Zagazig Journal of Horticultural Science 377-394

Zagazig J. Agric. Res., Vol. 43 No. (2) 2016

http:/www.journals.zu.edu.eg/journalDisplay.aspx?Journalld=1&queryType=Master

EFFECT OF NITROGENOUS FERTILIZATION AND WHEY PROTEIN HYDROLYSATES ON GROWTH, PRODUCTIVITY, ANTIOXIDANTS AND STORABILITY OF SWEET POTATO GROWN IN SANDY SOIL

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ABSTRACT

This work was carried out during the two successive summer seasons of 2013 and 2014 at a Private Vegetable Farm in El-Khattara Distract, Sharkia Governorate, Egypt, to study the effect of different nitrogen rates and whey protein hydrolysates (WPH) concentrations as foliar application on growth, enzymes, antioxidants, yield, tuber root quality and storability of sweet potato cv. Buregard under sandy soil conditions using drip irrigation system. Fertilizing sweet potato plants cv. Buregard grown in sandy soil with N at 60 kg/fad., and foliar spray with 0.15% WPH increased number of branches/ plant, leaf area/plant and shoots dry weight/plant, N, P and K uptake by shoots, average weight of tuber roots, marketable yield and total yield, TSS and total sugars as well as improved storability of tuber roots of sweet potato. Whereas, fertilizing plants with 80 kg N/fad., and spraying with 0.15% whey protein increased vine length, total chlorophylls in leaf tissues, peroxidase enzyme and antioxidants in shoots, starch content in tuber roots of sweet potato. On the other side, the highest concentration of glutathione oxidase enzyme in shoot and carotene content in tuber roots were recorded by the interaction treatment between 40 kg N/fad., and spraying with 0.15% whey protein. The study recommends by using nitrogen fertilizer at 60 kg/fad., and spraying with 0.15% whey protein to increase sweet potato yield grown in sandy soil.

Key words: Sweet potato, nitrogen, whey protein, enzymes, antioxidants, yield and storability.

INTRODUCTION

Sweet potato (*Ipomoea batatas* L.) which belongs to the family Convolvulaceae is becoming the most widely distributed root crop in most developing countries.

Nitrogen is an important factor in determining the yield and nutrient composition of root tubers, especially sweet potato. Nitrogen application to sweet potato was shown to linearly increase dry matter content, caroten and protein content of sweet potato (Constantin *et al*., 1984). Nitrogen also plays a vital role in the plant biochemistry as an essential constituent of cell wall, cytoplasmic proteins, nucleic acid, chlorophyll and other parts of the cell (Hay and Walker, 1989).

In this regard, Sadek (2000) showed that increasing the applied N-rates to sweet potato plants from 20 to 80 kg/fad., recorded significant increases in total and marketable yield, as well as yield/ plant (weight and number). Application of N up to 50kg/ha increased root yield of sweet potato, but at the highest N level (100kg/ha) uncontrolled vine growth resulted in lowering root yields (Hartmink *et al*., 2001). Under sandy soil conditions, Al-Easily (2002) indicated that increasing N up to 90 kg/fad., enhanced vine length, number of branches/ plant, leaf area and dry weight of vines, leaves and whole plant. Moreover, nitrogen application at a rate of 60 kg/fad., gave the highest storage roots dry weight. Farzana *et al*. (2007) reported that shoot dry weight, storage root dry weight, storage root weight and total yield /ha, N, P, K, Ca and Mg

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contents in shoots or storage roots of sweet potato were significantly increased with application of nitrogen at 30 kg/ha., comparing with 0 or 100 kg N/ha. Okpara *et al*. (2009) found that nitrogen application up to 120 kg N/ha., increased leaf area index and shoot dry matter, while the storage root yield was increased with increasing N application up to 80 kg N/ha. Garo *et al*. (2014) reported that 46kg N/ha., produced the longest vine length, maximum top weight and the highest percentage of dry top weight, storage root diameter, root yield and marketable yield than 23 kg N/ha., while the lowest yield and its components were recorded by control treatment (0 nitrogen). Saraswati and Suparno (2015) indicated that 100 kg N/ha., produced the highest tuber yields, while 200 kg N/ha., produced greater leaf area of sweet potato.

Whey or a liquid remaining from cheese or casein production is one of the most valuable protein sources in human food chain. In spite of its balanced nutrients, liquid whey is disposed as a waste product. Liquid whey has a high biological oxygen demand, so its disposal in rivers kills living organisms. Environmental pollution is also a concern in many countries (Thivend, 1977). The biological components of whey proteins, including β-lactoglobulin, α-lactalbumin, lactoferrin, lactoperoxidase, immunoglobulins and glycomacropeptides, demonstrate a wide range of immune enhancing properties, and act as antioxidant, antihypertensive, antitumer, antiviral, antimicrobial and chelating agent. They also improve muscle strength and body composition and prevent cardiovascular, cancer diseases and osteoporosis (Marshall, 2004).

Peptides with antioxidative activity can be used as natural antioxidants and can thus replace synthetic antioxidants which have been found to be carcinogenic. Bioactive peptides are inactive within the protein structure, from which they can be released by different methods (Korhonen and Pihlanto, 2006). Several commercial enzymes have been used to obtain bioactive peptides with antioxidants activity from milk proteins, for example by use of the digestive enzymes pepsin, trypsin, and chymotrypsin (De Gobba *et al*., 2014). In the present study, hydrolysis of goat whey protein with trypsin was monitored for 240 min. Hydrolysates obtained after 60, 120, 180 and 240 min. had DH values of 14%, 18%, 26% and 30%, respectively. The antioxidant activity of hydrolysate samples were evaluated by ABTS radical scavenging activity. Hydrolysis of goat whey by trypsin significantly ($P<0.05$) increased the antioxidant activity (~45% more activity than un-hydrolyzed goat whey) (data not shown).

