



Responses of different potato (*Solanum tuberosum* L.) cultivars to nitrogen fertilizer under sandy soil conditions

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Abstract: An experimental trial was carried out in the two successive seasons of 2014 and 2015 to study the effect of cultivars (Spunta, Nicola, Cara and Diamant) and nitrogen application (140, 160 and 180 kg N/fed.) on growth, yield and quality of potato plants. Each of the four cultivars showed different response to nitrogen application. Results of this work showed that the best effect on plant vegetative growth (plant height, number of stems, fresh and dry weights of halum), yield and its component (number of tuber, total yield and average tuber weight) and tubers quality (dry matter, total carbohydrates, specific gravity and starch) was obtained by using the highest concentration of nitrogen (180 kg N/fed.) with Cara cultivar. In addition, the interaction between cultivar and nitrogen rate resulted are significant. The lowest results were recorded with cultivar Nicola treated with 140 kg of N/fed.

Keywords: potato (*Solanum tuberosum* L.), nitrogen fertilizer, sandy soil.

Introduction

Potato (*Solanum tuberosum* L.) is one of the most important crops to feed the world population. Potato tuber is the fourth most important staple food after rice, wheat and maize. Potatoes are rich in certain antioxidants, such as polyphenolics (phenolcarboxylic acids), vitamin C, carotenoids and selenium¹. It was found that pigmented potato cultivars are rich source of anthocyanins, in particular acylated derivatives².

N fertilizer applied at or before tuberization can extend the vegetative growth period and delay tuber development, resulting in a lower tuber yield. However, too much N applied later in the season can delay maturity of the tubers, reducing yield and adversely affecting tuber quality and skin set. Conversely, low application of N at any point in the season also can result in lower tuber yields and reduces profits. Environmental considerations must also be taken into account in N fertilizer management. Nitrogen is a mobile nutrient in the soil and its excess can lead to losses via leaching or surface run off. These factors make the appropriate N rate critical for successful white potato production^{3,4}. Many scientists have studied the effect of N fertilizer rate and seed spacing on yield of potato cultivars. Nitrogen management is one of the most important aspects for potato production. Nitrogen fertilizer recommendations vary widely around the world.⁵ applied different N applications on potatoes cv. Kufri Badshah and found that the best N fertilizer rate is 200 kg N ha⁻¹ and produced highest yield.⁶ observed that the best amount of N fertilizer is 180 kg N ha⁻¹.⁷ in a farm experiment obtained the highest yield with 250 kg N ha⁻¹⁸ in a research on some cultivars including Diamant obtained the highest yield with applying 90 kg N ha⁻¹ and the Diamant showed the highest yield among other cultivars.⁹ also found that Diamant cultivar produced highest yield and dry matter with 285 kg N ha⁻¹¹⁰ by using 0, 120, 240 kg N ha⁻¹ and observed that Diamant cultivar produced highest yield with 120 kg N ha⁻¹.¹¹ noticed

that, potato shoots fresh weight and chlorophyll content were increased with each N dose increment (0, 40, 80, 120 kg N/feddan). Therefore, this study was intended to investigate the response of growth and yield of different potato cultivars to the application of different doses of nitrogen in the field.

Materials and Methods

Two experiments were performed at the Agricultural Production and Research Station, National Research Centre, El Nubaria Province, El Behira Governorate, Egypt during the two successive seasons of 2014-2015. These experiments were conducted to evaluate potato cultivars, namely Spunta, Nicola, Cara and Diamant under Egyptian Conditions. The cultivars Spunta, Nicola, Cara and Diamant were imported from Holland. The whole potato seed tubers were planted on 16th of January in the two seasons. Potato seed tubers were planted at distance 25 cm between plants and 75 cm between rows.

These experiments included 12 treatments which were the combinations of four potato cultivars and three different levels of nitrogen (N₂), i.e. 140, 160 and 180 kg of ammonium sulphate 20.6% N. The design of the experiments was split plot with three replications. The cultivars were in the main plots and the fertilizer treatments of nitrogen were in the sub plots. The plot area was 9.6 m² consisted of four inner rows of 3 m in length and 80 cm in width and was used for irrigation drip irrigation system.

The amount of nitrogen was added as side dressing in seven equal doses during soil preparing, and 6 batches with irrigation water in the form of ammonium sulphate 20.6% N. Other agricultural treatments for potato production were performed as recommended by the Ministry of Agriculture in Egypt.

Table (1): Physical and chemical properties of the experimental soil.

