.4
	C	76.8	3.50	1.69	128.7	25.65	114.65
	D	64.385	3.17	1.70	118.1	25.3	113.3
	E	63.515	3.33	1.50	110.95	24.5	104.35
	F	57.565	2.84	1.52	95.3	23.1	83.8
LSD at 5% level for cultivar		٢,٩١	٠,١٩	٠,٠٥	٦,٥٧	٠,٢٣	٤,١
Fertilizer		٣,٣١	٠,٣٩	٠,٠٩	٨,٧٦	٠,٦١	٦,٨٤
Cultivar × Fertilizer		٧,٦٨	٠,٦٥	٠,٢٧	١٢,٠٨	١,٣٣	١٠,٦٢

A = 100% of recommended mineral N, P fertilizer doses and uninoculated with bio-fertilizers (control).

B = 90% of recommended mineral N, P fertilizer doses plus seed tuber inoculation with bio-fertilizers.

C = 80% of recommended mineral N, P fertilizer doses plus seed tuber inoculation with bio-fertilizers.

D = 70% of recommended mineral N, P fertilizer doses plus seed tuber inoculation with bio-fertilizers.

E = 60% of recommended mineral N, P fertilizer doses plus seed tuber inoculation with bio-fertilizers.

F = 50% of recommended mineral N, P fertilizer doses plus seed tuber inoculation with bio-fertilizers.

earlier, there are genotypic differences in nutrients use efficiency at the same level of soil fertility can explain genotypic differences in nutrient uptake efficiency (Badawy and Ahmed, 2006).

Regardless of tested cultivars, results in Table (4) show that total N % in potato leaves decreased progressively and consistently with decreasing the recommended dose of mineral N,P fertilization. Decreasing mineral N,P fertilizers to half of the recommended+ bio-fertilizer caused more reduction of leaf N % than check treatment. These results are similar to that reported by Badawy and Ahmed (2006), who found that increasing mineral N,P fertilization significantly increased leaf N concentration of potato leaf grown under sandy soil conditions. Moreover, El-Gamal (1996a) have been reported that increasing N rate plus inoculation with bio-fertilizer significantly increased leaf N concentration.

The interactions between cultivars and fertilization treatments were significant in relation to leaf N concentration, The highest leaf N % was obtained when Spunta plants were treated with the recommended dose of mineral N, P compared to the lowest concentration recorded by Diamant cultivar subjected to 70 % mineral N, P plus bio-fertilizer.

2.4. Leaf total phosphorus percentage

Regarding the studied cultivars, data presented in Table (4) indicate that there were no significant differences between the studied cultivars in leaf phosphorus content, regardless of fertilization treatments.

Regarding the tested fertilization treatments, data in Table (4) reveal that reducing the recommended dose of mineral N, P to 90 and 80 % combined with bio-fertilizer inoculation significantly increased leaf P concentration. These two treatment were followed by the combination of bio fertilizer with 70, 60 or 50 % recommended mineral N, P dose, compared to the lowest values obtained under the check treatment. This result agrees with that obtained by El-Gamal (1996a) who recorded increment in foliage nutrient concentration with bio-fertilizers use. In this respect, Quastel (1965) and Zayed (1988) reported that soil micro organisms known as phosphate solubilizing bacteria play, fundamental role in converting P fixed form to be soluble and available for plant nutrition causing increase in P uptake and use efficiency.

Moreover, *Azospirillum* was found to have not only the ability to fix nitrogen but also to promote absorption of nutrients and photosynthesis process (Fayez *et al.*, 1985).

However, highest leaf P % was achieved by Spunta and Diamant cultivar under 90 and 80 % of the recommended dose of mineral N, P. While, the lowest interaction of leaf P % was obtained when plants had subjected to the check treatment in both cultivars.

2.5. Leaf total potassium percentage:

Data in Table (4) show that no significant difference were detected between the two used cultivars. In addition, no significant differences were achieved among the 6 tested fertilization levels. This may be to fact that all treatment have received ideal potassium quantity during the course of this study. Moreover, the interaction between potato cultivars and fertilization treatments did not record any significant differences in leaf potassium percentage.

3. Yield component:

3.1. Number of tubers per plant:

Data presented in Table (5) show that regardless of fertilization treatments, Spunta and Diamant potato cultivars differed significantly in number of tubers per plant. Diamant was the superior and recorded 20% more tubers per plant over Spunta one. The obtained result are in harmony with those obtained by Midan *et al*. (1986), who found significant differences in number of tuber per plant among 6 potato cultivars grown in Egypt and subjected to different N rates. This result might be due to the genetic differences between the two tasted cultivars.

Table (4): Effect of fertilizer treatments, cultivars and their interactions on chemical content in 5th expanded leaf of potato plants at 75 days after planting (combined analyses of 2005 and 2006 summer seasons).

Cultivar	Fertilizer treatments	Leaf chlorophyll reading (SPAD)	Leaf mineral (%)		
			Nitrogen	phosphorus	potassium
Spunta	A (control)	٥٣,٨	4.99	٠,٣٣	6.54
	B	٤٩,٥	4.96	٠,٥٦	٦,٢٣
	C	٣٨,٠	4.42	٠,٥٤	٦,٤٥
	D	٣7.9	4.11	٠,٤٨	٥,٥٨
	E	٣٦,٣	3.83	٠,٤٣	٥,٦٢
	F	٣٤,١	3.68	٠,٤٤	٥,١٠
Mean Spunta		**41.6**	**4.33**	**0.46**	**5.92**
Diamont	A (control)	٥٣,١	4.50	٠,٣٥	٦,٨٧
	B	٤٨,٧	4.58	٠,٥٤	٦,٤٠
	C	٣٨,٥	4.14	٠,٤٨	٥,٧٥
	D	3٨.3	3.52	٠,٣٨	٥,٨٥
	E	٣٥,٥	3.49	٠,٣٨	٥,٨٢
	F	٣٤,١	3.22	٠,٣٥	٥,٤٢
Mean Diamant		**41.4**	**3.91**	**0.41**	**6.02**
Mean fertilizer	A (control)	53.5	4.75	0.34	6.71
	B	49.1	4.77	0.55	6.32
	C	38.3	4.28	0.51	6.10
	D	38.1	3.82	0.43	5.72
	E	35.9	3.66	0.41	5.72
	F	34.1	3.45	0.40	5.26
LSD at 5% level for cultivar		NS	٠,١٢	NS	NS
Fertilizer		١,٥٣	٠,٣٧	0.05	NS
Cultivar × Fertilizer		٢,٠٣	٠,٦٦	0.06	NS