In this connection, Abdelbacki *et al.* (2010) found that when plant was sprayed using 20 ml of the native and chemically modified whey proteins fraction at concentration of 1 mg/ml. shows that whey protein inhibits the virus replication completely in infected plants either the native or the modified form even after seven days from spraying and then increased total yield of tomato.

Erman *et al*. (2011) showed that the greatest yield, nitrogen and phosphorus content in seeds and shoots were obtained with the treated chickpea plants with whey protein mycorrhizal and Rhizobium alone or in combination than untreated plants.

Therefore, the aim of this work was to minimize using of nitrogen fertilizer by whey protein hydrolysates application to obtain a high tuber root yield with good quality as well as enhancing storability of sweet potato grown in sandy soil.

MATERIALS AND METHODS

Field Experimental Design

This research was carried out during the two successive summer seasons of 2013 and 2014 at a Private Vegetable Farm in El-Khattara Distract, Sharkia Governorate, Egypt, to study the effect of different nitrogen rates and whey protein hydrolysates concentrations as foliar application on growth, enzymes, antioxidants, yield, tuber root quality and storability of sweet potato cv. Buregard under sandy soil conditions using drip irrigation system.

The physical and chemical properties of experimental soil in the two seasons showed that it was sandy in texture and had 0.08 and 0.09% organic matter, 8.13 and 8.07 pH, 1.82 and 1.85 mmhos/cm EC, 4.75 and 4.78 ppm available N,

3.42 and 3.58 ppm available P and 9.57 and 9.52 ppm available K, respectively.

This experiment included 12 treatments, which were the combinations between three rates of mineral nitrogen (40, 60 and 80 kg N/ fad.) and three concentrations of whey protein hydrolysates (0.05, 0.10 and 0.15% as well as control treatment (tap water). These treatments were arranged in a split plot design in a randomized complete block design with three replications. Nitrogen rates were randomly distributed in the main plots, while the concentration of whey protein were randomly arranged in the sub- plots.

Stem cuttings of sweet potato (about 20 cm length) were dipped in 0.2% Rhizolex solution as fungicide for 20 minutes before transplanting and transplanted at 25 cm apart on April 20^{th} and 24^{th} in the 1^{st} and 2^{nd} seasons, respectively and Buregard cultivar was used in this experiment.

The experimental unit area was 12.6 m^2. It contains three dripper lines with 6m length each and 70 cm distance between each two dripper lines. One line was used for taking the samples to measure the morphological and chemical traits and the other two lines were used for yield determinations.

Nitrogen rates were applied with irrigation water (fertigation) weekly into six equal portions beginning 25 days after transplanting in the form of ammonium sulphate (20.5% N).

Plants were sprayed with the different concentrations of whey protein or tap water four times at 15 days intervals beginning 25 days after transplanting in both seasons. Each plot received 2 l. solutions of each concentrations using spreading agent in all treatments to improve adherence of the spray to the plant foliage for increasing whey protein absorption by the plants. The untreated plants (check) were sprayed with tap water and spreading agent. One dripper line was left between each two experimental plots without spraying as a guard row to avoid the overlapping of spraying salutation.

All treatments received equal amounts of calcium superphosphate (15.5% P_2O_5) and potassium sulphate (48.5% K_2O) at a rate of 150 and 120 kg/fad., respectively. One third of K_2O amount and all amount of P_2O_5 were added during soil preparation with FYM which was added at the rate of 20 m^3/fad. The rest of K_2O was added into four portions with irrigation water (as fertigation) at 15 days intervals beginning one month after planting. The other conventional practices were applied.

Preparation of Whey Hydrolysate

Goat milk was obtained from Food Science Department, Faculty of Agriculture, Zagazig University, Egypt. Sweet whey was prepared from goat milk by rennet coagulation according to Ha *et al*. (2014). The resultant sweet whey was pasteurized at 73°C/15s, cooled, lyophilized and freeze at -20°C until use. Lyophilized goat whey (11% protein) was dissolved in distilled water (100g/l) and hydrolyzed by treatment with Trypsin from porcine pancreas EC 3.4.21.4) from Sigma Chemical Company, St. Louis, MO, USA (E/S ratio of 1:300 (*W/W*) at 37°C and pH 8. The hydrolysis was allowed to proceed for 4 hrs., the pH was kept at 8 during hydrolysis by addition of 1M NaOH and the degree of hydrolysis (DH) was determined every 1 hr., during hydrolysis according to Adler-Nissen, (1986). At the end of hydrolysis, the enzyme was inactivated by heating at 80°C for 20 min. Hydrolysate was clarified by centrifugation at 4000 g for 30 min at 16°C to remove insoluble substrate fragments, and the supernatant was lyophilized and freeze at -20°C until further use. The antioxidant activity of hydrolysate was evaluated by their ability to scavenge ABTS radicals according to the method described by De Gobba *et al*. (2014).

Data Recorded

Plant Growth

A random sample of three plants from every experimental unit were randomly taken at 110 days after transplanting in the two growing seasons to measure the plant growth and plant chemical constituents as follows:

a. Vine length (cm) and number of branches/ plant,

b. Leaf area/plant: It was calculated according to the formula described by Koller (1972), and

c. Dry weight of shoots: Leaves and branches of each plant were dried at 70°C till constant weight and then weighed.

Plant Chemical Constituents

Photosynthetic pigments

Total chlorophyll was determined in the fourth leaf according to the method described by Wettestein (1957).

Uptake of N, P and K in shoots

Nitrogen, phosphorus and potassium percentages in shoots (leaves and branches) were determined in dry matter according to the methods described by AOAC (1995) and N,P and K uptake by shoots were calculated (mg/ shoot).

