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Effect of Different Phosphorus Sources on the Plant Growth, Tubers Yield and Nutritional Value of Potatoes

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ABSTRACT

Two field experiments were carried out during the two successive fall seasons of 2012/2013 and 2013/2014 in sandy soil at Sadaat city, Taba farm, EL-Menofyia Governorate, Egypt to investigate the effect of different phosphorus sources such as triple super phosphate, mono-ammonium phosphate (MAP) and di-ammonium phosphate (DAP) on the plant growth, tubers yield and nutritional value of potatoes. The obtain results indicate that addition of phosphorus fertilizer in form of DAP resulted in vigor plant growth expressed as plant height, number of leaves / plant and shoots/plant, fresh and dry weight, leaf area, leaf area index, relative growth rate and Net assimilation rate if compared with other two P sources. But the statistical analysis of the obtained data reveals that, the differences within DAP and MAP were not great enough to reach the 5 % level of significant. The heaviest tubers yield of potato as expressed by total tons/fed., and marketable one recorded with plants which received its phosphorus requirements as DAP source followed in decreasing order by that supplied MAP source. The addition of phosphorus as super phosphate source resulted in the heaviest un-marketable tuber yield. The best physical properties as expressed by average weight and number of tubers / plant, length and diameter as well as specific gravity, all of them recorded their highest values with that plants supplied DAP and MAP as phosphorus source. The highest values of nutritional values, i.e. starch, carbohydrates, total sugar, N, P, K, Ca, Fe, Zn, Mn, and Cu were estimated with that plants fertilizer by MAP and DAP.

Key words: Phosphorus, potato, DAP, MAP, growth, yield, nutritional values.

Introduction

Potato (*Solanum tuberosum* L.) is recognized as one of the most important vegetable crops for local consumption and exportation and is known as the fourth most important world crop, after rice, wheat, and maize.

Under Egyptian conditions, Phosphorus availability is considered one of the major growth-limiting factors for growing plants. The P of the applied fertilizers converts fast to unavailable form for plant absorption by its reaction with the soil constituents (Dawa *et al*., 2007).This could be explained why the cultivated soils require a high amount of mineral P fertilizers to complete supplies of plants. The most commonly used fertilizer Phosphorus sources are triple super phosphate, di ammonium phosphate (DAP) and mono ammonium phosphate (MAP). These Phosphorus fertilizer sources are highly water soluble (>80 %) thus dissolves quickly in soil to release plant-available phosphate and ammonium. Now MAP and DAP are widely used sources of P fertilizer, and they are popular in most locations in Europe counters due to their high P nutrient content and its excellent physical properties. (Rosen *et al*., 2014).

Moreover, Balemi (2009), Hopkins (2011) and Rosen *et al*. (2014) reported that DAP and MAP phosphorus sources gained the best plant growth parameters if compared to the other phosphorus sources. Rosen and McNearney (2003); Hill *et al*. (2011) and Rosen *et al*. (2014) on potato plants found that DAP or MAP as phosphorus fertilizer sources gained the highest values of tuber yield and its components. The phosphorus play a great role in improving the chemical consistent of potato yield, whereas it may be increase the starch, protein, carbohydrate, sugar, N, P, K, Zn, Fe, Cu (Carl *et al*. 2011; El-Sayed *et al.* 2011 and Abdel-Razzak *et al*. 2013).

Therefore, the present investigation was undertaken to find out the beneficial effect of different phosphorous fertilizer sources (MAP and DAP) as well as calcium super phosphate on the productivity and quality of potato plants.

Materials and Methods

Two field experiments were carried out in sandy soil at Sadaat city, Taba farm, EL-Menofyia Governorate during the two successive fall seasons of 2012/2013 and 2013/2014. The physical and chemical characteristics of experimental soils are presented in Table (1). These experiments were conducted to

