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Combined Effect of Organic and Mineral Fertilizers on Yield of Potato Grown under Coarse-Textured Soil Conditons

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THE PRESENT study was carried out under field conditions on sandy loam soil at Belbees, Sharkia governorate, Egypt during winter growing seasons of 2005 and 2006 to study the combined effect of organic and chemical fertilizers on plant growth and tuber yield and quality of potato (Var. Alpha) as well as chlorophyll content in the leaves, N, P and K concentrations in the leaves and tubers in addition to starch, ascorbic acid and nitrate content in tubers. The experiment was set up in a randomized complete block design with four replicates. Nine treatments were examined as follow; 100% of recommended chemical NPK fertilizer doses (control), which are 150 kg N + 75 kg P_2O_5 + 96 kg K_2O fed^{-1} (the recommendation rates given by Ministry of Agriculture), two treatments of full dose of the two manures, *i.e.*, (100% of farm yard manure (FYM) and 100% of chicken manure (CM) which were adjusted to the equivalent proper potato recommended rate of N (150 kg N fed^{-1}) based on the total nitrogen content of each organic manure (0.74% for FYM and 2.36% for CM), 75% of NPK + 25% of FYM or CM, 50% of NPK + 50% of FYM or CM and 25% of NPK+ 75% of FYM or CM.

The obtained results show that CM was more effective for all the studied traits than FYM when either the organic manures applied singly or in combination with chemical NPK fertilizers. The most pronounced treatments compared with control for all characters except nitrate content in tubers were (50% of NPK + 50% of CM) and (75%of NPK +25% of CM) with no significant difference between them in the most cases. The highest level of nitrate was detected in potato tubers produced from plants treated with full recommended doses of chemical NPK fertilizers. Raising the percentage of manures in the chemical fertilizers led to marked decrease in nitrate content where the lowest levels were recorded in tubers receiving 100% FYM or CM particularly the latter.

Also, the results ensure the importance of partial replacement of chemical NPK fertilizers by the use of organic ones as CM in producing potatoes under coarse-textured soil conditions. Its application would reduce the consumption of chemical fertilizers which in turn reduce the production costs as well as decrease nitrate content in the tubers besides, saving the environment from chemical pollution.

Keywords: Chicken manure (CM), Farmyard manure (FYM), Chemical fertilizers of NPK, Potato, Coarse textured soil.

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.

Nutritional requirements of potato crop are quite high and the application of chemical fertilizers is considered essential to obtain high tuber yields. Intensive use of chemical fertilizers led to increase the pollution in soil, water and food. The progressive rise in the cost of these fertilizers and their relative low efficiency, particularly in developing countries such as Egypt, give an account for finding out a partial or full substitution for the usual classic applied chemical fertilizers. Organic fertilizers are potential substitutes for such chemical fertilizers. They are environmentally safe and appropriately effective and economical.

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-Ghamry & EL-Naggar, 2001; Abdel-hamid *et al.*, 2004 and EL-Ghamry *et al.*, 2005).

The combination of the organic input and supplementary application of chemical fertilizers has been found as more attractive management option in order to achieve a resource saving and balanced nutrient supply and a high production of different vegetative crops (Ashour & Sarhan, 1998; Mahmoud, 2000; Youssef *et al.*, 2001; Awad, 2002; Rizk *et al.*, 2002; Shehata *et al.*, 2004 Ahmed *et al.*, 2005 and El-Metwally, 2007).

Therefore, the objective of the present work was to investigate the response of potato plants to the complete or partial replacement of recommended doses of chemical NPK fertilizers by some manures namely, farmyard manure (FYM) or chicken manure (CM) under coarse- textured soil condition.

Material and Methods

A two successive year's field experiment under completely randomized block design with 4 replicates was carried out during the winter season of 2005 and 2006 to achieve the objectives as the follows:

Soil: A soil from Belbees in Sharkia governorate, Egypt which was sandy loam in texture` (*Entisols, Orthents Torriorthents*). The main analytical values

were: clay =17.5%, silt =4.9%, sand =77.6%, $CaCO_3$ (%) =4.5, pH (1:2.5 water suspension) =7.94, EC_e (soil paste extract) =2.63 dSm^{-1}, OM =0.85%, available N =18.00 mg kg $soil^{-1}$, available P =5.4 mg kg $soil^{-1}$ and available K = 210 mg kg $soil^{-1}$.