A = 100% of recommended mineral N, P. fertilizer doses and uninoculated with bio-fertilizers (control).
B = 90% of recommended mineral N, P. fertilizer doses plus seed tuber inoculation with bio-fertilizers.
C = 80% of recommended mineral N, P. fertilizer doses plus seed tuber inoculation with bio-fertilizers.
D = 70% of recommended mineral N, P. fertilizer doses plus seed tuber inoculation with bio-fertilizers.
E = 60% of recommended mineral N, P. fertilizer doses plus seed tuber inoculation with bio-fertilizers.
F = 50% of recommended mineral N, P. fertilizer doses plus seed tuber inoculation with bio-fertilizers.

Data presented in Table (5) also show that regardless of potato cultivars, the number of tubers per plant as well as total tuber weight/plant differed significantly among the tested fertilization levels. The highest number of tuber/plant and highest tuber weight were achieved when potato plants were fertilized with the recommended mineral N, P dose and that of 90 and 80% of recommended mineral N, P plus bio-fertilizer inoculation, without any significant differences among these three levels. On the contrary, the lowest tuber number /plant, total tuber weight/plant as well as lowest yield per feddan were recorded when the recommended mineral N, P level was reduced to the half plus bio-fertilizer inoculation. These three treatments led to highest number of tubers/plant, therefore, highest tuber weight and highest yield can be expected. It is widely accepted that nitrogen and phosphorus are the most limiting nutritional factor to crop production. Adequate levels should be established for good growth, economic yield and sustainable productivity (Al-Moshileh *et al*., 2005). Moreover, the highest number of tubers/plant, tubers weight and yield produced with decreasing mineral N, P levels to 90 and 80 % plus bio-fertilizer application may be due to the role of bio-fertilizer in enhancing nutrient availability and absorption (Zayed, 1988) releasing promoting phytohormones (GA and IAA) (Fayez *et al* 1985) vitamins (Becking, 1981), These findings are in accordance with those reported by El-Gamal (1996a), who found that increasing N rate or inoculation with bio-fertilizer significantly increased exportable and total tuber yields, and also with Ghosh and Das (1998), who mentioned that total tuber number/plant and total tuber yield were the greatest from using mineral fertilizer and inoculation with bio-fertilizer.

The highest tuber number per plant were obtained by Diamant plant treated with recommended mineral N, P dose (check treatment) and that subjected to 90% of mineral N, P + bio-fertilizer. On the other hand, the lowest values were obtained when Spunta plants were treated with half mineral N, P dose combined with bio-fertilizer application. This means that reducing the recommended mineral N, P dose to 70% in combination with seed tubers inoculation with bio-fertilizer recorded approximately equal yield to that obtained when recommended cultural management were used.

3.2. Mean tuber weight:

Data presented in Table (5) show that mean tuber weight differed significantly between the two tested cultivars where, Spunta recorded higher values compared to Diamant. The obtained result could be explained based on differences in growth behavior of the two tested cultivars where Spunta recorded the higher values regarding plant growth (Table, 3) and lowest tuber number per plant. In this regard, the increase in leaf area, weight, and chlorophyll content, all of which determine the photosynthetic activity of the leaf and ultimately dry matter production and allocation to the various organs of plants (Aluko and Fiscer, 1987). This means that more assimilates may be produced by Spunta plants and early translocated to least number of tubers hence the increase in tuber weight and size could be expected. (Khalil *et al.*, 2006).

Data in Table (5) also show that mean tuber weight was increased progressively and constantly with reducing recommended dose of mineral N, P from 100% to 60 and 50% combined with seed tuber inoculation with bio-fertilizer. This increment in tuber weight may be due to lower number of tubers per plant recorded when plants were subjected to these two treatments (E and F treatment). Similar result was found by Kundu and Gaur (1980), who mentioned that large and medium sized tubers were the greatest from reducing mineral fertilizer level and inoculation with bio-fertilizer. In this respect, Badawy & Ahmed, (2006) have been recorded significant reduction in tuber weight with decreasing mineral N, P and K fertilizers level. However,

Table (5): Effect of fertilizer treatments, cultivars and their interactions on yield characteristics of potato plants, at harvest (combined analyses of 2005 and 2006 summer seasons).

Cultivar	Fertilizer treatments	No. tubers / plant	Mean tuber weight (g)	Total tubers weight (g) / plant	Yield (ton) / fed.
Spunta	A (control)	٨,٣٣	93.78	٧٨١,٢٠	11.15
	B	٩,٠٠	81.79	٧٣٦,٠٨	10.51
	C	٧,٦٦	95.43	٧٣١,٠٠	10.14
	D	٧,٣٣	85.36	٦٢٥,٦٦	9.98
	E	٦,٦٧	87.29	٥٨٢,٢١	9.53
	F	٦,٠٠	80.55	٤٨٣,٢٨	6.90
Mean Spunta		**7.50**	**87.37**	**656.57**	**9.38**
Diamont	A (control)	١٠,٣٣	97.26	٨١٠,١٤	11.57
	B	٩,٣٣	88.91	٨٠٠,٢٢	11.43
	C	٩,٠٠	103.13	٧٩٠,٠٠	11.09
	D	٨,٦٧	87.57	٦٤١,٨٨	10.87
	E	٨,٣٣	88.92	٥٩٣,٠٨	9.97
	F	٦,٣٣	75.39	٤٥٢,٣١	6.46
Mean Diamant		**9.67**	**90.20**	**681.27**	**9.73**
Mean fertilizer	A (control)	9.33	95.52	795.67	11.36
	B	9.17	85.35	768.15	10.97
	C	8.33	99.28	760.50	10.62
	D	8.00	87.47	633.77	10.43
	E	7.50	88.11	587.65	9.75
	F	6.17	77.97	467.80	6.68
LSD at 5% level for cultivar		٠,٦٣	NS	٢٢,١٩	٠,٢٨
Fertilizer		١,١٢	١,٦١	٦٨,٩٧	٠,٩٥
Cultivar × Fertilizer		١,٦٨	٢,٢١	٩٧,٥٠	١,٣٢