Antioxidant determination

Total antioxidants concentration in shoots in response to the treatment was determined by the method of Gupta *et al*. (2004) with slight modifications by El-Sayed *et al*. (2012). Briefly, 1 g of plant leaves was homogenized in mortar containing 20 ml protein extraction buffer (50mM Tris-HCl pH 7.5, 20 mM EDTA) with 0.5 g sterile sea sand. After 10 min. of homogenization in ice bath, the mixtures were filtered, then the filtrate was centrifuged at 5000 for 10 min. The supernatant was used as the source of antioxidants and intracellular compounds. For antioxidant concentration, 0.5ml of the plant extract was mixed with 100 µl of 20mM ferrous chloride and 100 µl of 30% ammonium thiocyanate. The developed red complex was measured at 500nm.

Peroxidase activity was estimated as described by Sarvesh and Reddy (1988). Glutathione oxidase activity was determined according to Bergmeyer *et al.* (1974) with minor modifications. The reaction contains 200 µl of enzyme preparation with 0.1 M glutathione in potassium phosphate buffer (pH 8.0), 0.2 mM guaiacol and 2U horseradish peroxidase. After 30 min incubation at 30°C, the reaction was stopped by freezing for 15 min, then the developed color was measured at 436 nm. Glutathione oxidase activity was calculated from the following formula:

One unit = A 436/min x 4/ 25.5 (Extinction co-efficient of tetra-guaiacol)

Yield and Its Components

At harvest time, (at 150 days from transplanting), all tuber roots of each treatment were classified into two grades (marketable and non-marketable roots), then weighed to determine the total yield per faddan (ton). Marketable tuber roots have a weight about 100 to 250 g, while non-marketable roots have a weight of less than 100 g or more than 250 g. In addition, average tuber root weight was calculated.

Tuber Root Quality at Harvest Time

Starch content (%)

It was determined in dried tuber roots according to the method described by AOAC (1995).

Total sugars (%)

It was determined according to the method described by Forsee (1938).

Total soluble solids (TSS%)

It was determined in flesh juice of tuber roots by Carle Zeis refractometer.

Caroten content

It was determined in fresh tuber root tissues according to the method reported by AOAC (1995).

Storability

At harvest time, the tuber roots from every experimental unit were translocated to a shady place in the same day for curing, and placed for one week. Samples of uniform cured tuber roots (5 kg) from every experimental unit were put in palm crates and stored at normal room temperature. The storage zero time was on September 28th, while the end time of storage was on January 28^{th,} (120 days) in both seasons. The following data were monthly recorded in both seasons:

Weight loss (%)

Tuber roots of each treatment were weighed at 30 days by intervals, then the cumulative weight loss percentage was calculated, and

Decay (%)

Decayed tuber roots were removed and weighed. They included all spoiled tuber roots resulting from fungal or bacterial infections. The percentage of decayed tuber roots was calculated in relation to the total initial weight of stored tuber roots.

Statistical Analysis

Recorded data were subjected to the statistical analysis of variance according to Snedecor and Cochran (1980), and means separation were done according to LSD at 5% level.

RESULTS AND DISCUSSION

Plant Growth

Effect of nitrogen rates

Data presented in Table 1 show that, fertilizing sweet potato plants grown in sandy soil with nitrogen fertilizer at different rates (40, 60 and 80 kg N/fad.) affected significantly the vine length, number of branches/ plant, shoots dry weight in both seasons and leaf area in the 1st season. Increasing nitrogen levels up to 80 kg N/fad., increased significantly vine length in both seasons and leaf area in the 1st season. Number of branches and dry weight of shoots/ plant were at the highest values under 60 kg N/fad., in both seasons. It is seen also, from the same data, that all the plant vegetative growth characters of sweet potato were at the lowest values under 40 kg N/ fad., in both seasons.

The observed increment in above ground biomass of sweet potato due to nitrogen fertilization may be attributed to the high levels of nitrogen stimulated the development of adventitious buds and shoots. Accordingly, the growth of vine length, branch number and leaf per plant contributed for the increment of above ground biomass (Garo *et al*., 2014). These results are in agreement with those obtained by Al-Easily (2002), Farzana *et al*. (2007) and Saraswati and Suparno (2015).

Effect of WPH

The same data in the same table show that, spraying sweet potato plants grown in sandy soil with 0.15% WPH (antioxidants agent) increased vine length, leaf area/plant, number of branches/ plant and dry weight of shoots/ plant in both seasons, without significant differences with WPH at 0.10% regarding number of branches/ plant in the 1st season and leaf area/ plant in both seasons. On the other hand, the lowest values of all vegetative growth characters of sweet potato were obtained by spraying plants with tap water in both seasons. These results are in conformation with that of Thomson *et al.* (2015).

Effect of interaction between nitrogen and WPH

Data in the Table 1 indicate that, the interaction between 60 kg N/fad., and spraying plants with 0.15% WPH increased significantly number of branches/plant, leaf area/ plant and shoots dry weight/plant in both seasons, without significant differences with the interaction between 60 kg N/fad., and spraying with 0.10% WPH in few cases. Whereas, the interaction between 80 kg N/fad., and spraying with 0.15% WPH increased significantly vine length in both seasons.

Total Chlorophyll and N, P and K Uptake

Effect of nitrogen rates

Data presented in Table 2 show that the highest concentration of total chlorophyll in leaf tissues were obtained with 80 kg N/fad., without significant differences with 60 kg N/fad., in both seasons.