Studied crop: Potato (*Solanum tuberosum* L.) Variety Alpha.

Date of planting: October 16th 2005 and October 20th 2006.

Experimental treatments: The following organic and mineral fertilization treatments were examined:150 kg N+ 75 kg P_2O_5 + 96 kg K_2O fed^{-1} (100% of recommended rates given by Ministry of Agriculture (Control), 100 % of farm yard manure (FYM), 75% of NPK + 25% of FYM, 50% of NPK + 50% of FYM, 25% of NPK + 75% of FYM, 100% of chicken manure (CM), 25% of NPK + 75% of CM, 75% of NPK + 25% of CM and 50% of NPK + 50% of CM. Some chemical properties of the organic manure are illustrated in Table 1 (Black, 1965).

During soil preparation, organic manures and 2/3 of different rates of p in the form of single super phosphate (15.5% P_2O_5) were added as basal dose. Nitrogen fertilizer was added at three equal doses with the 1st , 2nd and 3rd irrigations, respectively as ammonium sulphate (20.5% N), for the 1st dose and ammonium nitrate (33.5%N) for the 2nd and the 3rd ones. The rest of P fertilizer was applied also with the 1st irrigation. Potassium sulphate (48% K_2O) rates were divided into two equal doses and applied with the 2nd and the 3rd additions of N. Plot area was 10.5 m^2 which contained 3 ridges (5m length and 0.7 m wide). All agricultural practices of planting were done as recommended by Ministry of Agriculture.

TABLE 1. Some chemical properties of the investigated organic manures.

O.M. Sources / Parameters	Farmyard manure (FYM)	Chicken manure (CM)
Wight of m^3(kg)	535	410
Moisture (%)	23.5	48.2
pH(1:2.5 water suspension)	7.98	7.56
EC_e (saturated react) dSm^{-1}	2.47	4.32
Organic carbon (%)	12.38	28.44
Organic matter (%)	21.70	49.60
C/N ratio	17:1	12:1
Macro nutrients (%)		
N	0.74	2.36
P	0.36	1.26
K	1.55	2.30
Micro nutrients (mg kg^{-1})		
Fe	1420	1860
Mn	210	320
Zn	90	200
Cu	55	135

Studied Parameters

1. Dry weight of plant foliage (leaves and stems) after 70 and 90 days from planting.
2. Chlorophyll contents were determined in the leaves after 75 days from planting by a Minolta spad chlorophyll meter (Yadava, 1986).
3. Yield data; At 130 days after planting, the tuber yields of plants were harvested, and data were recorded for the following: weight of tuber yield fed^{-1} divided into; marketable yield of good shapes, healthy tubers which are more than 60 mm and from 30 to 60 mm in diameter and unmarketable yield; yield of culls (off shape, blemished, green and diseased) and less than 30 mm in diameter.
4. Tuber quality: Total Soluble Solids (T.S.S.) was determined using a hand refractometer, Dry matter content, and Specific gravity of tubers were estimated according to Schippers (1968).
5. Chemical composition: Ascorbic acid (Vitamin C) as described by Mondy & Ponnampalam (1986), Starch content determined in dry matter according to A.O.A.C (1990) and Nitrate was measured as described by Singh (1988). N, P and K contents were determined in leaves (70 and 90 days after planting) and tubers at harvesting time (130 days after planting) as described by Cottanie *et al.* (1982).

All data were statistically analyzed according to the technique of analysis of variance (ANOVA) and the least significant differences between the treatment means were compared as published by Gomez & Gomez (1984).

Results and Discussion

As the obtained results of both successive seasons were not significantly different, their average was taken into consideration.

1. Plant growth parameters

Dry weight (g/plant)

Data presented in Table 2 show that dry weights of plants differed significantly with different treatments. It is clear that all CM treatments were more effective than FYM ones in this respect. The superiority of CM treatments could be attributed to its higher content of organic matter and available nutrients as well as lower C/N ratio which increase available soil N. The data reveal also that, the combined application of chemical NPK fertilizers with FYM and CM in different rates significantly increased plant foliage dry weight at both growth stages compared with applying chemical NPK fertilizers or manures alone. The favorable effect of mixed manure with chemical fertilizers may be due to the effect of manure on increasing the efficiency of chemical fertilizers in addition to supply of many other essential nutrients.