A = 100% of recommended mineral N, P. fertilizer doses and uninoculated with biofertilizers (control).
B = 90% of recommended mineral N, P. fertilizer doses plus seed tuber inoculation with bio-fertilizers.
C = 80% of recommended mineral N, P. fertilizer doses plus seed tuber inoculation with bio-fertilizers.
D = 70% of recommended mineral N, P. fertilizer doses plus seed tuber inoculation with bio-fertilizers.
E = 60% of recommended mineral N, P. fertilizer doses plus seed tuber inoculation with bio-fertilizers.
F = 50% of recommended mineral N, P. fertilizer doses plus seed tuber inoculation with bio-fertilizers.

the interaction between the tested cultivars and fertilization treatment was significant, where the highest mean tuber weight was achieved by Spunta plants subjected to half quantity of recommended mineral N, P levels combined with bio-fertilizer inoculation.

3.3. Total tuber weight per plant:

Data in Table (5) also show that Diamant cultivar recorded that heigher tubers weight /plant compared to Spunta. In this respect, Midan *et al* (1986) have been reported significant differences among 6 tested cultivars in tuber weight /plant subjected to different rate of N fertilizer and with the result reported by Marines and Bodlander (1975), who found that the 9 tested potato cultivars differed in their total tuber weight /plant. The increase in total tuber weight per plant exhibited by Diamant cultivar may be partly due to fact that this cultivar had the higher number of tubers/plant and moderate high mean tuber weight, hence the highest tuber weight/plant can be expected.

The interaction between potato cultivars and fertilization treatment was significant regarding number of tubers /plant, total weight and yield/fed.

3.4. Tuber yield per feddan (ton):

Data in Table (5) show that the higher yield/fed was recorded by Diamant cultivar. In this respect, Midan *et al*. (1986) have been recorded significant differences in yield among Alfa, Aremen, Claudia, Claustar, Diamant and Nicola potato cultivars commonly grown in Egypt. The obtained increase in yield by Diamant cultivar could be explained due to the higher number of tubers/plant and higher tuber weight/plant and moderate high mean tuber weight. In addition, Abed El-Gadir *et al* (2003) have been reported that average yields vary between 20 and 40 t/ha in several tested cultivars.

As previously reported, the highest yield/fed was achieved when plants were subjected to the recommended NP levels and/or that subjected to 90, 80 and 70% of recommended NP + bio-fertilizer, whereas, the least yield was recorded when NP dose was reduced to the half of the recommendation rates.

4. Tuber quality characteristics:

Data presented in Table (6) show that Diamant cultivar recorded higher tuber specific gravity, dry matter % and tuber total carbohydrate percentage compared to Spunta cultivar regardless of fertilization treatments. The obtained results may be due to genetic differences between the two tested cultivars. Similar results were obtained by Ghosh *et al*. (2000), who found significant differences between May queen and Dejima potato cultivars in dry matter % also, agree with the result of Ilin *et al*. (1997), who reported differences in total carbohydrate % between Desiree and Kennebec potato cultivars subjected to different N and irrigation rates, also, with Marines and Bodlander (1975), who found significant differences in dry weight among 9 potato cultivars. Moreover, Midan *et al*. (1986) found that Alfa, Aremen, Claudia, Claustar, Diamant and Nicola potato cultivars commonly grown in Egypt had differed in their tuber specific gravity in response to increasing N fertilizer levels.

Data presented in Table (6) show that regardless of potato cultivars, the specific gravity of potato tubers was increased significantly by reducing the recommended dose of mineral N, P fertilizers. The highest values were recorded by the tubers produced from plants received 60 and 50% of recommended mineral N, P rates combined with seed tuber inoculation with bio-fertilizer. Whereas the lowest SG was obtained when check treatment was applied. The rest of fertilization treatments recorded intermediate values. Several reports have been positively correlated specific gravity (SG) with tuber weight (Abou-Hessein *et al*., 2002; Tawfik, 2001). Our results show that reducing mineral N, P recommended levels to 60 or 50% plus bio-fertilizer gave the highest mean tuber weight, therefore the highest specific gravity could be expected.

These results are in accordance with the results obtained by El-Gamal (1996a), who found that inoculation of seed potato tuber with bio-fertilizer had increased tuber SG. Also, Abou-Hessein *et al*. (2002) mentioned that using bio-fertilizer with half or quarter of recommended dose of mineral fertilizer caused increasing in SG of potato tuber. The effect of bio-fertilizer in increasing SG could be due to its fundamental role in converting fixed form of P or K to be soluble ready for plant nutrition making the uptake of nutrients by plants more easy (Quastel, 1965; Zayed, 1988).

However, the interaction between the two studied factors was significant, the highest SG was recorded when Spunta plants were subjected to both levels of 60 and 50% of mineral N, P recommendation combined with bio-fertilizer. While the lowest values were obtained when both Spunta and Diamant plants were subjected the check fertilizers treatment.