It is evident from the data illustrated in Table 2 that nitrogen rates reflected significant effect on N, P and K uptakes/shoot in both seasons. The medium level of nitrogen (60 kg N/fad.) showed enhancing effect on minerals uptake by shoots in both season, without significant differences with 80 kg N/fad., with respect to N uptake in the 1st season, P uptake in both seasons, and K uptake in the 1st season, while N,P and K uptake were at minimum values under low level (40 kg N/fad.). Nitrogen plays a vital role in the plant biochemistry as an essential constituent of cell wall, cytoplasmic proteins, nucleic acid, chlorophyll and other parts of the cell (Hay and Walker, 1989). Similar results were obtained by Phillips and Warren (2005) and Farzana *et al*. (2007) on sweet potato.

Effect of WPH

Data in Table 2 reveal that whey protein had significant effect on total chlorophyll in leaf tissues and NPK uptake/shoot in both seasons. It is quite clear that total chlorophyll, N, P and K uptake by shoots were at maximum values by spraying plants with 0.15% WPH without significant differences with 0.10% WPH with respect to total chlorophyll in leaf tissues in the 1st season and P uptake by shoot in both seasons.

Table 1. Effect of nitrogen rates, whey protein and their interactions on growth characters of sweet potato during 2013 and 2014 seasons

Treatments		Vine length (cm)		Number of branches/ plant		Leaf area/ plant (m^2)		Dry weight of shoots (g/plant)	
		2013 season	2014 season	2013 season	2014 season	2013 season	2014 season	2013 season	2014 season
Nitrogen rates				**Effect of nitrogen rates (kg N/fad.)**					
40 kg /fad.		106.82	109.67	10.94	10.39	0.63	0.72	59.07	56.09
60 kg /fad.		111.10	111.15	13.99	13.26	0.70	0.76	71.89	67.98
80 kg/fad.		119.20	118.17	13.62	12.12	0.74	0.76	70.06	66.35
LSD at 5% level		2.27	1.32	1.62	1.47	0.06	NS	0.98	1.29
Whey protein (%)				**Effect of whey protein rates (%)**					
0.0		105.23	115.83	9.40	9.17	0.57	0.62	50.52	50.65
0.05 (%)		112.23	111.96	12.57	11.90	0.66	0.72	66.33	59.02
0.10 (%)		114.93	115.67	14.21	12.92	0.75	0.80	74.19	70.17
0.15 (%)		117.10	119.13	15.21	13.71	0.78	0.84	76.99	74.05
LSD at 5 % level		1.99	2.85	1.56	0.42	0.05	0.09	0.86	1.13
Nitrogen rates	**Whey protein**			**Effect of interaction treatments**					
40 kg /fad.	**0.0**	102.80	101.60	7.73	7.50	0.56	0.59	46.82	48.29
	0.05 (%)	107.40	110.90	10.97	10.89	0.62	0.71	60.22	54.62
	0.10 (%)	10.860	113.10	11.96	11.20	0.66	0.77	63.47	58.06
	0.15 (%)	108.50	113.10	13.10	11.97	0.68	0.81	65.77	63.40
60 kg /fad.	**0.0**	106.10	108.50	10.08	10.18	0.57	0.63	53.48	51.62
	0.05 (%)	110.90	108.70	11.92	11.06	0.61	0.70	61.22	55.63
	0.10 (%)	112.10	111.00	16.63	15.60	0.75	0.80	81.21	80.12
	0.15 (%)	115.30	116.40	17.33	16.23	0.90	0.92	91.66	84.58
80 kg /fad.	**0.0**	106.80	107.40	10.40	9.84	0.58	0.64	51.26	52.06
	0.05 (%)	118.40	116.30	14.82	13.76	0.76	0.7	77.56	66.81
	0.10 (%)	124.60	121.10	14.04	11.96	0.85	0.84	77.90	72.34
	0.15 (%)	127.50	127.90	15.22	12.95	0.77	0.80	73.54	74.19
LSD at 5% level		3.45	4.93	2.74	0.74	0.09	0.15	1.49	1.96

Table 2. Effect of nitrogen rates, whey protein and their interactions on total chlorophyll in leaf tissues, N, P and K uptake (mg) by shoots of sweet potato during 2013 and 2014 seasons

Treatments		Total chlorophyll (mg/g DW)		N		P		K	
		2013 season	2014 season	2013 season	2014 season	2013 season	2014 season	2013 season	2014 season
Nitrogen rates				**Effect of nitrogen rates (kg N/fad.)**					
40 kg /fad.		3.98	4.02	1571	1420	315	303	1124	1108
60 kg /fad.		4.51	4.44	2049	1831	322	330	1445	1381
80 kg/fad.		4.85	4.84	1952	1664	356	349	1531	1550
LSD at 5 % level		0.36	0.45	187	135	36	30	109	118
Whey protein (%)				**Effect of whey protein rates (%)**					
0.0		3.78	3.71	1168	1127	249	256	866	882
0.05 (%)		4.41	4.21	1772	1451	328	296	1257	1204
0.10 (%)		4.75	4.81	2140	1886	374	382	1562	1507
0.15 (%)		4.85	4.98	2350	2089	372	375	1782	1793
LSD at 5 % level		0.12	0.14	106	101	31	29	83	113
Nitrogen rates	**Whey protein**			**Effect of interaction treatments**					
40 kg /fad.	**0.0**	3.58	3.48	936	1067	234	246	725	738
	0.05 (%)	4.05	3.80	1565	1343	319	289	1084	1037
	0.10 (%)	4.09	4.26	1808	1532	352	325	1282	1219
	0.15 (%)	4.19	4.52	1973	1737	355	355	1407	1439
60 kg /fad.	**0.0**	3.88	3.81	1369	1275	262	258	962	949
	0.05 (%)	4.23	3.81	1640	1446	287	267	1089	973
	0.10 (%)	4.94	5.06	2347	2203	373	432	1583	1538
	0.15 (%)	4.97	5.07	2841	2402	366	363	2144	2063
80 kg /fad.	**0.0**	3.87	3.84	1199	1041	251	265	912	957
	0.05 (%)	4.94	5.03	2109	1563	380	334	1597	1603
	0.10 (%)	5.22	5.12	2266	1924	397	390	1822	1765
	0.15 (%)	5.38	5.36	2235	2129	397	408	1794	1877
LSD at 5% level		0.24	0.24	185	175	55	50	145	197

These results are in harmony with those obtained by Erman *et al*. (2011). They showed that the nitrogen and phosphorus content in shoots were obtained with by treating chickpea plants with whey protein, mycorrhizal and *Rhizobium* alone or in combination than untreated plants .