In fact, organic fertilizers which include FYM and CM are one of the natural amendments which applied to correct and improve the physical, chemical and

biological properties of the soil and this consequently encourage the plant to have a good growth. Added manures increase the rate of organic matter in soil. Organic matter increment in coarse-textured soils contribute to reduce the leaching out of nutrients through: (1) improving soil structure toward maximizing the ability of this soil to retain and conserve irrigation water against rapid loss by leaching and deep percolation and (2) ability of the active groups of organic matter (fulvic and humic acids) to retain the inorganic elements in complex and chelate forms which broken down slowly by soil microorganisms and release the elements over a period of time. The extent of availability of such nutrients depends on the type of organic materials and microorganisms and the slow released nutrients permit the plants to benefit of it (Saha *et al.*, 1995).

TABLE 2. Combined effect of organic and chemical fertilizers on dry weight (g plant^{-1}) , N, P and K conc. (%) and chlorophyll readings (SPAD) at 70 and 90 days from planting.

Parameters / Treatments	Dry Weight (g plant^{-1})		N%		P%		K%		Chlorophyll readings (SPAD)
	70	90	70	90	70	90	70	90	
(100%NPK (Control)	14.10	32.36	2.56	2.28	0.364	0.298	4.48	4.18	52.55
75%of NPK + 25% of FYM	16.23	40.22	2.64	2.40	0.378	0.330	4.72	4.32	53.07
50% of NPK + 50% of FYM	16.05	40.36	2.70	2.50	0.386	0.338	4.72	4.36	53.35
25% of NPK + 75% of FYM	15.30	35.11	2.60	2.34	0.370	0.312	4.59	4.18	52.87
100% of FYM	12.95	28.46	2.32	1.90	0.338	0.250	4.16	3.48	51.28
75% of NPK + 25% of CM	17.24	42.66	2.86	2.60	0.395	0.342	4.86	4.48	53.58
50% of NPK + 50% of CM	17.37	42.78	2.82	2.68	0.400	0.350	4.90	4.56	53.97
25% of NPK + 75% of CM	16.59	38.17	2.68	2.48	0.380	0.320	4.68	4.42	52.95
100% of CM.	13.78	30.74	2.48	2.18	0.348	0.276	4.30	3.90	52.03
LSD at 0.05	0.38	0.41	0.14	0.13	0.01	0.01	0.15	0.12	0.12

The most pronounced treatments which gave the highest significant increases in plant foliage dry weight at both growth stages were 75% of NPK + 25% of CM and 50% of NPK + 50% of CM with no significant difference between such two superior treatments. The lowest plant foliage dry weight was recorded for the treatments received any of the organic manures alone especially FYM. These results are in agreement with those obtained by Badran & Safawat (2004); Abdel-Hady *et al.* (2005); Ahmed *et al.* (2005) and Mohamed & Medani (2005).

Chlorophyll readings (SPAD)

Data in Table 2 indicate that, chlorophyll readings of potato leaves at 75 days from planting differed significantly with various treatments. It is noticed that, application of CM gave higher values than those of FYM. Combining

FYM or CM with chemical NPK fertilizers at different rates significantly increased chlorophyll readings being higher with CM. This finding indicates the vital role of chemical-organic fertilization in more release of available N and other nutrients to be absorbed by potato plants which leading to the increase in the biosynthesis of chlorophyll pigments (Marschner, 1995 and Hedge *et al.*, 1999). The highest total chlorophyll content was resulted from the leaves of plants received CM + chemical NPK fertilizers at (50% + 50%). Application of FYM alone gave the lowest values. Obtained results are in harmony with those reported by Arisha & Bardisi (1999); Abdel-Mouty *et al.* (2001); El-Ghamry *et al.* (2005) and Shehata *et al.* (2004) who found that the highest amounts of chlorophyll a and b and total chlorophyll were resulted from sweet pepper plants fertilized with NPK + CM + cattle manure at 1/3+1/3+1/3. The lowest quantities of chlorophyll a, b and total chlorophyll were resulted from the plants fertilized with cattle manure only.

2. Tuber yields

As shown in Table 3, the results illustrate that application of chemical NPK fertilizers, manures and their mixtures had significant effect on total tuber yield as well as marketable yield. Combination of manures (FYM and CM) and chemical NPK fertilizers at different rates gave significant increases in both total tuber yield and marketable yield. CM combinations were superior to FYM ones.