Physical properties		Chemical analysis	
Sand	92.08	Ca (Mg/L)	7.01
Clay	9.28	Mg (Mg/L)	0.525
Silt	0.64	Na (Mg/L)	0.984
Texture	Sandy	K (Mg/L)	0.33
F.C. %	16.63	HCO ₃ (Mg/L)	1.2
W. P. %	5.21	Ca (Mg/L)	7.01
E. C. (ds/m)	1.8		
PH	8.4		

A random sample of ten plants was taken from each plot at 75 days after planting for the determinations of vegetative growth, i.e., plant height, number of stems and fresh and dry weights of haulm. Each experimental plot was harvested 120 days after planting and average tuber weight, number of tubers/plant and total yield were recorded.

A random sample of 30 tubers were selected from each experimental unit then washed, dried and cut into small pieces, which were mixed and grounded for the determination of starch in tubers. Tuber specific gravity was calculated from samples weights measured in air and water. Total carbohydrates were determined as glucose after acid hydrolysis and spectro photometrically determined using phenol acid reagent according to ¹². Dry matter content was range tests at 5% level of probability in the two seasons of experimentation. Data of experimental were statistically evaluated using the analysis of variance as outlined by ¹³ based on MSTATC program. The differences between means were compared using ¹⁴multiple rang test.

Results and Discussion

In this study, the vegetative parameters were affected by cultivars and nitrogen application. As shown in table (2) there were significant differences among potato cultivars in vegetative parameters. Cara cultivar showed highest mean value of plant height, number of stem, dry weight of halum Number of tubers and fresh weight of tubers in both growing seasons, however , Diamant cultivar gave the lowest mean values of plant height, number of stem, dry weight of halum, number of tubers and fresh weight of tubers in two study seasons.

The differences among potato cultivars vary according to the genetic potential^{15,16,17}. Based in this study Cara cultivar gave the highest value of most vegetative parameters. Increasing the nitrogen fertilizer was significantly effective on improving vegetative parameters in the two seasons.

Results cleared that vegetative characters were gradually and significantly increased by increasing level of nitrogen application from 140 , 160 up to 180 Kg N₂/ fed. in both seasons.

Nitrogen is a part of all living cells and is a necessary part of all proteins, enzymes and metabolic processes involved in the synthesis and transfer of energy. Nitrogen is a part of chlorophyll, the green pigment of the plant that is responsible for photosynthesis⁹.

Regarding the interaction between two studied factors (cultivars , nitrogen application) the results indicated that 180 Kg N₂/ fed. With Cara cultivar had the best vegetative parameters including plant height, number of stem, dry weight of haulm number of tubers and fresh weight of tubers in table (2). On the other hand, the lowest values of plant height, fresh weight of haulm, number of tubers and fresh weight of tubers were obtained with Nicole cultivar which received 140 Kg N₂/ fed. in first season, while Spunta cultivar which received 140 Kg N₂/ fed. gave the lowest values of most vegetative parameters in second season. The comparisons among the mean values of the yield growth of potato cultivars showed significant difference. Many investigators study the effect of cultivars, nitrogen application cultivars, nitrogen application on vegetative growth to some vegetable crops^{18,19,20}.

Table (2) : Effects of Cultivars and Nitrogen application of potato plant on vegetative growth (2014-2015)seasons.