Effect of interaction between nitrogen rates and WPH

The results in Table 2 indicate that the uppermost values of total chlorophylls in leaf tissues were obtained with the interaction between 80 kg N/fad., and spraying with 0.10 or 0.15% whey protein, while the lowermost values were obtained with 40 kg N/fad., and spraying with tap water in both seasons.

Concerning N, P and K uptake by shoots, the interaction between 60 kg N/fad., and spraying plants with 0.15% whey protein recorded the maximum values of N and K uptakes by shoots. Whereas, the maximum values of P uptake was obtained by the interaction between 80 kg N/ fad., and spraying plants with 0.10% whey protein in the 1st season and with the interaction between 60 kg N/fad., and spraying plants with 0.10% whey protein in the 2nd season (Table 2).

Enzymes and Antioxidants Activity

Effect of nitrogen rates

Data in Table 3 show that nitrogen rates reflected a significant effect on enzymes and antioxidant concentrations in sweet potato shoots. It is obvious that glutathione oxidase and peroxidase enzymes as well as antioxidants increased with increasing nitrogen rates up to 80 kg N/fad., with no significant differences with 40 kg N/fad., with respect to glutathione oxidase. These results suggested that exposing sweet potato plants to the highest level of nitrogen increased peroxidase enzyme and antioxidants and *vice versa* in both seasons.

Effect of WPH

The obtained results in Table 3 show that WPH treatments revealed quite comparable effects in both seasons on glutathione oxidase, peroxidase enzymes and antioxidants. Moreover, applying 0.15% WPH led to significantly increment in glutathione oxidase, peroxidase and antioxidants concentration in shoots when compared with other whey protein treatments. In addition, plants sprayed with tap water (control) recorded the lowest values of enzymes and antioxidants.

The biological components of whey proteins, including β-lactoglobulin, α-lactalbumin, lactoferrin, lactoperoxidase, immunoglobulins and glycomacropeptides, demonstrate a wide range of immune enhancing properties, and act as antioxidant, antihypertensive, antitumer, antiviral, antimicrobial and chelating agent (Marshall, 2004).

The antioxidant activity of hydrolysate samples were evaluated by ABTS radical scavenging activity. Hydrolysis of goat whey by trypsin significantly ($P<0.05$) increased the antioxidant activity (~45% more activity than un-hydrolyzed goat whey) (data not shown).

Mehrabian *et al.* (2011) recorded that salicylic acid (SA) is a phenolic compound with antioxidant properties, and involved in the regulation of physiological processes in plants. SA effects on catalase and peroxidase enzymes. The plants treated with salicylic acid increased the activity of enzymes such as catalase, peroxidase, superoxide dismutase, ascorbate peroxidase, glutathione reductase, *etc.* (Manochehrifar, 2010).

Effect of interaction between nitrogen rates and WPH

Data in Table 3 show that 40 or 80 kg N/fad., interacted with any rates of whey protein recorded the best results for glutathione oxidase enzyme comparing with 60 kg N/fad., under any rate of WPH in both seasons. Concerning, peroxidase enzyme and antioxidants in shoots, the same data in the Table 3 show that, the interaction between 80 kg N/fad., and spraying with 0.15% WPH recorded the highest concentration of peroxidase enzyme and antioxidants in shoot of sweet potato in both seasons. As for glutathione oxidase, the highest concentration in shoots of sweet potato was obtained by the interaction between 40 kg N /fad., and 0.15% WPH in both seasons. On the other hand, the interaction between 40 Kg N/fad., and untreated plants (check) gave the lowest concentration of peroxidase enzyme and antioxidants in shoots of sweet potato in both seasons.

Table 3. Effect of nitrogen rates, whey protein and their interactions on enzymes and antioxidants in shoots of sweet potato during 2013 and 2014 seasons

Treatments		Glutathione oxidase (U/ml)		Peroxidase (POx) U/ ml^{-1}		Antioxidants (µg/ ml^{-1})	
		2013 season	2014 season	2013 season	2014 season	2013 season	2014 season
Nitrogen rates				**Effect of nitrogen rates (kg N/fad.)**			
40 kg /fad.		5.59	5.54	6.52	6.52	108.12	108.62
60 kg /fad.		4.95	4.93	6.79	6.80	136.62	139.00
80 kg/fad.		5.53	5.58	7.48	7.47	178.25	179.75
LSD at 5 % level		0.20	0.07	0.03	0.08	5.78	4.74
Whey protein (%)				**Effect of whey protein rates (%)**			
0.0		5.33	5.30	6.63	6.61	124.33	127.83
0.05 (%)		5.29	5.33	6.89	6.87	137.16	139.00
0.10 (%)		5.28	5.20	7.03	7.08	148.00	149.83
0.15 (%)		5.53	5.56	7.15	7.16	154.50	153.16
LSD at 5% level		0.11	0.08	0.04	0.02	2.97	4.28
Nitrogen rates	**Whey protein**			**Effect of interaction treatments**			
40 kg /fad.	**0.0**	5.56	5.51	6.32	6.23	97.00	101.00
	0.05 (%)	5.54	5.57	6.44	6.47	104.00	105.00
	0.10 (%)	5.63	5.43	6.61	6.66	111.50	111.50
	0.15 (%)	5.63	5.67	6.70	6.73	120.00	117.00
60 kg /fad.	**0.0**	4.80	4.80	6.72	6.76	123.00	126.00
	0.05 (%)	4.77	4.75	6.77	6.77	131.00	136.50
	0.10 (%)	4.76	4.71	6.81	6.84	145.00	145.00
	0.15 (%)	5.38	5.45	6.86	6.83	147.50	148.50
80 kg /fad.	**0.0**	5.54	5.61	6.86	6.85	153.00	156.00
	0.05 (%)	5.56	5.68	7.47	7.37	176.50	175.50
	0.10 (%)	5.45	5.47	7.68	7.74	187.50	193.00
	0.15 (%)	5.58	5.56	7.91	7.93	196.00	194.00
LSD at 5% level		0.19	0.14	0.06	0.04	5.15	7.45