TABLE 3. Combined effect of organic and chemical fertilizers on total, marketable and unmarketable tuber yield (ton fed^{-1}) and tuber quality.

Parameters / Treatments	Tuber yield (ton fed^{-1})			Tuber quality		
	Total tuber yield (ton fed^{-1})	Marketable (ton fed^{-1})	Unmarketable (ton fed^{-1})	DM %	TSS %	Specific gravity
(100% NPK (Control)	12.57	10.94	1.63	20.73	5.67	1.082
75%of NPK + 25% of FYM	14.29	13.07	1.22	21.58	5.80	1.090
50% of NPK + 50% of FYM	14.25	13.05	1.20	21.47	5.87	1.093
25% of NPK + 75% of FYM	12.86	11.54	1.32	19.88	5.40	1.079
100% of FYM	11.80	10.33	1.47	19.13	5.33	1.074
75% of NPK + 25% of CM	15.30	14.12	1.18	22.13	5.87	1.098
50% of NPK + 50% of CM	15.34	14.17	1.17	22.24	5.93	1.099
25% of NPK + 75% of CM	13.23	11.91	1.32	20.74	5.67	1.080
100% of CM.	12.08	10.68	1.40	19.34	5.40	1.075
LSD at 0.05	0.57	0.46	NS	0.32	0.12	0.004

Chemical fertilizers are considered as available source of macro-and micro-nutrients, but the elements are leached easily. On contrary, the organic fertilizers are considering as sufficient slow released fertilizers. Combining the chemical fertilizers with the organic ones supplies the plants with sufficient and available nutrients besides, reducing the leaching of the elements. This will enable more tubers to be developed and give enough time for tubers filling.

Thus, resulting in heavier tubers. The enhancing effect of the combinations between manures and chemical N, P and K fertilizers on the yield could be attributed to the increase in foliage dry weight of plant, chlorophyll contents and NPK concentrations (Table 2) which resulted in more accumulation of stored food in tubers. Thus, the response of potato to the combinations between organic and chemical fertilizers may give the possibility to substitute the chemical fertilizers partially by organic manures especially CM under conditions of this study.

The highest total tuber yield was obtained under treatment received 50% of CM + 50% of NPK which did not differ significantly than treatment received (25% of CM + 75% of NPK). The percentage of increase for such two treatments over 100% of NPK treatment (Control) amounted to about 22%. The marketable yield takes the same trend where the percentage of increase was approximately 30%.

The lowest values for the total and marketable yields were obtained from the treatments fertilized with FYM or CM only. In this respect, Youssef *et al.* (2001) found that 25% of organic manure + 75% of mineral NPK fertilizers was the best treatment for producing early and total yield of tomato. While, the lowest values were obtained from application of organic manure only with no significant difference between these treatments and the control particularly when applying CM.

Regarding unmarketable yield, data indicate that there were no significant differences between various treatments. However, application of FYM or CM either alone or combined with chemical NPK fertilizers resulted in decreases in unmarketable yield compared to control especially CM combinations with chemical NPK. The most effective treatments in reducing this parameter were (50% of CM + 50% of NPK) and (25% of CM + 75% of NPK). The obtained results are in correspondence with those reported by Ashour & Sarhan (1998), Tawfik (2001); Shehata *et al.* (2004); Abou-Hussien (2005) and El-Metwally (2007) on potato tubers.

3. Tuber quality

It can be noticed from data in Table 3 that the different tested treatments exerted significant effect on tuber quality of potatoes (*i.e.*, dry matter (DM%), total soluble solids (T.S.S.%) and specific gravity.. The highest significant increase in dry matter (%) of tubers was obtained from treatments received (50% of NPK + 50% of CM) followed by that received (75% of NPK + 25% of CM) with no significant difference between such two treatments. Application of FYM or CM alone recorded lowest significant decreases compared to control.

Total soluble solids and specific gravity of tubers followed the same pattern of changes as DM % of tubers. It could be attributed that the chemical-organic fertilizer maintain nutrients supply to the plants during growth period more than

the chemical fertilizers which led as mentioned earlier to vigorous plants and total tuber yield which in turn reflects on the tuber quality. These results are similar to those obtained by Arisha & Bardisi (1999); El-Banna *et al.* (2001); Tawfik (2001); Youssef *et al.* (2001) and Abou-Hussien (2005).