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investigate the effect of phosphorus sources i.e., triple super phosphate (TRI) , Mono-Ammonium Phosphate(MAP) and Di-Ammonium Phosphate (DAP) on Potato Productivity. Certified of seed potato tubers of cultivar diamante (locally produced and cold stored), obtained from General Authority for Producers and Exporters of Horticulture Crops, Cairo, Egypt, were used in two seasons. The tubers were planted on the first week of October month during the two seasons on one side of ridge at distance of 25 cm between tubers and 75 cm within rows. This experiment included 3 treatments of Phosphorous fertilizer sources, i.e. triple super phosphate "TSP" (15.0% P2O5), Mono-Ammonium Phosphate "MAP" (12-52-0) and Di-Ammonium Phosphate "DAP" (18-48-0). All experimental plots received their phosphorus needs in equal amounts (90 P_2O_5/fed). The total quantity of Calcium super phosphate was added once time during soil preparation, but the MAP and DAP was added as two equal portions at ,30 and 45 days after planting with drip irrigation water. Nitrogen fertilizer was added in the form of ammonium sulphate (20.6 N /fed) at 120 units/ fed., as two equal portions (30 and 45 day old). Potassium sulphate at rate of 90 K_2O unit /fed., were addition the same time of nitrogen fertilizer added. The chemical properties of phosphorus fertilizer sources are shown in Table (2).

Table 1: Physical properties and Chemical analysis of the experimental soil.

Properties	Values
Physical	
Sand %	90
Silt %	5
Clay %	5
Texture Sandy	sandy
Available nutrient	
N %	Traces
P %	0.443
K %	0.575
Chemical properties (meq/L)	
pH	8.20
EC ds/m	1.50
$CaCO_3$ %	5.50
Ca^{++}	2.65
Mg^{++}	2.40
Na^{+}	4.34
CO_3^{-}	Zero
HCO_3^{-}	3.85
Cl^{-}	53.00
SO_4^{-}	55.65

Table 2: The chemical properties of Phosphorous fertilizer sources.

Chemical Properties	MAP	DAP	TSP
Chemical formula	$NH_4H_2PO_4$	$(NH_4)_2HPO_4$	$NH_4(H_2PO_4)_2$
N %	12	18	
P_2O_5 %	52	48	15.5
Hydrogen %	5	7	2
Oxygen %	56	49	55
Ca %	-	-	17
Water solubility g/L	370	588	-
Solution pH	4-4.5	7.5	-

MAP (Mono-Ammonium Phosphate). DAP (Di-Ammonium Phosphate). TSP (Triple Super Phosphate).

Experimental design:

A complete randomized design with four replicates was used. The normal agricultural practices were used for the potato production, i.e. irrigation, weed control as well as diseases and pest control, where followed according to the recommendation of the Egyptian Ministry of Agriculture.

Recorded data:

Vegetative growth.

A random sample of 3 plants was taken at 70, 80 and 90 days after planting for the determination of the following characters.

Plant height (cm), number of leaves / plant, number of shoots / plant, fresh and dry weight of whole / plant and its leaves and shoots. Leaf area (m^2/plant), net assimilation rate (g/m^2/day) and relative growth rate (mg/g/day) and were measured according the method described by Gardner *et al.*, 1985.

Tubers yield and its categories:

Tubers yield:

Weight of tubers g/plant, Number of tubers / plant, Average weight of tubers g/ tuber, Average weight of tubers tons/fed., Marketable tubers yield (yield of good shapes and healthy) and Unmarketable tubers yield (off shape, blemished, green and diseased). The total tubers yield of each experimental plot was divided into three categories i. e. large (weight more than 200 g/tuber), medium (weight within 100-200 g/tuber) and small (weight less than 100 g/tuber) and the percentages of each category was calculated.

Physical properties of tubers yield:

Samples of tubers yield were taken randomized for determination of physical properties as following: diameter of tuber as cm.- length of tuber as cm.- volume of tuber as cm3/tuber- and specific gravity as g/cm^3. Where the average specific gravity of the tuber was determined by dividing the tuber weight by its volume.

Nutritional values:

Dry matter percentage, Total carbohydrates was determined according to Dobbis *et al*. (1956), Starch content was determined using the method of Somogi (1952) , Total sugars (were determined according to the method described by Dobbis *et al*. 1956). Total nitrogen was determined according to the procedures described by Cottenie *et al*. (1982). Phosphorus content was determined according to the procedures described by Cottenie *et al.* (1982). Potassium and Calcium content was measured as described by Chapman and Pratt 1982), Fe, Zn, Mn and Cu were determined as described by Chapman and Pratt (1982), and Sulphur was determined using the modified colorimetric method using spectrophotometer (SPECTRONIC 200, Milton Roy Co., Ltd, USA).

Statistical Analysis

Obtained data were subjected to the analysis of variance procedure and means were compared to the L.S.D. test at 5 % level according to Gomez and Gomez (1984).

