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POTATO YIELD AND NUTRIENTS CONTENT AS AFFECTED BY SILICATE BACTERIA AND BOTH FYM AND POTASSIUM RATES

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ABSTRACT

A field experiment was carried out at private farm (Kafr El-Arab, Talkha, Dakahlia Governorate, Egypt) during winter 2005/2006 season to study the effect ot of silicate bacteria (*Bacillus circulans*) and both farmyard manure and K fertilizer rates on yield, tuber quality and chemical constituents of potato plants (*Solanum tuberosum L.*) CV. Spunta cultivar grown on alluvial soils. Treatments were representing all combination of FYM rates (0, 10 and 20 m^3 fed^{-1}) and K fertilizer rates (0, 50 and 100 kg fed^{-1} as potassium sulphate; 41.5% K) in presence of silicate bacteria (with and without addition) in split split plot design with three replicates.

The obtained results could be summarized as follows:

- Except for fresh and dry yields, N content of tops (kg fed^{-1}) and P% in potato organs (tops + tubers), the differences among means of starch content (%), specific gravity (g cm^{-3}), N, P, K% and its contents (kg fed^{-1}) of top and tuber by inoculation of silicate bacteria (*Bacillus circulans*) reached at the level of significance (*p=0.05*) during the growing successive season.
- Statistical analysis indicates that fresh and dry yield of potato organs (top + tubers), tuber quality i. e. starch % and Sp. gravity (g cm^{-3}) and N, P, K% and its contents (kg fed^{-1}) of tops and tubers except for P% in tubers and K% in tops + tubers were significantly increased with increasing of farmyard manure rates from 0 up to 10 and 20 m^3 fed^{-1}, respectively.
- Data indicate that additional rates of K-fertilizer significantly increased fresh top and tuber yields (ton fed^{-1}), starch %, specific gravity (g cm^{-3}), N, K% and its content (kg fed^{-1}) of tops and tubers during the growth season. Meanwhile, dry top and tuber yields (ton fed^{-1}), P% and its content (kg fed^{-1}) of potato plants materials insignificantly increased with increasing K fertilizer rates. Generally, the highest means were recorded with the potassium rate of 100 K kg fed^{-1} (K_2).
- The multiple linear regression shows that there is a highly significant correlation (*P = 0.01*) among potato tuber yield (y) and starch %, top yield, top N and K and tuber P contents except for N tuber and top P and tuber K contents (r^2 = 94.7%). The expected equation to predict the tuber yield was:

  Tuber yield (Y) = - 39.6 + 3.19 Starch % + 0.728 top yield - 0.079 tuber N content + 0.005 top N contents + 1.26 tuber P contents - 1.26 top P contents - 0.010 tuber K contents + 0.284 top K contents.
- Also, Path analysis reveals that the most closely variables related to tuber yield is; top yield, starch % and tubers N content.

Keywords: FYM, silicate bacteria, K-fertilizer, potato plants

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important food crops all over the world including Egypt, which it ranks after wheat, rice and maize as the fourth most important crop for human consumption (Ewing, 1997). In Egypt, potato is cultivated in large areas and ranks the first vegetable crop for exportation and local consumption.

No doubt that bio-fertilizers are very safe for human, animal and environmental and using them lower the great pollution occurred in our environment. Soil microorganisms, known as silicate decomposing bacteria (SDB) play a fundamental role in converting K fixed from to be soluble ready available for plant nutrient. So, many studies were conducted on using silicate decomposing bacteria especially on vegetable crops.

So, Balabel, Naglaa (1997); El-Banna and Tolba (2000); El-Banna, (2001) and Ramadan (2007) found that inoculation orthoclase with silicate decomposing bacteria (SDB) (*Bacillus circulans*) gave better effects on yield and nutrient contents of potato plants. Potassium plays some irreplaceable and versatile roles that catalyze the metabolic activities at the cellular and organ rates which be translated at the whole plant into promotion in energy conversion, carbohydrate assimilation and translocation and nutrient uptake, transfer and metabolism (Johanston, 1997 and Krauss, 2003).