4. Chemical composition

N, P and K concentration

Data in Tables 2 and 4 demonstrate that N, P and K concentrations in potato leaves at 70 and 90 days from planting and in tubers at harvest were influenced significantly by different treatments. It is obvious that N, P and K concentration were in the same previous trend of that obtained by plant foliage dry weight. Where, CM was superior to FYM either if the manure was applied singly or combined with chemical NPK fertilizers. All the combinations between FYM or CM and chemical NPK fertilizers significantly increased N, P and K (%) in potato leaves and tubers compared to 100% of chemical NPK fertilizers (Control).

No doubt that, enrichment of chemical NPK fertilizers with organic manures improved moisture retention in the soil and nutrients use efficiency of both organic and chemical fertilizers and consequently increased the amounts of absorbed N, P and K by potato plant. The highest increases in N, P and K concentrations in the leaves and tubers were obtained from plants fertilized with (75% of NPK + 25%of CM) and (50% of NPK + 50% of CM) without any significant difference among them. 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 strong rooting system which in turn contributes to increase in N, P and K concentrations. In this respect, Ahmed *et al.* (2005) showed that application of CM at the rate of $15m^3$ fed^{-1} combined with chemical NPK fertilizers at the rate of 120kg N + 60 kg P_2O_5 + 96 kg K_2O/fed gave the highest values of N, P and K uptake by eggplants. On the other hand, the lowest values in N, P and K (%) in the leaves and tubers were produced from the plants fertilized with FYM only. These results are in accordance with those obtained by Youssef *et al.* (2001) on tomato, Shehata *et al.* (2004) on sweet pepper and Abou-Hussien (2005) on potato plants.

Ascorbic acid and starch content in tubers

Data in Table 4 show that, the amounts of ascorbic acid and starch content in tubers were significantly affected by application of manures, chemical NPK fertilizers and their combinations. Applying FYM or CM alone or when combined with chemical NPK fertilizers significantly increased the amount of ascorbic acid and starch content in tubers compared to the full recommended dose of chemical NPK fertilizer (Control) with superiority for CM treatments. The highest amount was found in potato tubers of plants fertilized with (50% of NPK + 50% of CM) and (75%of NPK + 25% of CM) with no significant difference between them, whereas the lowest amount was recorded in tubers of plants fertilized with 100% of NPK for the ascorbic acid and 100% of FYM for

starch content. These results are in agreement with those reported by Tawfik (2001); Shehata *et al.* (2004) and Abou-Hussien (2005).

TABLE 4. Combined effect of organic and chemical fertilizers on N, P and K (%) in tubers, Ascorbic acid (mg 100g FW^{-1}), Starch (%) and Nitrate content (mg kg DW^{-1}) in tubers.

Parameters / Treatments	Macronutrients conc. (%) in tubers			Ascorbic acid (mg 100 g fw^{-1}) of tubers)	Starch content % in tubers	Nitrate content (mg kg^{-1}dw) of tubers
	N	P	K			
(100% NPK (Control)	1.62	0.250	2.60	14.30	14.62	64.40
75%of NPK + 25% of FYM	1.98	0.288	3.08	21.87	15.58	58.80
50% of NPK + 50% of FYM	2.06	0.296	3.16	22.00	15.66	54.40
25% of NPK + 75% of FYM	1.88	0.268	2.60	20.43	14.30	50.70
100% of FYM	1.32	0.204	1.93	16.40	13.44	42.50
75% of NPK + 25% of CM	2.44	0.312	3.40	22.27	15.77	55.60
50% of NPK + 50% of CM	2.48	0.318	3.48	22.40	15.86	51.0
25% of NPK + 75% of CM	2.02	0.282	2.73	20.80	14.72	44.30
100% of CM.	1.54	0.224	2.10	17.62	13.64	38.80
LSD at 0.05	0.10	0.010	0.10	0.34	0.12	1.19

Nitrate content in tubers

Data in Table 4 indicate that nitrate content in tubers was significantly influenced by different treatments. The highest level of nitrate was detected in tubers produced from plants treated with full recommended doses of NPK fertilizers. Raising manures and decreasing chemical fertilizers led to marked decrease in nitrate level in potato tubers, where the lowest levels were recorded in the potato tubers received organic fertilizers on particularly CM. The steady release of the nitrogen from organic fertilizers may have resulted that nitrogen has been taken up mainly in the form of ammonium which probably caused low nitrate contents of the tubers (Kolbe *et al.*, 1995). Our results are in accordance with those reported by El-Banna *et al.* (2001); Tawfik (2001); Awad (2002) and Ibrahim *et al.* (2006).