Treatments	First season					Second season							
	Plant height (Cm)	Fresh weight of haulm (g/plant)	Number of Stems / plan	Dry weight of Halum (g /plant)	Number of tubers /plant	Fresh weight of tubers (g/plant)	Plant Height (Cm)	Fresh weight of haulm (g/plant)	Number of Stems / plan	Dry weight of Halum (g /plant)	Number of tubers /plant	Fresh weight of tubers (g/plant)	
Effect of cultivars													
Diamant	63.09 D	287.77 C	4.00 B	51.43 C	6.08 C	555.67 B	61.42 D	298.47 C	4.10 A	50.63 B	7.00 B	438.77 D	
Spunta	66.13 C	329.70 A	3.56 C	60.82 B	6.35 B	514.89 C	65.60 C	324.40 A	3.65 B	55.08 A	7.49 B	516.18 B	
Nicola	67.53 B	271.52 D	3.75 C	35.19 D	6.37 B	451.60 D	68.41 B	277.67 D	3.67 B	40.45 C	7.56 B	451.69 C	
Cara	74.11 A	310.27 B	4.53 A	66.44 A	6.44 A	655.00 A	74.19 A	322.89 B	4.31 A	56.03 A	8.27 A	628.23 A	
Effect of nitrogen fertilizer level													
140	64.55 C	287.00 C	3.93 C	51.48 C	5.59 C	522.09 C	65.70 C	299.39 C	3.77 C	52.71 C	6.89 C	468.69 C	
160	67.93 B	303.19 B	4.09 B	53.77 B	6.54 B	526.19 B	68.43 B	303.49 B	4.24 B	54.42 B	7.81 B	478.87 B	
180	70.16 A	324.20 A	4.95 A	54.46 A	6.76 A	536.63 A	71.12 A	320.18 A	4.78 A	56.70 A	8.44 A	485.11 A	
Effect of interaction													
Diamant	140	49.58 de	277.10 e	3.67 d	5.67 e	550.00 d	436.70 d	61.57 d	277.90 e	4.00 cd	49.77 e	6.67 c	436.70 f
	160	51.03 d	289.70 d	4.00 c	6.00 d	556.70 c	446.00 d	63.27 cd	303.40 c	4.33 b	51.00 de	7.00 bc	446.00 e
	180	52.31 d	310.40 c	5.00 ab	6.67 c	574.70 c	457.00 d	65.30 c	336.70 a	4.67 b	52.83 d	7.67 ab	457.00 e
Spunta	140	60.76 c	318.70 c	3.33 e	5.67 e	515.00 e	513.00 c	62.07 cd	325.30 ab	3.33 d	55.03 cd	5.67 d	513.00 d
	160	62.85 bc	342.00 b	3.67 d	7.33 b	517.30 e	517.70 c	65.50 c	331.50 a	4.00 cd	57.87 c	7.33 b	517.70 cd
	180	64.40 b	361.20 a	5.00 ab	7.33 b	519.30 e	525.00bc	72.77 b	346.10 a	5.00 ab	59.23 bc	7.33 b	525.00 c
Nicola	140	34.87 e	254.00 f	3.67 d	6.33 cd	455.70 f	448.70 d	68.10 bc	275.50 d	3.33 d	39.20 f	7.33 b	448.70 e
	160	35.84 e	274.70 e	3.67 d	6.67 c	458.30 f	450.30 d	70.10 b	283.90 d	4.33 c	40.17 ef	8.00 ab	450.30 e
	180	36.82 e	303.10 d	4.67 b	7.00 bc	471.70 f	465.00 d	70.47 b	285.00 d	4.33 c	44.83 e	8.67 a	465.00 e
Cara	140	64.12 b	305.00 d	4.33 bc	7.33 b	654.00 b	622.70 b	71.60 b	313.40 b	4.33 c	64.47 b	5.33 a	622.70 b
	160	65.95 ab	314.30 c	5.00 ab	9.00 ab	668.70ab	630.70 ab	77.53 ab	322.30 ab	4.33 c	66.13 ab	7.33 b	630.70 ab
	180	68.25 a	324.00 bc	5.33 a	9.67 a	682.30 a	647.00 a	79.10 a	346.70 a	5.33 a	67.40 a	7.00 bc	647.00 a

Values following by the same letter(s) are not significantly different 5%

As presented in table (3) the highest mean values of total yield, average tuber weight, dry matter, specific gravity, total carbohydrates and starch were obtained by Cara cultivar with slight differences among others cultivars, *i.e.*, Diamant, Spunta and Nicola in both seasons.

However, Nicola cultivar recorded the lowest number of tubers compared to all other cultivars table (2). The observed genotype differences in relation to rates of photosynthesis could be the major factor explaining the variation in growth and total production in this study as was observed in previous study¹⁹. Differences in tuber yield may also be brought about by differences in growing periods to reach maturity specified for each genotype.

¹⁹ found that the differences in the growing period of the cultivars may have contributed to the differences in total biomass yield.

The effects of different levels of N fertilizer on yield characters of potato are presented in (Table3). Increasing levels of nitrogen application from 140 to 180 kg of N₂ per fed caused increment in yield characters (total yield, average tuber weight, dry matter, specific gravity, total carbohydrates and starch) of plant. The highest values of these parameters were recorded with the application of 180 kg of N₂ per fed.

Significant interaction between cultivars and nitrogen fertilization levels for yield and yield parameters were noticed in both seasons (table 3). All yield parameters were increased by increasing the nitrogen level for all cultivars. Cara cultivar produced the highest most yield parameters in two seasons. While, Spunta cultivar gave the highest value of specific gravity in first seasons. The observed improvement in tuber quality parameters (carbohydrates and starch) as affected by nitrogen nutrition can be explained on the basis of the positive effect on enzymes and metabolic processes as reported by^{3, 6, 22}. The results are in agreement with those obtained by^{18,19,23}.