Results and Discussion

A- Effect of different phosphorus sources on Plant growth characteristics:

Height of plant, leaves and shoot number as well as fresh and dry weight of plant

Tables (3) Show clearly that, the application of phosphorus fertilizer in the DAP (Di-ammonium phosphate) resulted in the highest potato plant followed in descending order by that plants which received MAP (Mono-ammonium phosphate) source, but the shortest potato plants were recorded with that plants supplied phosphorus fertilizer in the triple super-phosphate form. Moreover, the obtained data revealed that, the differences within sources were significant only between the highest and the lowest values of the measured parameters. However, in most cases both DAP (Di-ammonium phosphate) and MAP (Mono-ammonium phosphate) sources of phosphorus gained no significant variation. These findings were true in both seasons. Generally, it could be concluded that applying DAP or MAP as phosphorus source caused a superiority in height, number of leaves or shoots per plant compared with applying triple supper-phosphate form.

Results in Tables (3) show also that the addition of phosphorus fertilizer in the form of DAP resulted in the heaviest fresh weight and dry weight of whole potato plant ad its organs, i.e., leaves and shoots. On the contrary, the using of super-phosphate as phosphorus fertilizer gained the lowest values in the two tested season. Moreover, data indicated that the differences within the three phosphorus fertilizer sources were significant. All these findings were true for different stages of potato plant growth. Whereas, DAP had an enhancement in leaves and shoots as well as total fresh weight over super-phosphate.

As for dry weight, data detected that the significant differences were found only between the additions of MAP or DAP sources with super-phosphate addition. It means, the differences within DAP and MAP were not significant. These findings were true for various plant growth stages of fresh and dry weight of total potato plant, and its leaves or shoots during the two studied seasons.

Leaf area, relative growth rate and net assimilation rate

In Table (4) results show that, the highest values of leaf area, relative growth rate and net assimilation rate were estimated in plants which received phosphorus fertilizer in the DAP form, followed in descending order by that plants supplied MAP as phosphorus source. On the contrary, the lowest values of leaf area, relative growth rate and net assimilation rate were detected with that plants which applied by super-phosphate in both seasons. Moreover data of the first season, shows that phosphorus sources had no significant effect on relative growth rate in both estimation periods and net assimilation rate (only within period between 70 – 80 days). In the second season, no significant effects were detected as the relative growth rate and net assimilation rate at the first period of estimation (70 – 80 days).

Table 3: Effect of different phosphorous fertilizer sources on some vegetative growth characters at different growth stages of potato plant during 2012/2013 and 2013/2014 seasons.

Characters	Triple super phosphate			Mono ammonium phosphate			Di ammonium phosphate			L.S.D. at 5 % level		
	Days after planting											
	70	80	90	70	80	90	70	80	90	70	80	90
	First season											
Plant height (cm)	70.89	72.00	72.39	78.00	77.78	79.06	76.44	78.89	79.56	2.55	2.63	2.87
Number of leaves / plant	64.22	64.56	64.89	74.44	74.89	75.33	74.56	75.11	75.78	3.58	3.66	3.40
Number of shoots / plant	4.89	4.89	5.22	6.67	6.67	7.00	6.33	6.76	7.22	1.22	1.22	0.50
Fresh wt. of leaves g/plant	329.53	334.30	339.64	429.81	435.92	443.49	442.17	449.53	458.65	37.17	40.20	41.34
Fresh wt. of shoots g/plant	179.03	181.81	183.70	235.11	238.99	242.55	236.52	241.75	245.41	15.52	18.69	21.19
Total fresh weight	508.56	516.12	523.34	664.91	674.91	686.04	678.69	691.28	704.06	51.86	57.53	60.34
Dry wt. of leaves g/plant	45.48	49.04	52.48	55.72	60.72	64.27	56.87	62.31	66.76	2.91	6.01	5.30
Dry wt. of shoots g/plant	20.07	20.96	22.29	23.33	24.55	26.44	24.16	26.27	28.49	0.76	0.64	1.47
Total dry weight g/plant	65.55	70.00	74.78	79.04	85.26	90.71	81.03	88.58	95.25	2.96	5.93	4.42
	Second season											
Plant height (cm)	68.11	69.33	71.33	75.22	77.00	79.22	76.56	78.28	81.11	1.14	1.75	1.98
Number of leaves / plant	61.11	64.89	66.67	71.56	74.11	76.67	73.89	75.78	78.67	3.42	2.70	2.31
Number of shoots / plant	4.78	4.78	4.78	6.56	6.67	6.89	6.78	7.00	7.33	0.80	0.91	0.82
Fresh wt. of leaves g/plant	314.03	321.34	322.46	420.70	429.08	449.97	434.14	441.31	464.17	21.46	17.00	39.55
Fresh wt. of shoots g/plant	187.23	192.68	197.81	235.61	243.14	253.70	244.18	250.79	261.72	5.45	5.54	8.55
Total fresh weight	501.26	514.02	520.27	656.31	672.23	703.66	678.32	692.10	725.88	21.93	13.43	31.48
Dry wt. of leaves g/plant	37.14	40.54	47.95	50.54	55.22	64.59	56.87	62.31	66.76	1.02	5.56	2.32
Dry wt. of shoots g/plant	18.45	20.04	24.59	21.20	24.17	35.00	24.16	26.27	28.49	0.76	2.17	2.86
Total dry weight g/plant	55.59	60.58	72.55	71.74	79.39	99.59	81.03	88.58	95.25	0.96	4.55	4.44