Also, organic fertilization is very important not only for providing the plants with their nutritional requirements without having any undesirable impacts on the environment but also for improving physical, chemical and biological properties of the soil (Mahmoud, 2000; El-Fayomy and Hammad, 2001 and Abdel-Hamid *et al.*, 2004) found that a high quality and crop yield was obtained at the combined application fertilizer and manure and the separate application of manure or fertilizers at different rates was less effective.

Therefore, the objective of the present work was to study the combined effect of silicate bacteria *(Bacillus circulans)* and both organic manure and potassic fertilizer rates on yield and quality as well as N, P and K contents of potato plants under alluvial soil conditions.

MATERAILS AND METHODS

A field experiment was carried out at private farm (Kafer EL-Arab, Talkha, Dakahlia Governorate, Egypt during winter 2005/2006 to study the combined effect of organic manure, potassic fertilizer in presence of silicates decomposing bacteria as biofertilizer on yield and chemical constituents of potato tubers (*Solanum tuberosum L.*) cv. Spunta cultivar.

Soil is considered a clay loam in texture (alluvial soils) and was 42.90% clay, 37.35% sand and 18.02% silt. Also, the analysis illustrated that soil pH was 7.35. The soil is non saline where (EC) was 2.91 dSm^{-1} and soil organic matter content was 1.85 %. In addition, soil before planting was low to medium in both available soil-N (50.7 mg kg $soil^{-1}$) and available soil-K (200 mg kg $soil^{-1}$), while the soil is high in available soil-P(17.0 mg kg $soil^{-1}$), The experimental design was split plot design. Main plots were assigned to the three farmyard manures were done in sub plots, while the two treatments of silicate bacteria (B) were the sub-plots, and the three treatments of potassium (K) were the sub-sub plots. Hence, the total number of present trial was 2 treatments (silicate bacteria) × 3 rates (FYM) × 3 rates (K) = 18 treatments.

Each treatment was replicated 3 times to give a total number of 54 experimental units.

1.The first factor (3 treatments): Three rates of farmyard manures were applied as follows:

- (F_0): (control without application), (F_1): 10 ton Farm yard manure/fed.
- (F_2): 20 ton Farm yard manure/fed.

Table 1: Farm yard manure analysis

Source	Total nutrients elements (%)			O.M %	C %	C/N ratio	pH
	N	P	K				
FYM	1.18	0.29	2.0	42.0	14.0	21:1	8.6

2. The second factor (2 treatments): biofertilizer was applied at two rate 0 and 2 kg fed^{-1} as the following:-

- B_0: Without inoculation and B_1: With silicate bacteria (Inoculation).

Efficient inoculants of silicates decomposing as the biofertilizer (*Bacillus circulans*) were obtained from Integrated Control Res. Dept., plant pathology Res. Inst., Agric. Res. Centre, Giza. The prepared biofertlizer was added to feldspar at rate of 50 ml kg^{-1} of each other to the soil immediately before the first irrigation. Potato seeds were mixed with efficient inoculated with silicates decomposing before planting.

3. The third factor (3 treatments): potassium was applied in the form of potassium sulfate (41.5% K) at three rates 0, 50 and 100 kg K fed^{-1} as the following:-

- (K_0): (control), (K_1):100 kg K fed^{-1} which equal 120 kg fed^{-1} and (K_2): 150 kg K fed^{-1} which equal 240 kg fed^{-1}.

Farmyard manures were incorporated into the soil and then soil was irrigated and left for 15 days before sowing. Also, potassium sulfate (41.5% K) treatments were applied as one dose with the third irrigation.

Potato tuber pieces (CV. Spunta) were planted in October 12th 2005 in the 1st season and harvested in Feb 2th 2006.

1. Yield and Yield Components:

Potatoes were harvested after 110 days from planting and the following parameters were recorded:

- Fresh and dry top yields (ton fed^{-1}).
- Fresh and dry tuber yields (ton fed^{-1}).

2. Tuber Quality Parameters:

- Specific gravity: it was determined according to the methods of Smith (1975).

$$\text{Specific gravity (g cm}^{-3}\text{)} = \frac{\text{Weight in air}}{\text{Weight in air - Weight in water}}$$

- Starch content (%): it was calculated according to the formula of Burton (1948): Starch (%) = 17.546+199.07x (S.g.-1.0988)

3. Chemical composition:

Samples of leaves and tubers from three potato plants were chosen randomly after harvesting stage and these were oven dried at 70°C till constant weight then were ground to a fine powder and sub samples of 0.2 g were wet digested using a mixture of sulfuric and perchloric acids to determine the percentages of total nitrogen, phosphorus and potassium (Cottenie *et al.*,1982).