U = unit / ml , µg/ ml^{-1} = microgram / liter,

Yield and Its Components

Effect of nitrogen rates

It is obvious from the data in Table 4 that average tuber root weight, marketable and total yield/ fad., in both seasons were significantly increased with increasing nitrogen rate up to the medium level (60 kg N/fad.), while unmarketable yield in the 2nd season was significantly decreased.

Increasing the applied nitrogen rate to sweet potato plants up to 60 kg N/fad., increased the total yield by 39.7 and 40.80% over the plants received 40 kg N/fad., in the 1st and 2nd seasons, respectively and 23.60 and 25.80% over the plants received 80 kg N/fad., in the 1st and 2nd seasons, respectively. The increase in total tuber yield was clearly achieved owing to the increases in average tuber weight. In addition, the obtained results with yield and its components reflected similar trend to that obtained with plant growth.

Since nitrogen stimulates branch development and leaf production which indirectly contribute for root yield. In addition, the availed nitrogen in the soil is important in tuber initiation and tuber enlargement (Sikka, 1982).

This result agreed with those reported by Garo *et al*. (2014) and Saraswati and Suparno (2015) on sweet potato. They found that, the highest yield was increased under the moderate rate of nitrogen.

Effect of WPH

It is obvious from the data in Table 4 that, spraying sweet potato plants with 0.15% WPH led to attain the highest values of tuber weight, marketable and total yield/fad., and reduction of unmarketable yield in both seasons. The total yield/fad., increased by about 20.10 and 12.60% after spraying with 0.15% WPH than plants sprayed with tap water in the 1st and 2nd seasons, respectively. These results are in harmony with those reported by Abdelbacki *et al.* (2010) on tomato and Erman *et al*. (2011) on chickpea.

In the present study, the WPH recorded antioxidants activity. Increasing the production of green pods and dry seeds of pea with high quality could be achieved through using the foliar application of plant growth substances and antioxidants (Thomson *et al*., 2015).

Effect of interaction between nitrogen rates and WPH

The interaction between 60 kg N/fad., and spraying plants with 0.15% WPH was the most favourable treatment for increasing average weight of tuber roots, marketable yield and total yield compared with all other interaction treatments, whereas the interaction between 60 kg N/fad., and 0 WPH increased unmarketable yield. The interaction between 40 kg N/fad., and spraying with distilled water (check) gave the lowermost values of yield and its components (Table 4). In addition, the total yield/fad., increased by about 71.70 and 60.70% after fertilizing plants with 60 kg N/fad., and spraying plants with 0.15% WPH than plants received 40 kg N/fad., and sprayed with tap water in the 1st and 2nd seasons, respectively.

Tuber Root Quality

Effect of nitrogen rates

Data in Table 5 illustrate that TSS, total sugars content in tuber roots were at the highest values under the moderate rate of nitrogen (60 kg N/fad.), while carotene and starch contents in tuber roots were at the highest with 40 and 80 kg N/fad., respectively. Excessive amounts of N may encourage excessive vine growth and result in cracked and poor storage quality (Lerner, 2001).

This result was in agreement with Essilfie (2015) who found that higher beta-carotene content tubers occurred in sweet potato grown under fertilization rate 15 kg N/ha., while higher tuber starch content was recorded from plants grown under fertilization rate 30 kg N/ha.

Effect of WPH

It is evident that WPH had significant effect on starch, TSS, and total sugars in tuber roots in both seasons. But, they had no significant effect on carotene content in both seasons (Table 5). It is also clear that, 0.15% WPH increased starch, TSS, and total sugars contents with no significant differences with 0.10% WPH.

It could be concluded that 0.10% WPH increased starch, TSS and total sugars in tuber roots.

Table 4. Effect of nitrogen rates, whey protein and their interactions on yield and its components of sweet potato during 2013 and 2014 seasons