Regarding tuber dry matter % and tuber carbohydrate %, data in Table (6) show that the highest values were recorded when plants were treated with 90 % of recommended mineral N, P levels combined with bio-fertilizer compared to the lowest values which obtained when plants were subjected to either 60 or 50 % mineral N, P + bio-fertilizer. Moreover, no significant differences were achieved among check treatment and those in which the recommended mineral N, P levels was reduced to 80 or 70 % combined with bio-fertilizer. This result may be due to the promotive effect of bio-fertilizer with reducing mineral N, P levels on leaf total carbohydrate (Table 5) or increasing N and P uptake by plants in turn enhancing photosynthesis process in which more final products will be produced and translocated to storage organs. The obtained result agrees with that reported by Abou-Hessein *et al*. (2002), who found that applying bio-fertilizer to potato crop with reducing mineral fertilizers level had increased leaf N, P, K, Mg content, tuber dry matter, tuber specific gravity and tuber total carbohydrate percentage.

The interaction between potato cultivars and fertilization treatments was significant regarding both tuber DM and total carbohydrate%. Lowest DM and total carbohydrate% were obtained when Spunta plants were subjected to bio-fertilizer with reducing mineral N, P level to 50% of that recommended for commercial production ,while, the highest values were obtained by Diamant tubers produced from plants subjected to bio-fertilizer inoculation with reducing mineral N, P level to 90%.

4.1. Nitrate and nitrite concentration:

Data presented in Table (6) and illustrated in Fig. (1 & 2) show that nitrate and nitrite concentrations in Spunta and Diamant potato tubers differed significantly, the highest values were recorded by Spunta tubers. Several reports have been delt with nutrient concentration in potato tubers.

Table (6): Effect of fertilizer treatments, cultivars and their interactions on potato tuber characteristics, at harvest (combined analyses of 2005 and 2006 summer seasons).

Cultivar	Fertilizer treatments	Specific gravity (g/cm^3)	Dry matter (%)	Total carbohydrates (%)	Nitrate content (No_3)ppm	Nitrite content (No_2) ppm
Spunta	A (control)	1.11	٢٦,٧١	٤٨,٤٢	٣٣٩,١٣	١٧٩,٤٩
	B	1.13	٢٧,١١	٤٩,٢١	٣١٨,٠٩	١٨٢,٥٧
	C	1.14	٢٦,٣٢	٤٧,٢١	٢٨٧,٨١	١٦٢,١٨
	D	1.14	٢٥,٤٦	٤٦,١٠	٢١٢,٧٦	١١٥,٢٥
	E	1.15	٢٦,١١	٤٤,٢٩	٢١٢,١٤	١٠٧,١٠
	F	1.16	٢٤,٢١	٤٣,٠٠	١٩٣,٩٠	١٠٣,٢٠
Mean Spunta		**1.14**	**٢٥,٩٩**	**٤٦,٣٧**	**269.64**	**154.97**
Diamont	A (control)	1.09	٢٧,٦١	٤٩,٢١	٣٢٦,٤٣	١٧٠,٢٨
	B	1.11	٢٨,١١	٥٠,٢٦	٣١١,١١	١٦٦,٣٣
	C	1.12	٢٧,٦٢	٤٩,٦١	٢٨٣,٢٤	١٥٥,٥٦
	D	1.13	٢٦,١١	٤٩,٤٣	١٩٨,٢٦	١١٣,٠٠
	E	1.14	٢٥,٧١	٤٧,٦١	١٨٨,١٢	١١٢,١٥
	F	1.14	٢٥,٣١	٤٦,٩٢	١٨٠,٦٣	٩٩,٤٢
Mean Diamant		**1.12**	**٢٦,٧٥**	**٤٨,٨٤**	**256.97**	**149.46**
Mean fertilizer	A (control)	1.10	27.16	48.82	332.78	174.89
	B	1.12	27.61	49.74	314.60	174.45
	C	1.13	26.97	48.41	285.53	158.87
	D	1.14	25.79	47.77	205.51	114.13
	E	1.15	25.91	45.95	200.13	109.63
	F	1.15	24.76	44.96	187.27	91.31
LSD at 5% level for cultivar		0.005	0.23	٠,٤٧	٨,٨٩	٣,٨٠
Fertilizer		0.008	0.36	٠,٨٢	٢١,١٧	١٣,٢٤
Cultivar × Fertilizer		٠,٠٢٢	0.48	١,٣٣	٥٦,٧٧	٢٢,٠٤

A = 100% of recommended mineral N, P. fertilizer doses and uninoculated with bio-fertilizers (control).
B = 90% of recommended mineral N, P. fertilizer doses plus seed tuber inoculation with bio-fertilizers.
C = 80% of recommended mineral N, P. fertilizer doses plus seed tuber inoculation with bio-fertilizers.
D = 70% of recommended mineral N, P. fertilizer doses plus seed tuber inoculation with bio-fertilizers.
E = 60% of recommended mineral N, P. fertilizer doses plus seed tuber inoculation with bio-fertilizers.
F = 50% of recommended mineral N, P. fertilizer doses plus seed tuber inoculation with bio-fertilizers.

In this respect, Midan *et al* (1986) have been recorded significant differences in N, P, K, nitrate and nitrite concentrations among 6 potato varieties grown under different N fertilization rates. Also, Hamouz (1991) found that Klara and Resyes potato cultivars differed significantly in nitrate accumulation where Klara was 62% higher than Rosyes when subjected to 40 ton/ha FYM and 0-240 kg N/ha. As indicated earlier, there are genotypic differences in nutrients use efficiency at the same level of soil fertility. Better spatial exploitation of the root system, release of acidifying and/or chelating substances can explain genotypic differences in uptake efficiency Badawy and Ahmed, (2006).