The statistical analysis of the obtained data was done according to the methods described by (Gomez and Gomez, 1984). The obtained data of the tuber yield (y) and starch %, top yield, top and tuber N contents, top and tuber p contents and top and tuber K contents were subjected to simple correlation and regression. Also, the results of aforementioned characters were subjected to multiple linear regression and path coefficient analysis. Partial coefficient of determination (R^2) was estimated for each component to evaluate the relative contribution and to construct the prediction model of the tuber yield (y) according to the following formula:-

$Y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4$..............(Snedecor and Cochran, 1982).

RERSULTS AND DISCUSSION

1. Effect of silicate bacteria and both FYM and K fertilizer rates on Yields:-

Data in Table 2 shows that the inoculation of silicate bacteria gave a slight effect on both fresh and dry top and tuber yields (ton fed^{-1}) as compared with the control. These results are in agreement with those of **Abdel-Ati *et al.*, (1996); El-Banna *et al.*, (2001) and El-Banna (2001) on potato plants.**

Also, Table 2 reveal that the fresh and dry top yields (ton fed^{-1}) of potato plants (ton fed^{-1}) increased significantly with farmyard manure applications during 2005/2006 season. The increase % in fresh tuber yield for such two treatments over control amounted to about 21.21 and 31.8 %.

Table 2: Means of fresh and dry yields of potato plants (ton fed^{-1}) as affected by silicate bacteria and both FYM and K fertilizer rates during 2005/2006 season.

Characters / Treatments	Tops		Tubers	
	Fresh	Dry	Fresh	Dry
Silicate bacteria				
Without	4.30	0.37	16.11	2.30
With	4.34	0.38	17.61	3.48
F. Test	NS	NS	*	*
Farmyard manure rates (m^3 fed^{-1})				
Control	3.83	0.32	14.33	2.50
10	4.46	0.36	17.37	3.34
20	4.66	0.38	18.88	3.43
LSD at 5%	0.12 *	0.52 *	0.86 *	0.25 *
K. Fertilizer rates (kg fed^{-1})				
K_0	3.50	0.37	14.20	2.70
K_1	5.00	0.38	16.10	3.26
K_2	5.50	0.38	17.60	3.40
LSD at 5%	0.13 *	NS	0.42 *	0.30 **

Generally, the beneficial effects of organic manure on vegetative growth might be related to the application of organic materials improved the physical conditions of the soil, provided energy for microorganisms' activity, increased nutrient supply and improved the efficiency of macro elements as well as its ability to meet some micro nutrient requirements (Tisdale *et al.*, 1985 and Hammad, 1996).

Table 2 shows that the application of K-fertilizer increased insignificantly the dry top yields, significantly fresh and dry top yields and a highly significant for dry tuber yields during 2005/2006 season.

These results explain that the potassium plays vital role in physiological processes inside the plant, enzyme activities, water absorption, transpiration and increasing the outward translocation of photosynthesis from the above ground parts to the subterranean storage root organs (roots). These results are agreeable with those obtained by Arisha and Bardisi (1999); Abdel-Kader (2002) and Selim (2003).

2. Effect of silicate bacteria and both FYM and K fertilizer rates on tuber quality:-

The statistical test in Table 3 shows that, the differences in mean values of starch content (%) and specific gravity (g cm^{-3}) in tubers with inoculation of silicate bacteria was significant (*p=0.05*) at maturity during the 2005/2006 season. The work by Ramadan (2007) on potato tubers confirmed our results.

Table 3: Means of tuber quality of potato plants as affected by silicate bacteria and both FYM and K rates during 2005/2006 season.