Table 4: Effect of different Phosphorous fertilizer sources on leaf area, leaf area index, relative growth rate and net assimilation rate at different growth stages of potato plant during 2012/2013 and 2013/2014 seasons.

Phosphorus sources	Leaf area (m^2 / plant)			Relative growth rate (mg /g / day)		Net assimilation rate (mg /m^2/ day)	
	Days after planting			Days after planting			
	70	80	90	70-80	80-90	70-80	80-90
First season							
Triple super phosphate	1.38	1.57	1.77	4.51	5.67	0.18	0.23
Mono ammonium phosphate	1.54	1.74	1.95	4.74	7.15	0.21	0.34
Di ammonium phosphate	1.71	1.89	2.09	4.86	7.79	0.22	0.38
L.S.D. at 5 % level	0.20	0.12	0.13	N.S.	N.S.	N.S.	0.06
Second season							
Triple super phosphate	1.43	1.57	1.77	4.42	5.73	0.17	0.23
Mono ammonium phosphate	1.57	1.74	1.95	4.79	7.32	0.22	0.35
Di ammonium phosphate	1.80	1.89	2.09	5.14	8.22	0.23	0.40
L.S.D. at 5 % level	0.11	0.12	0.13	N.S.	1.44	N.S.	0.06

Finally, it could be concluded that, the highest plant growth vigor obtained from using either DAP or MAP over using super-phosphate may be due to the increase in one or more of the estimated attributes either in leaves or shoots. The increase in dry weights of leaves and/or shoots may be attributed to the increase in both leaves or shoots number and leaf area which led to more active photosynthesis and in turn more carbohydrates accumulation. However, the higher values of relative growth rate (RGR) and net assimilation rate (NAR) might be due to the improvement effect of DAP or MAP on leaf number and its area as well as the advancement effect on weight of plant organs (leaves and shoots).

Concerning to the advantages of DAP over MAP as phosphorus sources, these might be attributed to one or more the following, the higher nitrogen content (18 %), the highest water solubility (588 g/L.) and/or its pH value (7.5 to 8.0), comparing by 10 – 12 N %, 370 g/L., solubility and 4.0 to 4.5 pH value for MAP. In spite the properties variation within DAP and MAP, but the obtained results clearly showed that the differences were not significant concerning most plant growth parameter. The obtained results are in good accordance with those reported by Balemi (2009); Hopkins (2011) and Rosen *et al*. (2014).

Effect of different phosphorus sources on Tubers yield and its components:

Tubers yield:

Data in Table (5) show that, the supplying potato plants with phosphorus in the form of DAP or MAP caused an increase in tubers yield /fed., weight of tubers/plant as well as average tuber number/plant and the average weight of tuber if compared with that plants which received its phosphorus requirements in the classic form (Super-phosphate). Moreover, the total tubers yield and its components recorded the higher values if applied DAP as phosphorus source when compared with MAP source. In spite this superior, but the obtained data reveals that, the differences within the two phosphorus sources i. e., DAP and MAP were not significant. In the two seasons, with except total tuber yield as tons/fed., and the average tubers weight as g/plant in the first season.