Data presented in Table (6) and illustrated in Figures (1 and 2) reveals the effect of reducing mineral N, P fertilizers and bio-fertilizer on nitrate and nitrite contents of potato tubers. It could be noticed that the highest nitrate and nitrite contents were achieved in case of check treatment (recommended mineral N, P levels) and the reverse was true in case of using half of the check. Corresponding decrease in nitrate and nitrite contents was 10% when mineral N, P level was reduced to 70% with bio-fertilizer application and reached 30 % when bio-fertilizer was used with 50% of mineral N, P level. Data reveal that an increment of mineral N, P rates led to significant increase in nitrate and nitrite content in potato tubers. In this regard, Singe (1986) detected increment in nitrate N in the tuber with increasing N rates. Therefore, the role of bio-fertilizer in the reeducation of nitrate and nitrite accumulation in the edible part of potato plants was clear as compared to mineral N, P application at recommended dose, however, it is considered hazardous to human health. In this respect, Ahmed *et al*. (1997) detected pronounced decrease in nitrate accumulation by using bio fertilizer combined with 50% of nitrogen supply in both Jew's mallow and radish plants, these results strongly confirmed the suggestion that several plants species accumulate No_3 as a result of an excess of N uptake.

As regard to tuber yield/plant and per feddan and that of nitrate and nitrite accumulation, it is clear that application of a bio-fertilizer in combination with 70% of mineral N, P supply achieved moderately highest tuber yield with significant decrease in nitrate and nitrite compared to check treatment. Whereas, application of bio-fertilizer combined with 50% mineral N, P supply caused reduction in yield compared to check treatment with highly significant reeducation in nitrate and nitrite accumulation than the check (full mineral N, P dose). This result agree with the results obtained by (Rabie *et al*. (2002), who found that using bio-fertilizer with half N dose significantly reduced nitrate and nitrite accumulation in potato Diamant cultivar tubers. Also agree with the result reported by Abou-Hessein *et al*. (2002), who found that the highest tuber nitrate was obtained when the recommended dose of mineral N, P K was applied while the lowest one was detected in tubers produced from plants received the quarter recommended fertilizer level with bio-fertilizer. With contra result in relation to highest yield which was achieved by (Rabie *et al*, 2002) when half N dose was applied and lower nitrate and nitrite content.

The interaction between the two tested factor was significant, the highest nitrate and nitrite content were obtained by Spunta tubers produced from plants received the recommended dose of mineral N, P compared to lowest values recorded by Diamant tubers produced from plants received

50% of mineral N, P + bio-fertilizer inoculation.

5. Densities of micro organisms:

Effect of inoculation with N_2-fixers and phosphate dissolving bacteria on the microbial (*azotobacters, azospirilla*) counts in the soil rhizosphere of potato plants determined at 30, 60 and 90 days from planting are illustrated in figures (3, 4, 5 and 6).

It clear from the data presented in Fig (3) that total bacterial counts were considerably affected by sampling date and suing bio-fertilizer with mineral NP fertilizers. Where seed potato tuber inoculation with bio-fertilizer combined with reducing NP rates significantly increased the microbial counts compared to check treatment without tuber inoculation. Corresponding increase in microbial count caused by reducing NP level combined with bio-fertilizer reached the highest count after 60 days from planting under combination treatment of 50% of recommended NP level plus bio-fertilizer and reached 1.84 and 1.93 x 10^8 cfu. g^{-1} in Spunta and Diamant cultivars, respectively. While, the lowest count was recorded when both cultivars were subjected to the full NP rates.

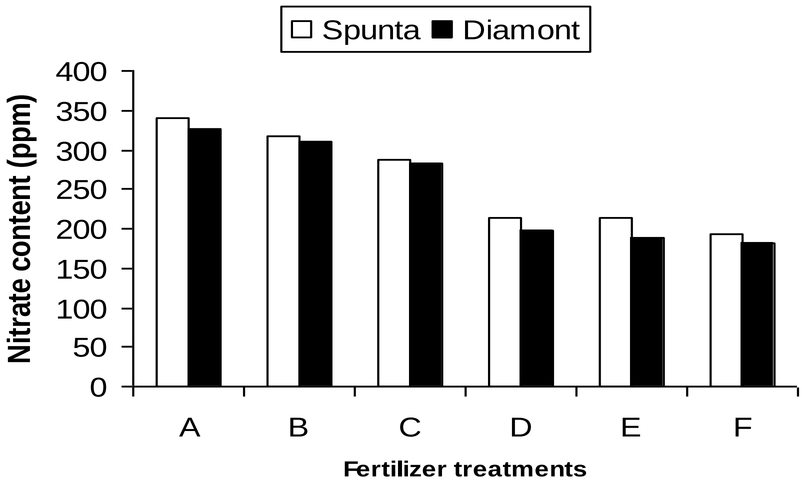

Fig. (1): Effect of interactions between fertilizer treatments and cultivars on nitrate content (ppm) in potato tuber, at harvest (combined analyses of 2005 and 2006 summer seasons).

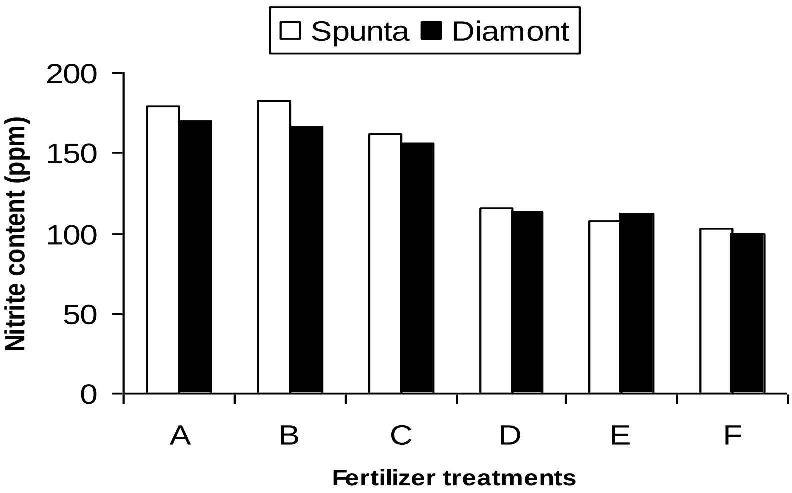

Fig. (2): Effect of interactions between fertilizer treatments and cultivars on nitrite content (ppm) in potato tuber, at harvest (combined analyses of 2005 and 2006 summer seasons).