Characters / Treatments	Starch (%)	specific gravity (g cm^{-3})
Silicate bacteria		
Without	15.32	1.01
With	15.62	1.02
F. Test	*	NS
Farmyard manure rates (m^3 fed^{-1})		
Control	14.80	1.02
10	15.49	1.02
20	156.60	1.02
LSD at 5%	0.05 *	NS
K. Fertilizer rates (kg fed^{-1})		
K_0	15.38	1.02
K_1	15.45	1.02
K_2	15.50	1.03
LSD at 5%	0.03 *	0.01 *

At maturity, data in Table 3 appear that the additional rates of farmyard manures significantly affected on starch content (%) and insignificantly affected on specific gravity (g m^{-3}) of potato tubers at 5% level of probability.

These results discuss that the farmyard manures increase soil aggregation which leads to a good soil aeration, stimulate plant roots, absorption of nutrients and photosynthesis process which led to produce vigorous plants, numerous tubers, large sized-tubers, consequently total tuber yield, and hence, reflects on the tuber quality. Our results are confirmed with those reported by Tawfik, (2001); Shehata *et al.*; (2004); Abou-Hussien (2005) and El-Mancy and Selim (2007).

As for the effect of K-fertilizer rates on starch content % and specific gravity (g cm^{-3}) in potato tubers, Table 3 shows that, additional rates of potassium fertilizer significantly increased starch content % and slightly increased on specific gravity (g cm^{-3}). Generally, the highest records were obtained when plants received 100 kg K fed^{-1} as compared the other rates. The beneficial effect of such treatments on tuber quality could be expected since K plays an important role in presence of water where, it is promoting the translocation on newly synthesized photosynthesis and mobilization of stored materials as well as promoting the synthesis of sugars and polysaccharides. Our results are agreeable with those obtained by Mengel and Kirkby (1987); Arisha and Bardisi (1999).and Selim (2003) on potato plants.

3. N, P and K concentration and its contents as affected by silicate bacteria and both FYM and K fertilizer rates:-

Nitrogen and its contents of both top and tuber (kg fed^{-1}) as influenced by silicate and both FYM and K fertilizer rates presented in Table 4.

Table 4: Means of nitrogen contents (kg fed^{-1}) of top and tuber as affected by silicate bacteria and both FYM and K fertilizer rates during 2005/2006 season.

Characters / Treatments	Tops		Tubers	
	N%	N content (kg fed^{-1})	N%	N content (kg fed^{-1})
Silicate bacteria				
Without	2.34	8.86	1.21	35.79
With	2.38	9.45	1.38	43.89
F. Test	NS	NS	*	**
Farmyard manure rates (m^3 fed^{-1})				
Control	2.18	5.74	1.15	32.97
10	2.30	7.15	1.23	41.31
20	2.41	9.36	1.36	44.75
LSD 5%	0.03 *	1.25 *	0.08 *	2.18 *
K. Fertilizer rates (kg fed^{-1})				
K_0	2.20	8.82	1.18	40.06
K_1	2.31	8.86	1.24	40.14
K_2	2.36	9.24	1.28	41.81
LSD at 5%	1.02 *	0.06 *	0.05 *	0.25 *

Except for N uptake by tops, N % in tubers and tops as well as its content of tubers significantly increased by inoculation of silicate bacteria at 5% level of probability.

Data indicate that there was positive and significant effects on N (%) in tops and tubers with increasing rates of farmyard manure compared with untreated plants. Moreover, additional rates of farmyard manure highly significant increased amounts of N absorbed by top and tuber (kg fed^{-1}), respectively, during 2005/2006 season. These results may be attributed to the high capacity of the plants received such treatments in building metabolites which reflect on more vigorous plant growth and rooting system which in turn contributes to increase in N concentration. These results are in accordance with those obtained by Abou-Hussien (2005) and El-Mancy and Selim (2007) on potato plants.

In addition, the same Table reveals that mean values of N% and its contents (kg fed^{-1}) of top and tuber tissues were significantly increased with increasing the rates of K fertilizer, respectively. The favorable effect of potassium on chemical constituents of tubers might be due to potassium serve to balance the changes of anions and influence their content and transport (Abdel-Kader 2002 and Selim 2003).

Phosphorus % and its contents (kg fed^{-1}) of both top and tuber tissues as affected by silicate bacteria and both FYM and K fertilizer rates illustrated in Table 5.

Table 5: Means of phosphorus (%) and its contents (kg fed^{-1}) of top and tuber as affected by silicate bacteria and both FYM and K fertilizer rates during 2005/2006 season.