The marketable tuber yield of potato as affected by phosphorus sources (Table 5), responded completely the same mentioned trend in both two seasons. But regarding the un-marketable tuber yield the obtained data reveals that the lowest no significant value was recorded with that supplied MAP as phosphorus source.

Generally, it could be concluded that, the total tubers yield, and its components, recorded their highest values when phosphorus needs added as DAP source. The opposite was true for un-marketable yield, where the lowest non-significant values were found with the MAP source. The highest potato yield and its components obtained from using DAP may be due to the increase in one or more of the estimated attributes to plant growth measurements. It could be concluded that, the superiority of DAP over the MAP may be attributed to its higher water solubility and/or its pH value and/or its higher nitrogen content.

The previous investigations concerning the response of potato yield and its components to the various phosphorus sources were confirmed that obtained by Rosen and McNearney (2003), Hill *et al*. (2011) and Rosen *et al*. (2014).

Table 5: Effect of different Phosphorous fertilizer sources on tubers yield parameters of potato plant during 2012/2013 and 2013/2014 seasons.

Phosphorus sources	Tubers/ plant		Average tuber Wt. (g)	Average tuber Wt. (ton/fed.)	Tuber yield (ton/fed.)	
	Wt. (g)	No.			Marketable	Un marketable
First season						
Triple super phosphate	579.09	6.22	92.86	9.27	7.807	1.463
Mono ammonium phosphate	866.35	7.44	115.88	13.86	12.679	1.181
Di ammonium phosphate	966.11	7.89	121.68	15.46	14.154	1.306
L.S.D. at 5 % level	94.94	0.59	5.37	1.52	1.503	0.29
Second season						
Triple super phosphate	611.33	6.22	98.13	9.78	8.325	1.455
Mono ammonium phosphate	961.03	8.14	117.73	15.38	14.487	0.893
Di ammonium phosphate	958.19	8.33	114.86	15.33	14.292	1.038
L.S.D. at 5 % level	53.95	0.58	4.89	0.86	0.56	N.S.

Physical properties:

In Table (6) the addition phosphorus fertilizer for potato plants in the form of DAP or MAP gained the better physical properties as expressed by diameter, length, size and specific gravity of potato tubers if compared with addition the traditional phosphorus source, i.e. super-phosphate. Also, the obtained data reveals that DAP was more active than MAP. These held good for all physical properties during the two seasons. Whereas, the recorded data indicated that, the differences within addition the three phosphorus sources were great enough to be significant. The best physical properties of tubers were estimated with plants were received DAP as phosphorus source, and the poorest physical properties recorded with that plants supplied with triple super-phosphate as phosphorus source. The literature review of Rosen, and McNearney (2003) and Rosen *et al*., (2014) are supported our obtained results.

Table 6: Effect of different Phosphorous fertilizer sources on physical tubers quality of potato plant during 2012/2013 and 2013/2014 seasons.

Phosphorus sources	Physical tubers quality				The percentages of various grades of tuber		
	diameter (cm)	length (cm)	Volume (cm^3 / tuber)	Specific Gravity (g / cm^3)	Small g. 100 <	Medium -200 g.100	Large g. 200>
First season							
Triple super phosphate	6.11	7.40	183.33	0.90	61.38	38.62	0.00
Mono ammonium phosphate	7.50	9.17	220.00	1.00	36.11	48.02	15.87
Di ammonium phosphate	8.06	9.89	230.00	1.04	32.67	49.18	18.14
L.S.D. at 5 % level	0.49	0.50	0.25	0.09	3.90	7.38	3.92
Second season							
Triple super phosphate	5.94	7.14	175.00	0.54	57.94	42.06	0.00
Mono ammonium phosphate	7.06	9.00	230.00	0.70	30.27	54.87	14.86
Di ammonium phosphate	7.5	9.72	233.33	0.82	28.40	53.09	18.52
L.S.D. at 5 % level	0.49	0.20	8.74	0.01	3.04	4.01	2.50

Also, Table (6) demonstrated that the highest percentage of both large and medium tuber weight was associated with that plants received phosphorus as the DAP form followed in descending order by that received MAP form. On the contrary, the lowest percentage were recorded with that plants supplied the traditional form of phosphorus fertilizer. These findings are completely similar in both seasons. Moreover, the obtained data revered that no significant differences were recorded within the using of DAP and MAP. It could be concluded that more than half of tuber yield was small size (61.38 and 57.94 % in 1st and 2nd seasons respectively) when using super phosphate as phosphorus fertilizer. These means that the applying of DAP or MAP gained tubers yield more suitable for exportation compared with triple super-phosphate. These might be attributed to that DAP and MAP phosphorus fertilizer are highly soluble and thus dissolves quickly in soil to realse plant available phosphate and ammonium which needs for absorption by rooting zone, consequently resulted healthy plant growth and superiority of tuber yield and its quality. Moreover, phosphorus caused an enhancement in tuber numbers and their size. The obtained data are in good harmony with that obtained by Carl *et al*. (2011).