A = 100% of recommended mineral N, P fertilizer doses and uninoculated with bio-fertilizers (control).
B = 90% of recommended mineral N, P fertilizer doses plus seed tuber inoculation with bio-fertilizers.
C = 80% of recommended mineral N, P fertilizer doses plus seed tuber inoculation with bio-fertilizers.
D = 70% of recommended mineral N, P fertilizer doses plus seed tuber inoculation with bio-fertilizers.
E = 60% of recommended mineral N, P fertilizer doses plus seed tuber inoculation with bio-fertilizers.
F = 50% of recommended mineral N, P fertilizer doses plus seed tuber inoculation with bio-fertilizers.

Densities of N2-fixers:

***Azotobacters and azotosprilla* counts:**

Data illustrated in Fig. (4) show that uninoculated treatment harbored less recorded densities of *azotobacters* than inoculated one. The highest densities of *azotobacters* after 60 days from planting was recorded when 50% of recommended NP doses was applied ,i.e., it reached 4.84 and 5.1 x 10^6 cfu g^{-1} in dry rhizosphere soil of Spunta and Diamant cultivars, respectively. Whereas, using the full dose of NP fertilizers showed the lowest counts of *azotobacters* of 0.36 and 0.62 x 10^6 cfu g^{-1} in dry rhizosphere of Spunta and Diamant cultivars, respectively. The similar trend previously noticed in the densities of *azotobacters* in potato rhizosphere as affected by inoculation with N2-fixers, phosphate with different doses of mineral fertilizers was noticed in the case of *azospirilla* counts Fig. (4). The remarkable increase in *azospirilla* densities recorded by potato plants received 50% of recommended NP doses were 32.2 x $l0^6$ and 29.8 x 10^6 cfu g^{-1} in dry rhizosphere soil of Spunta and Diamont cultivars, respectively.

Densities of phosphate dissolving bacteria (PDB) in rhizosphere of potato plant:

Data illustrated in Fig (6) show the effect of inoculation with multi inoculats of *Bacillus megaterium var. Phosphaticum* count in rhizosphere of potato plant. It could be concluded from the results that, the highest count of PDB after 60 days from planting was achieved when 50% of recommended NP doses plus bio-fertilizer inoculation was applied reached 6.44 x $l0^6$ and 4.71 x $l0^6$ cfu g-1 in dry rhizosphere soil of Spunta and Diamant cultivars, respectively. On the contrary, application full NP dose without seed tuber inoculation showed the lowest counts of 4.7 x $l0^6$ and 4.22 x $l0^6$ cfu g^{-1} in dry rhizosphere soil of Spunta and Diamant cultivars, respectively. The interactions between functional groups of soil microflora are a key to understand the dynamic processes that depict plant-soil relationships. The interrelationship between the microorganisms and the host plant can play an important role in improving the crop productivity through the manipulation of the rhizoplant or rhizosphere microorganism communities. In the present work, the effect of inoculation with asymbiotic N_2-fixers *(Azotobacter chrococcum* and *Azospirillum spp.),* phosphate dissolving bacteria *(Bacillus megaterium var phosphaticum)* on the total bacterial inoculated asymbiotic N_2-fixers, phosphate dissolver and silicate bacteria counts were studied. The results showed that the numbers increased by increasing plant growth till 60 days of growth and after that the numbers decreased with increasing potato plant growth. The proliferation of many groups of microorganisms including bacteria in the rhizosphere of potato plant compared with that of rhizosphere free-soil may be due to increased inoculation and/or nutrients from root exudates, sloughed root tissues, mucigel and residues of root hairs as affected by bio-fertilization .The population of these bacteria are influenced by groups of abiotic, micro biotic and biotic factors. The same trend of results were obtained by El-Gamal (1996b). They studied the effect of potato tuber inoculation with add *Azotobacter* and that of Leinhos and Vacek (1994). They reported that high numbers of P solubilzers in the rhizosphere are of great relevance to plants. The substitution of mineral fertilizers (NP) partially by biological alternative (multi-strains inoculants) has become of a great importance due to its highly positive economical and ecological effects. Such practice reduced the needs to the expensive mineral fertilizers and chemical fungi and bactericides and therefore , agricultural costs considerably decreased. From the ecological point of view, this replacement appreciably minimizes environmental pollution and helps in the production of clean agriculture production causing no health hazards.

Generally, minimizing mineral NP rates combined with bio-fertilizer significantly enhanced microbial count in potato root growth rhizospher and resulted effectively in promoting growth, yield and tuber quality as well as reduced the amount of NP commonly applied at excessive rates which in turn reduced the total production costs.

We could conclude from the present investigation that, the most promising treatment is bio-fertilizer combined with 70% of recommended mineral N, P dose which satisfy the objective of producing high quality tuber with low nitrate and nitrite level and save about 30% of the cost of nitrogen and phosphorus fertilizers. On the other hand, microbial of densities of bacterial counts, *azotobacter, azospirilla* and bacillus in the rizosphere increased gradually with advanced reducing mineral fertilizers.