Characters / Treatments	Tops		Tubers	
	P%	P content (kg fed^{-1})	P %	P content (kg fed^{-1})
Silicate bacteria				
Without	0.18	0.94	0.04	6.05
With	0.19	1.06	0.07	6.28
F. Test	NS	*	NS	*
Farmyard manure rates (m^3 fed^{-1})				
Control	0.19	0.76	0.05	5.67
10	0.22	1.06	0.09	6.06
20	0.28	1.19	0.10	7.02
LSD at 5%	0.06 *	0.22 *	NS	0.75 *
K. Fertilizer rates (kg fed^{-1})				
K_0	0.21	0.94	0.06	4.52
K_1	0.24	1.03	0.06	5.34
K_2	0.23	1.05	0.07	6.88
LSD at 5%	NS	0.09 *	NS	1.00 *

It was evident from the data in Table 5 indicate that the maximum mean values of P % and it's absorbed by potato tops and tubers were achieved in presence of silicate bacteria.

Data reveal that the differences between the means of P (%) in top materials as affected by farmyard manure rates were significant, while the differences between P (%) means of tubers tissues were insignificant with increasing farmyard manure rates.

The benefits of organic compounds are; increasing movement and availability of phosphorus and micronutrients; increasing nutrient supply and improving the efficiency of macro elements as well as its ability to meet some micro nutrient requirements (Tisdale *et al.*, 1985 and Giusquiani *et al.*, 1988).

It is quite obvious from the data presented in Table 5 that plants were fertilized with potassium produced the highest mean values of P% and its content of tops and tubers as compared to the *control at maturity*. These results stood in a good agreement with those obtained by Arisha and Bardisi (1999) and Selim (2003).

Potassium % and its contents (kg fed^{-1}) in both top and tuber as affected by silicate bacteria and both FYM and K fertilizer rates illustrated in Table 6.

Table 6: Means of potassium contents (kg fed^{-1}) of top and tuber as affected by silicate bacteria and both FYM and K fertilizer rates during 2005/2006 season.

Characters / Treatments	Tops		Tubers	
	K%	K content (kg fed^{-1})	K%	K content (kg fed^{-1})
Silicate bacteria				
Without	3.08	7.00	0.85	43.93
With	3.09	9.58	1.03	55.10
F. Test	NS	*	*	*
Farmyard manure rates (m^3 fed^{-1})				
Control	2.89	6.48	0.82	41.53
10	3.18	8.85	1.07	51.56
20	3.55	9.47	1.09	55.34
LSD at 5%	0.11	1.00	NS	4.96
K. Fertilizer rates(kg fed^{-1})				
K_0	2.89	7.20	1.06	40.65
K_1	3.25	8.24	1.20	46.35
K_2	3.50	9.56	1.32	55.25
LSD at 5%	0.29	1.19	0.21	2.54

Relevant data in Table 6 show that, application of silicate bacteria increased the mean values of K % and its content of tops and tubers as compared to the check treatment during 2005/2006 season.

The increase in tubers K content under silicate bacteria (SB) strain reflects an enhanced growth which might be possibly due to the role of SB in supplying great amounts of both water-soluble and amorphous potassium which was reflected in plant content (Balabel, Naglaa, 1997; Afify, Aida and Bayoumy, Samia, 2001; El-Banna, 2001 and Ramadan, 2007).

Table 6 show that the additional rates of farmyard manure significantly increased potassium % in tops and insignificantly increased in tubers during 2005/2006 season. A progressively enhance in accumulated potassium by potato plant organs (foliage + tubers) was achieved by additional rates of farmyard manure, respectively. Generally, the beneficial effects of organic manure on increasing nutrient supply and improving the efficiency of macro elements as well as its ability to meet some micro nutrient requirements. These results are in accordance with those obtained by Abou-Hussien (2005) and El-Mancy and Selim (2007).

Looking at the mean values of K % and it's absorbed by tops and tubers (kg fed^{-1}), data in Table 6 reveal that incremental rates of potassium fertilizer significantly increased the K% and absorbed by potato organs (tops + tubers) during 2005/2006 season. The increment content of K by different plant parts may be due to higher availability of the nutrients with increase in the fertilizer application which ultimately resulted in better root growth and increased physiological activity of roots to absorb the nutrients and thereby, nutrient content was found closely linked with productivity (Veeranna *et al,* 1997).