Table (3) : Effects of Cultivars and Nitrogen application of potato plant on yield and yield parameters (2014-2015)seasons.

Treatments	First season						Second season						
	Total yield (Ton/fed.)	Average tuber weight (g)	Dry matter (%)	Specific gravity (g/cm3)	Total Carbohydrates (%)	Starch (%)	Total yield (Ton/fed.)	Average tuber weight (g)	Dry matter (%)	Specific gravity (g/cm3)	Total Carbohydrates (%)	Starch (%)	
	First season						Second season						
Effect of cultivars													
Diamant	16.02 C	108.29 C	26.22 C	1.07 B	43.88 C	68.77 B	17.66 B	121.01 C	23.07 C	1.08 B	46.71 C	68.77 B	
Spunta	17.34 B	125.32 B	27.57 B	1.05 C	45.51 B	68.00 B	17.87 B	136.09 B	24.09 B	1.07 C	48.57 B	68.63 B	
Nicola	12.54 D	94.49 D	22.77 D	1.03 D	40.54 D	65.15 C	13.11 C	102.70 D	19.77 D	1.04 D	40.26 D	66.15 C	
Cara	18.09 A	132.00 A	28.89 A	1.09 A	49.85 A	70.65 A	18.09 A	144.28 A	25.07 A	1.09 A	53.20 A	70.65 A	
Effect of nitrogen fertilizer level													
140	16.29 C	113.87 C	26.10 A	1.06 B	45.49 B	68.25 A	16.46 B	124.11 C	22.68 B	1.07 A	46.58 C	69.11 A	
160	17.54 B	115.92 B	26.36 A	1.07 A	43.77 C	68.27 A	16.92 B	126.60 B	22.83 B	1.07 A	48.78 B	69.09 A	
180	18.08 A	118.69 A	26.85 A	1.07 A	49.81 A	68.66 A	17.40 A	129.91 A	23.09 A	1.07 A	50.88 A	69.23 A	
Effect of interaction													
Diamant	140	16.16 c	107.30 f	26.24 c	1.07 b	42.62 cd	68.67 bc	17.60 b	117.00 cd	22.74 c	1.07 c	45.49 d	69.67 b
	160	16.48 c	109.00 e	26.46 c	1.07 b	44.69 c	69.00 bc	17.78 b	118.70 cd	22.93 c	1.08 b	47.71 cd	69.67 b
	180	18.27 a	111.00 e	26.66 c	1.07 b	46.40 bc	69.67 bc	18.13 ab	121.30 c	23.10 b	1.08 b	49.19 c	70.67 ab
Spunta	140	15.79 d	124.00 d	27.48 b	1.07 b	44.40 c	67.67 c	17.61 b	134.70 bc	23.92 b	1.08 b	47.37 cd	68.00 b
	160	16.03 c	126.00 cd	27.68 b	1.08 a	46.99 bc	68.00 bc	17.99 b	137.00 b	24.17 ab	1.08 b	50.16 bc	69.33 b
	180	16.30 c	128.70 c	27.96 d	1.08 a	48.35 b	69.00 bc	18.33 ab	139.30 b	24.45 ab	1.08 b	51.59 b	68.67 b
Nicola	140	16.32 c	92.33 g	22.42 d	1.03 f	38.97 e	64.33 d	12.81 d	100.30 e	19.74 de	1.04 e	41.66 e	65.33 c
	160	17.32 ab	95.00 g	22.89 d	1.04 d	41.54 d	66.00 c	13.29 c	103.00 e	19.82 de	1.04 e	44.32 de	67.00 bc
	180	18.10 a	100.00 e	23.38 d	1.04 d	43.39 cd	67.33 c	13.69 c	108.70 d	20.26 d	1.06 d	46.29 d	68.33 b
Cara	140	17.45 b	131.00 bc	29.07 ab	1.03 f	49.07 b	70.00 b	17.78 b	142.70 b	25.03 ab	1.09 a	52.39 b	71.00 ab
	160	17.90 ab	134.00 b	29.28 a	1.04 d	51.36 ab	71.33 a	18.52 ab	145.70 ab	25.34 a	1.09 a	54.80 b	71.67 ab
	180	18.79 a	139.00 a	29.75 a	1.06 c	52.68 a	71.33 a	19.49 a	148.30 a	25.63 a	1.09 a	56.23 a	72.33 a

Values following by the same letter(s) are not significantly different 5%

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