Treatments		Average weight of tuber root (g)		Unmarketable yield (ton/fad.)		Marketable yield (ton/fad.)		Total yield (ton/fad.)		Relative increases in total yield (%)	
		2013 season	2014 season	2013 season	2014 season	2013 season	2014 season	2013 season	2014 season	2013 season	2014 season
Nitrogen rates						**Effect of nitrogen rates (kg N/fad.)**					
40 kg /fad.		136.89	146.34	2.760	3.223	7.250	6.985	10.010	10.208	100.0	100.0
60 kg /fad.		160.38	164.70	2.565	2.663	11.419	11.710	13.984	14.373	139.7	140.8
80 kg/fad.		141.75	147.96	2.705	2.708	9.671	10.129	12.376	12.838	123.6	125.8
LSD at 5 % level		4.90	7.18	NS	0.550	0.157	0.228	0.236	0.593	--	--
Whey protein (%)						**Effect of whey protein rates (%)**					
0.0		124.92	129.24	3.481	3.883	7.503	7.734	10.983	11.617	100.0	100.0
0.05 (%)		141.12	153.00	2.796	3.461	8.898	8.977	11.694	12.438	106.5	107.1
0.10 (%)		154.44	160.92	2.627	2.280	9.996	10.478	12.623	12.757	114.9	109.8
0.15 (%)		164.88	168.84	1.802	1.836	11.389	11.241	13.191	13.077	120.1	112.6
LSD at 5% level		4.28	6.27	0.178	0.238	0.137	0.199	0.239	0.273	--	--
Nitrogen rates	**Whey protein**					**Effect of interaction treatments**					
40 kg /fad.	**0.0**	116.64	122.04	2.992	3.503	5.641	5.712	8.633	9.215	100.0	100.0
	0.05 (%)	135.00	149.04	2.893	3.421	6.607	6.800	9.500	10.271	110.0	110.9
	0.10 (%)	143.64	157.68	2.956	3.589	7.599	7.212	10.555	10.801	122.3	117.2
	0.15 (%)	152.28	156.60	2.197	2.380	9.153	8.215	11.350	10.595	131.5	115.0
60 kg /fad.	**0.0**	128.52	135.00	3.666	4.110	9.006	9.700	12.672	13.810	146.8	149.9
	0.05 (%)	157.68	164.16	2.279	2.842	11.838	11.347	14.117	14.189	163.5	154.0
	0.10 (%)	169.56	172.80	2.540	2.042	11.786	12.639	14.326	14.681	165.9	159.3
	0.15 (%)	185.76	186.84	1.777	1.657	13.044	13153	14.821	14.810	171.7	160.7
80 kg /fad.	**0.0**	129.60	130.68	3.786	4.035	7.860	7.792	11.646	11.827	134.9	128.3
	0.05 (%)	130.68	145.80	3.216	4.119	8.249	8.785	11.465	12.904	132.8	140.0
	0.10 (%)	150.12	152.28	2.385	1.208	10.604	11.583	12.989	12.791	150.5	138.8
	0.15 (%)	156.60	163.08	1.433	1.472	11.97	12.356	13.403	13.828	155.3	150.1
LSD at 5% level		7.42	10.87	0.327	0.416	0.238	0.345	0.416	0.475	--	--

Effect of interaction between nitrogen rates and WPH

Data in Table 5 reveal that the interaction between nitrogen rates and WPH had significant effect on all traits of tuber roots quality. In general, the interaction between 60 kg N/fad. and 0.10 or 0.15% WPH gave the highest values regarding TSS and total sugars, while carotene content in tuber roots was the highest with the interaction between 40 kg N/fad., and foliar spray with 0.15% WPH in both seasons. On the other side, the best result for starch content was obtained by the interaction between 80 kg N/fad., and spraying plants with 0.10 or 0.15% WPH in both seasons.

It could be concluded that, the interaction between 40 kg N/fad., and 0.10% WPH increased carotene content, whereas the interaction between 60 kg N/fad., and 0.10% WPH increased TSS and total sugars and the interaction between 80 kg N/fad., and 0.10% WPH increased starch content.

Storability (Weight Loss and Decay %)

Effect of nitrogen rates

It is evident from data in Tables 6 and 7 that, the obtained values of weight loss and decay (%) gradually increased by increasing storage period and reached their maximum peak at 120 days after harvest time (the end of storage period) under the conditions of this study.

Furthermore, it is quite clear from the obtained results that the lowest values of all storability parameters (weight loss and decay) of sweet potato tuber roots; *i.e.,* during storage period were more achieved when sweet potato plants received 60 kg N/fad., during the growing season. Moreover, such treatment being the best one for increasing the storability of sweet potato tuber roots.

From the above mentioned results, it could be suggested that sweet potato tuber roots produced from the highest level of nitrogen (80 kg N/fad.) were faster in weight loss and decay percentage as compared with the other treatments during storage period (120 days after harvest time).

This result was in agreement with Essilfie (2015), who found that application of moderate level of nitrogen (15 kg /ha.) recorded the lower weight loss (%) in tuber roots during storage of sweet potato than 30 kg N/ha. Also, Fatideh and Asil (2012) found that the least weight loss percentage was recorded in the bulbs grown under nitrogen fertilization at 100 kg/ha., than 150 kg/ha., on onion.

Effect of WPH

It is obvious from such data that, weight loss and decay (%), gradually, increased by increasing storage period and recorded the maximum values at 120 days after harvest time (the end of storage period) under the conditions of this study (Tables 6 and 7).

Spraying plants with 0.15 % WPH being the most effective and favourable treatment for giving the minimum values of weight loss (%) and decay (%) in tuber roots during storage period. In other words, such treatment increased the storage period of sweet potato tuber roots, as well as being the superior treatment in this respect as compared with the other treatments.

This result agreed with those reported by Al-Mughrabi (2007) who showed that the combination between compost tea and WPH reduced disease severity by 21% in potatoes.

Effect of interaction between nitrogen rates and WPH

It is quite clear from data presented in Tables 6 and 7 that, the best interaction treatments for decreasing weight loss and decay (%) were fertilizing sweet potato with 60 kg N/fad., and spraying plants with 0.10 or 0.15% WPH in both seasons. On the other hand, the highest values of weight loss and decay (%) were obtained by fertilizing plants with 80 kg N/fad and spraying plants with 0.0% WPH (distilled water).

Finally, it could be concluded that, fertilizing sweet potato plants cv. Buregard grown in sandy soil with N at 60 kg/fad., and foliar spray with 0.15% WPH was the best treatment for enhancing plant growth, improving yield and best quality at harvest as well as storability of tuber roots of sweet potato.