Effect of different phosphorus sources on nutrition values of potato tubers:

In Tables (7) results showed that phosphorus fertilizer addition in the traditional form, i.e. super-phosphate gained the lowest percentage values of the estimated parameters, the opposite was occurred when either DAP or MAP phosphorus source added. The presented data also showed that, the highest starch content in potato tubers was associated with that plants received MAP source, but the percentage of dry matter and total carbohydrate were recorded by that plants supplied by the DAP phosphorus source.

Also, data in Tables (7), indicate that, the significant highest nitrogen and phosphorus content were found in potato tubers of that plants received MAP as phosphorus fertilizer. On the contrary, the nutritional elements, i.e. K, Ca, P, Fe, Mn, Zn and Cu, recorded their highest values with that plants fertilized by DAP as phosphorus fertilizer source. These results were true in both seasons. The values of K, Fe and Cu (two seasons), and S (first season) did not show any significant effect within the addition of DAP or MAP sources. Generally, it could be concluded that, potato plants which received DAP as phosphorus fertilizer source gained the best nutritional values if compared with the other phosphorus sources in both seasons, except starch, N and P contents, where using MAP gained the highest values. However, the collected data reveals that the differences within different phosphorus sources concern to their effects on the nutritional values of potato tubers were significant. In the two seasons except the total sugar content. Also, the obtained data indicate that, the lowest nutritional values, i.e. the percentages of tuber dry matter, starch, carbohydrate, sugars, as well as N, P, K, Ca, S, Fe, Mn, Zn and Cu, all of them recorded with that plants supplied super-phosphate. It could be summarized that, the best of most nutritional values of potato tuber were gained with that plants supplied with DAP as phosphorus fertilizer. This might attributed to the high solubility and it's highly nitrogen content.

The available literature concerning the effect of MAP or DAP as phosphorus fertilizer sources on the nutritional values of potato tubers yield was scanty. As a general, it could be concluded that, the phosphorus play a great role in improving the chemical consistent of potato yield, where it may be increase the starch, protein, carbohydrate, sugar, N, P, K, Zn, Fe, Cu (El-Sayed *et al.,* 2010; Abdel-Razzak *et al*., 2013 and Rosen *et al.,* 2014).

Table 7: Effect of phosphorous fertilizer sources on nutritional values content of potato tubers during 2012/2013and 2013/2014 seasons.

Phosphorus sources	%									ppm			
	Dry matter	Starch	Carbohy-drate	Total sugars	N	P	K	Ca	S	Fe	Mn	Zn	Cu
First season													
Triple super phosphate	14.58	49.41	53.56	0.620	1.48	0.57	3.64	0.93	0.19	219.67	23.52	28.40	16.57
Mono ammonium phosphate	16.86	65.23	61.34	0.669	1.93	1.70	4.54	1.40	0.30	298.78	31.82	33.62	32.89
Di ammonium phosphate	17.52	60.11	64.19	0.677	1.81	1.61	5.00	1.56	0.31	328.33	38.14	34.54	37.11
L.S.D. at 5 %	0.44	5.76	0.91	N.S.	0.10	0.04	0.46	0.08	0.02	36.65	4.24	0.74	6.09
Second season													
Triple super phosphate	15.14	48.19	54.22	0.626	1.44	0.60	3.13	0.95	0.20	212.67	24.27	29.16	15.20
Mono ammonium phosphate	16.27	64.34	62.90	0.676	1.95	1.78	4.68	1.43	0.28	305.22	30.41	34.04	29.00
Di ammonium phosphate	17.78	59.53	65.09	0.677	1.85	1.71	4.77	1.60	0.30	333.44	38.48	34.84	31.44
L.S.D. at 5 %	0.80	5.32	1.13	N.S.	0.09	0.05	0.57	0.05	0.02	30.75	1.73	0.67	4.82

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