With regard to tuber yield, matrix of simple correlation coefficient (r) between the tuber yield (y) and starch %, top yield, top and tuber N contents, top and tuber p contents and top and tuber K contents indicated that the tuber yield was positively and significantly associated with the aforementioned characters, respectively. The simple correlation coefficient values between tuber yield and these characters were; 0.99**, 0.81*, 0.66*, 0.87**, 0.78*, 0.90**, 0.76* and 0.87*, respectively.

Meanwhile, the multiple linear regression showed that there is a highly significant correlation (*P = 0.01*) among potato tuber yield and starch %, top yield, top N and K and tuber p contents except for N tuber and top P and tuber K contents (R^2 = 94.7 % and the adj.R^2 = 93.7 %). The expected equation to predict the tuber yield was:

Tuber yield =- 39.6 + 3.19 Starch % + 0.728 top yield - 0.079 tuber N content + 0.005 top N content + 1.26 tuber P contents - 1.26 top P contents - 0.010 tuber K content + 0.284 top K content

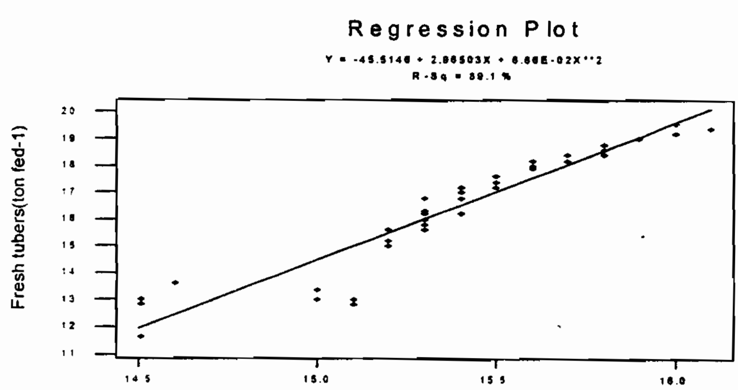
Also, Path analysis reveal that the most closely variables related to tuber yield are; top yield, starch % and tuber N contents. Therefore, the predicting equation of linear regression for tuber yield was computed as;

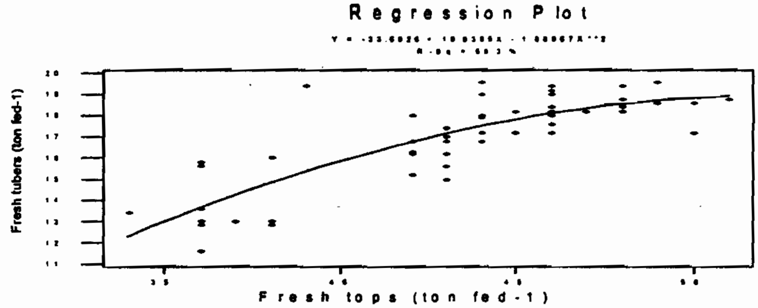
Y = -45.5146 + 2.95503X + 6.96E-02X**2 with (R^2 = 89.1 %) for starch %,

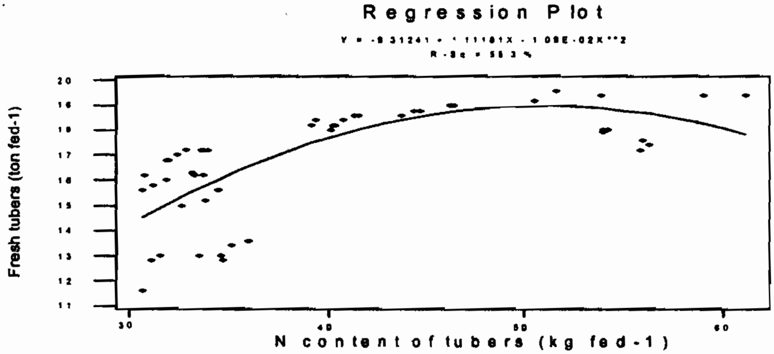
Y = -9.31241 + 1.11181X - 1.09E-02X**2 with (R^2 = 55.3 %) for fresh tops and