As a conclusion, the obtained results ensure the importance of partial replacement of chemical NPK fertilizers by the use of more safe and economical organic fertilizers in producing potato plants under coarse-textured soil conditions. generally, the most pronounced treatments for improving plant growth and tuber yield and quality compared to recommended dose of NPK (control) was (50%of NPK + 50% of CM) followed by (75% of NPK + 25%of CM) with no significant difference between such two treatments. In addition, its application would reduce the costs as well as decrease nitrate content in tubers.

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تأثير إضافة الأسمدة العضوية مع الأسمدة المعدنية على محصول البطاطس تحت ظروف الأراضي ذات القوام الخشن

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أجريت تجربة حقلية بمنطقة بلبيس-محافظة الشرقية- مصر- تحت ظروف الأراضي ذات القوام الخشن على نباتات البطاطس صنف (ألفا)، وذلك من خلال العروة الشتوية لعامي٢٠٠٥ و٢٠٠٦- بهدف دراسة امكانية استبدال الأسمدة الكيماوية جزئياً أوكلياً بالأسمدة العضوية وتأثير ذلك على النمو ومحصول الدرنات وجودتها بالإضافة إلى محتوى الأوراق من الكلوروفيل وكذلك تركيزعناصر النيتروجين والفوسفوروالبوتاسيوم في الأوراق والدرنات، وأيضاً محتوى الدرنات من النشا وحامض الأسكوربيك والنترات.

استخدم في التجربة التصميم الاحصائي قطاعات كاملة العشوائية في ثلاث مكررات واشتملت على تسع معاملات هي: التسميد الكيماوي بالمعدلات الموصي بها من قبل وزارة الزراعة لمحصول البطاطس من عناصر النيتروجين

والفوسفور والبوتاسيوم (معاملة المقارنةNPK ١٠٠٪of) والتسميد العضوي بالمعدل الكامل (١٠٠٪) من مصدرين (السماد البلدي وسماد الدواجن) والذي حسب على أساس المعدل الموصي به من النيتروجين لمحصول البطاطس (١٥٠كجم نيتروجين/فدان)، وأيضاً على أساس تركيزالنيتروجين في كلا المصدرين العضويين (٠,٧٤٪ في السماد البلدي، ٢,٣٦٪ في سماد الدواجن)، بالاضافة إلى ستة معاملات عبارة عن خليط من الأسمدة الكيماوية والأسمدة العضوية بنسب مختلفة وقد أوضحت االنتائج أن:

سماد الدواجن كان أكثر تأثيراً من السماد البلدي في زيادة جميع الصفات المدروسة- سواء أضيف السماد العضوي منفرداً أومع الأسمدة الكيماوية مقارنة بالمعاملة NPK ١٠٠٪of (الكنترول) و تم الحصول على أعلى زيادة في جميع الصفات المدروسة فيما عدا تركيز النترات في المعاملتين (٥٠٪ من أسمدة النيتروجين والفوسفور والبوتاسيوم + ٥٠٪ من سماد الدواجن)، (٧٥٪ من أسمدة النيتروجين والفوسفور والبوتاسيوم + ٢٥٪ من سماد الدواجن) مع عدم وجود فرق معنوي بينهما في معظم الحالات.

في حين كان أعلى تركيز للنترات في درنات النباتات المسمدة بالمعدلات الموصى بها من أسمدة عناصر النيتروجين والفوسفوروالبوتاسيوم(الكنترول) وتسبب زيادة نسبة إضافة أي من السمادين العضويين مع خفض نسبة إضافة الأسمدة الكيماوية على انخفاض تركيز النترات في الدرنات والتي وصلت إلى أقل تركيز لها عند إضافة أي من السمادين العضويين فقط خصوصاً سماد الدواجن.

وتؤكد نتائج هذه الدراسة أهمية الاحلال الجزئي للأسمدة الكيماوية باستخدام سماد الدواجن لانتاج البطاطس تحت ظروف الأراضي ذات القوام الخشن وقد نتج عن ذلك تقليل استخدام الأسمدة الكيماوية والذي ترتب عليه خفض تكلفة الانتاج وخفض تركيز النترات في الدرنات.