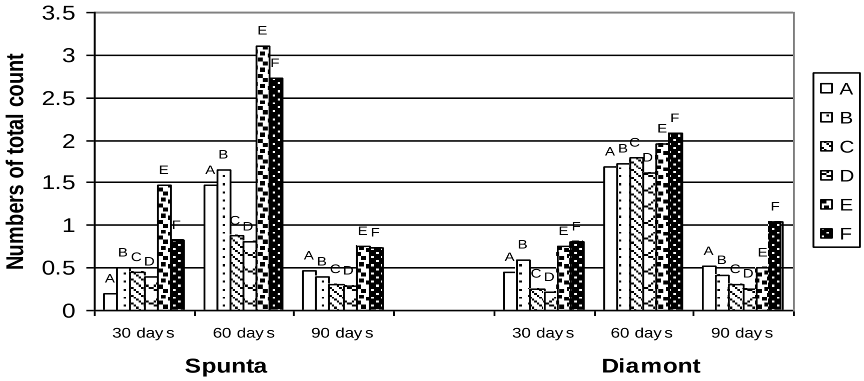

Fig. (3) Densities of total count of bacteria (×10^8) in potato plants cvs. Spunta and Diamant rhizosphere as affected by bio-fertilization and / or different level of mineral fertilizers (combined analyses of 2005 and 2006 summer seasons).

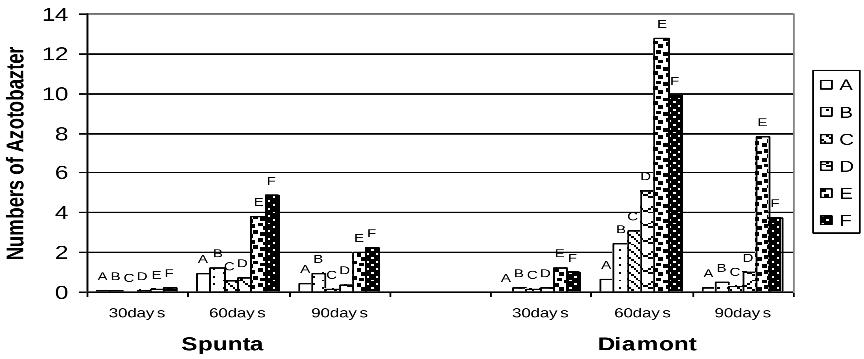

Fig. (4) Densities of *azotobacter sp*. (×10^6) in potato plants cvs. Spunta and Diamant rhizosphere as affected by bio-fertilization and / or different level of mineral fertilizers (combined analyses of 2005 and 2006 summer seasons).

A = 100% of recommended mineral N, P fertilizer doses and uninoculated with bio-fertilizers (control).
B = 90% of recommended mineral N, P. fertilizer doses plus seed tuber inoculation with bio-fertilizers.
C = 80% of recommended mineral N, P fertilizer doses plus seed tuber inoculation with bio-fertilizers.
D = 70% of recommended mineral N, P fertilizer doses plus seed tuber inoculation with bio-fertilizers.
E = 60% of recommended mineral N, P fertilizer doses plus seed tuber inoculation with bio-fertilizers.
F = 50% of recommended mineral N, P fertilizer doses plus seed tuber inoculation with bio-fertilizers.

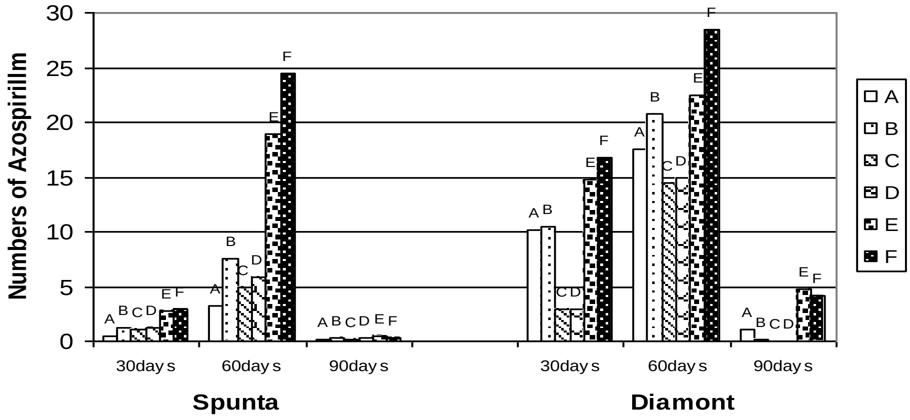

Fig. (5) Densities of *azospirillm sp.* (×10^6) in potato plants cvs. Spunta and Diamant rhizosphere as affected by bio-fertilization and / or different level of mineral fertilizers (combined analyses of 2005 and 2006 summer seasons).

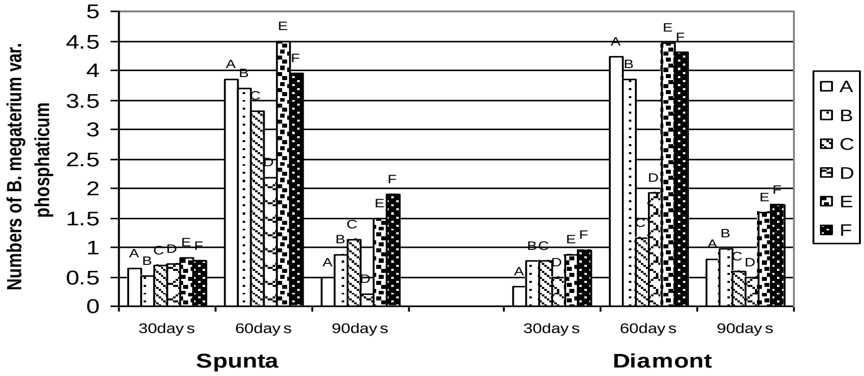

Fig. (6) Densities of *Bacillus megaterium var. phosphaticum* (×10^6) in potato plants cvs. Spunta and Diamant rhizosphere as affected by bio-fertilization and / or different level of mineral fertilizers (combined analyses of 2005 and 2006 summer seasons).