Y = -33.6926 + 19.9355X - 1.88597X**2 with (R^2 = 69.3 %) for tuber N contents

It could be concluded that the potential of producing high and good tuber yields of potato plants at a rate 20 m^3 fed^{-1} of farmyard manure and 100 K kg fed^{-1} with inoculation of silicate bacteria as a biofertilizer







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محصول البطاطس ومحتواه من العناصرالغذائية تحت تـأثير بكتريـا الـسيليكات ومعدلات التسميد العضوي والبوتاسي

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أجريت تجربة حقلية بمزرعة خاصة بكفرالعرب – طلخا – محافظة الدقهليـة– خـلال الموسـم الزراعي الشتوي ٢٠٠٥/٢٠٠٦ على محصول البطاطس صنف أسبونتا لدراسة تأثيرمستويات السماد البلدي (صفر، ١٠ ، ٢٠م٣/فدان)، والتلقيح بالبكتريا المذيبة للسليكات مقارنة بدون تلقيح بكتيري ، ومعدلات التسميد البوتاسي (صفر، ٥٠ و١٠٠ بو كجم/فدان) علي محصول الدرنات، وصفات الجـودة والتركيـب الكيمـاوي لنباتات البطاطس، ويمكن تلخيص أهم النتائج كالأتي:-

- فيما عدا الوزن الطازج والجاف للمحصول (طن/فدان)، وكذلك محتوى العرش (%، كجم/فدان) للفـسفور في العرش والدرنات كانت الفروق بين متوسطات جميع الصفات تحت الدراسة عنـد مـستوى معنويـة ($P=0.05$) في حالة التلقيح ببكتريا السيليكات (*Bacillus circulans*) بالمقارنة بـالكنترول خـلال موسم النمو ٢٠٠٥/٢٠٠٦.
- أوضح التحليل الإحصائي أن الوزن الطازج والجاف لكل من العرش والدرنات وصفات الجودة مثل النشا (%) والكثافة النوعية (جم/سم٣)، ومحتوي العرش والدرنات (كجم/فدان) مـن النتـروجين، والفوسـفور، والبوتاسيوم ماعدا % للفوسفور في الدرنات و% للبوتاسيوم في العرش والدرنات زادت معنويـاً بزيـادة معدلات السماد البلدي من صفر إلى ١٠ حتى ٢٠م٣/فدان.
- كذلك أشارت البيانات إلى أن زيادة معدلات التسميد البوتاسي أدى إلى زيادة معنوية في كل مـن الـوزن الطازج للعرش والدرنات (طن/فدان)، % للنشا، والكثافة النوعية للدرنات (جـم/سـم٣)، % للنتـروجين والبوتاسيوم بالاضافة إلى الممتص (كجم/فدان) بواسطة العرش والدرنات خلال موسم النمو. بينما كانـت الزيادة غيرمعنوية في المحصول الجاف للعرش والدرنات، و% للفوسفوروالممتص مـن (كجـم/فـدان)، وعموماً كانت أعلى متوسطات لهذه الصفات تم الحصول عليها عند إضافة ١٠٠ كجـم بوتاسـيوم/فـدان بالمقارنة بالمعاملات الأخرى.
- كما أظهرت معادلة تحليل الانحدارالمتعدد أن محصول الدرنات (y) مرتبط إيجابياً ومعنوياً ($P = 0.01$) بتركيز النشا(%)، ومحصول العرش(طن/فدان)، ومحتوى العرش من النتروجين والبوتاسيوم (كجم/فـدان)، ومحتوى الدرنات من الفوسفور(كجم/فدان). لذلك تعتبر النشا (%)، ومحصول العرش ، ومحتوى الدرنات من النتروجين هي العوامل الأكثر تأثيراً في محصول الدرنات (طن/فدان)، حيث كانـت معادلـة التنبـؤ بمحصول الدرنات كالتالي:-

Tuber yield (Y) = - 39.6 + 3.19 Starch % + 0.728 top yield - 0.079 tuber N contents + 0.005 top N contents + 1.26 tuber P contents - 1.26 top P contents - 0.010 tuber K contents + 0.284 top K contents.