A = 100% of recommended mineral N, P fertilizer doses and uninoculated with bio-fertilizers (control).
B = 90% of recommended mineral N, P fertilizer doses plus seed tuber inoculation with bio-fertilizers.
C = 80% of recommended mineral N, P fertilizer doses plus seed tuber inoculation with bio-fertilizers.
D = 70% of recommended mineral N, P fertilizer doses plus seed tuber inoculation with bio-fertilizers.
E = 60% of recommended mineral N, P fertilizer doses plus seed tuber inoculation with bio-fertilizers.
F = 50% of recommended mineral N, P fertilizer doses plus seed tuber inoculation with bio-fertilizers.

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أثـر تقليـل مسـتوى التسـميد المعدنى النيتروجينـى و الفوسـفاتى مقرونـاً مـع التسـميد الحيوى على نمو و محصول و جوده درنات نباتات البطاطس.

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يهدف هذا البحث الى دراسة مدى امكانية تقليل استخدام الاسمده الكيميائية المعدنية النيتروجينية والفوسفاتية اللازمة لإنتاج نباتات البطاطس مع تعويض هذا التقليل بالإمداد بالتسميد الحيوي عن طريق مثبتات الأزوت الجوي وميسرات الفوسفات الحيوية مع دراسة مدى إمكانية الحصول على محصول متقارب من المسمد معدنياً كلياً وذو صفات جودة أفضل لما للإسمدة الحيوية من فوائد عديدة مثل انتاجها لمواد منشطة للنمو النباتي وتيسيرها للعناصر علاوة على المحافظة على البيئة والتقليل من مصروفات التسميد المعدني التي هي في إزدياد مستمر وأجريت هذة الدراسة على محصول البطاطس صنفي " أسبونتا – دايمونت " وذلك خلال موسمي ٢٠٠٥ ، ٢٠٠٦ وذلك بمحافظة الجيزة بأرض طميية وتم التسميد الحيوي بخليط من سلالات بكتيرية لا تكافلية متعددة تتكون من بكتريا , .*Azospirillum spp* .*Azotobacter spp* المثبتة للأزوت الجوي ولقاح بكتريا *Bacillus megaterium* var *phosphaticum* المذيبة والميسرة للفوسفور وذلك بأضافتهما من خلال معاملة التقاوي وكذلك بعد الزراعة بمعاملة النباتات بعد تمام التزريع وظهور النباتات فوق سطح التربة مع مستويات مختلفة من التسميد النيتروجيني والفوسفاتي المعدني وكانت المعاملات كالأتي ١٠٠% تسميد معدني (معاملة المقارنة) ، ٩٠% ، ٨٠% ، ٧٠% ، ٦٠% ، ٥٠% كمستويات معاملة من التسميد المعدني الموصي به مضافاً اليها التسميد الحيوي لتعويض هذا النقص من التسميد المعدني وتم دراسة أثر ذلك على خصائص النمو الخضري لنباتات البطاطس ممثلاً في إرتفاع النبات وسمك الساق الرئيسي وعدد الأفرع والأوراق على النبات ومساحة الأوراق وكذلك الوزن الجاف للمجموع الخضري للنبات مع قراءة مؤشر الكلوروفيل بالأوراق ومحتواها من عنصر النيتروجين والفوسفور والبوتاسيوم وتم تقدير المحصول ممثلاً في عدد الدرنات بالنبات ومتوسط وزن الدرنة ووزن الدرنات بالنبات وكذا محصول النبات / الفدان كما تم تقدير جودة المحصول ممثلة في الكثافة النوعية للدرنات ومحتواها من الكربوهيدرات الكلية وكذلك محتواها من النترات و النيتريت. وأيضاً تم دراسة أثرالتخصيب الحيوي علي الكثافة العددية بالنسبة إلى التعداد الكلي للميكروبات المثبتة للأزوت والميسرة للفوسفور وكذلك العد الفردي لها في منطقة الريزوسفير بالتربة لكلاً من الصنفين وأوضحت النتائج ان كلاً من صنف " اسبونتا و دايمونت " أعطت اختلافات معنوية من ناحية النمو والمحصول والجودة حيث أعطى الصنف اسبونتا أفضل النتائج من ناحية النمو وكذلك وزن الدرنات والمحصول. وأن انخفاض مستوي التسميد المعدني بإستخدام ٩٠% ، ٨٠% ، ٧٠% من الكميات الموصى بها من التسميد المعدني مع التسميد الحيوي أعطي محصولاً متساوياً مع التسميد المعدني مع الأخذ في الأعتبار قلة تراكم النترات والنيتريت بالدرنات مما يزيد من جودتها كعامل آمان وعند الوصول إلى مستوي ٦٠% ، ٥٠% من التسميد المعدني مع التسميد الحيوي زادت الكثافة النوعية للدرنات وقلل من تراكم النترات والنيتريت بالدرنات مما يزيد من جودة الدرنات. وأوضحت النتائج زيادة الكثافة العددية بالنسبة إلى التعداد الكلي للميكروبات (اعداد الأزوتوباكتر و الأزوسبيريلم وبكتريا الباسيلس ميجاثيريم المذيبة للفوسفور وذلك في منطقة الريزوسفير في التربة في كلاً من صنفي البطاطس المستخدمة وبلغت أقصاها خلال مرحلة عمر ٦٠ يوم وكذلك مع المعاملة ٦٠% ، ٥٠% من التسميد المعدني والمقرونة مع التسميد الحيوي.

وبذلك يمكن التوصية في مثل ظروف هذا البحث بأنه يمكن الوصول إلى ترشيد من ١٠-٣٠% من التسميد النيتروجيني المعدني وكذلك الفوسفاتي مع تعويض هذا النقص من التسميد بالتخصيب الحيوي المعدني للحصول على محصول متقارب كماً من المسمد معدنيا ١٠٠%. علاوة على الحصول على ميزة نسبية وهي الحصول على محصولاً اعلي في الجودة وفي نفس الوقت نكون قد أسهمنا في خفض جزء من تكلفة التسميد المعدني مع الحفاظ على جودة عالية للدرنات الناتجة.

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