Table 5. Effect of nitrogen rates, whey protein and their interactions on tuber root quality of sweet potato at harvest time during 2013 and 2014 seasons

Treatments		Starch (%)		TSS (%)		Total sugars (%)		Carotene (mg/g FW)	
		2013 season	2014 season	2013 season	2014 season	2013 season	2014 season	2013 season	2014 season
Nitrogen rates					**Effect of nitrogen rates (kg N/fad.)**				
40 kg /fad.		44.09	43.20	8.81	8.88	8.61	8.24	10.97	10.81
60 kg /fad.		45.24	46.24	9.30	9.43	9.29	9.51	10.43	10.29
80 kg/fad.		50.39	50.87	7.64	7.80	7.95	7.73	9.38	9.31
LSD at 5 % level		2.98	1.60	0.45	0.49	0.37	0.43	0.39	0.27
Whey protein (%)					**Effect of whey protein rates (%)**				
0.0		44.02	43.31	8.01	8.02	7.95	7.71	9.73	9.81
0.05 (%)		45.73	46.08	8.65	8.64	8.58	8.60	9.89	10.14
0.10 (%)		47.59	48.30	8.75	8.94	8.89	8.78	10.61	10.20
0.15 (%)		48.95	49.40	8.92	9.22	9.05	8.89	10.81	10.40
LSD at 5 % level		2.01	2.57	0.54	0.47	0.37	0.46	NS	NS
Nitrogen rates	**Whey protein**				**Effect of interaction treatments**				
40 kg /fad.	**0.0**	40.62	39.79	8.50	8.31	7.96	7.87	10.27	10.21
	0.05 (%)	42.49	42.46	8.92	8.65	8.55	8.60	10.76	10.85
	0.10 (%)	46.2	45.22	8.78	9.08	8.85	8.30	11.23	11.03
	0.15 (%)	47.04	45.34	9.04	9.47	9.08	8.20	11.63	11.14
60 kg /fad.	**0.0**	43.93	42.57	8.35	8.43	8.03	8.03	10.09	10.17
	0.05 (%)	45.43	46.21	9.24	9.59	9.34	9.81	9.92	10.36
	0.10 (%)	45.43	47.03	9.70	9.75	9.80	9.97	10.91	10.29
	0.15 (%)	46.17	49.16	9.90	9.96	10.00	10.23	10.79	10.33
80 kg /fad.	**0.0**	47.5	47.58	7.17	7.33	7.85	7.22	8.84	9.04
	0.05 (%)	49.27	49.56	7.80	7.68	7.85	7.40	8.98	9.21
	0.10 (%)	51.14	52.64	7.77	7.98	8.01	8.08	9.70	9.27
	0.15 (%)	53.65	53.71	7.83	8.22	8.08	8.23	10.01	9.73
LSD at 5% level		3.49	4.47	0.94	0.83	0.65	0.79	0.42	0.56

Table 6. Effect of nitrogen rates, whey protein and their interactions on weight loss (%) in tuber roots of sweet potato during storage period of 2013 and 2014 seasons

Treatments		Weight loss (%)							
		Days from storage							
		30		60		90		120	
		2013 season	2014 season	2013 season	2014 season	2013 season	2014 season	2013 season	2014 season
Nitrogen rates		**Effect of nitrogen rates (kg N/fad.)**							
40 kg /fad.		9.30	9.67	17.88	21.83	34.43	38.56	45.11	45.31
60 kg /fad.		7.01	7.73	13.73	17.00	26.58	32.45	38.35	38.68
80 kg/fad.		9.37	8.81	17.85	20.14	36.07	36.38	52.52	52.33
LSD at 5 % level		0.48	0.78	0.79	1.63	0.98	1.61	2.06	1.96
Whey protein (%)		**Effect of whey protein rates (%)**							
0.0		9.51	10.35	18.62	21.21	35.48	39.60	53.91	52.08
0.05 (%)		8.95	9.33	17.13	21.36	33.69	37.28	45.92	46.33
0.10 (%)		8.31	8.16	15.47	18.84	30.58	33.83	42.05	43.37
0.15 (%)		7.47	7.11	14.72	17.21	29.68	32.48	39.42	39.97
LSD at 5% level		0.37	0.48	0.71	1.14	0.86	1.42	2.65	1.71
Nitrogen rates	**Whey protein**	**Effect of interaction treatments**							
40 kg /fad.	**0.0**	10.32	11.24	21.07	23.08	39.31	41.36	58.55	56.24
	0.05 (%)	9.28	10.04	18.64	23.76	33.57	40.09	43.83	44.88
	0.10 (%)	8.72	9.28	16.44	20.65	32.47	38.02	39.44	43.91
	0.15 (%)	8.88	8.12	15.36	19.82	32.36	34.77	38.63	36.19
60 kg /fad.	**0.0**	7.83	8.80	13.65	17.59	27.95	35.93	45.22	44.19
	0.05 (%)	7.83	8.43	15.29	19.03	29.50	34.94	39.27	40.19
	0.10 (%)	6.68	7.40	13.52	17.09	24.63	29.83	35.29	35.90
	0.15 (%)	5.68	6.29	12.46	14.29	24.25	29.09	33.62	34.42
80 kg /fad.	**0.0**	10.37	11.01	21.14	22.95	39.17	41.51	57.97	55.81
	0.05 (%)	9.73	9.52	17.47	21.30	38.01	36.80	54.67	53.93
	0.10 (%)	9.52	7.79	16.46	18.79	34.65	33.63	51.43	50.29
	0.15 (%)	7.85	6.92	16.34	17.51	32.43	33.59	46.01	49.29
LSD at 5% level		0.65	0.72	1.22	1.98	1.49	2.47	4.60	2.97

Table 7. Effect of nitrogen rates, whey protein and their interactions on decay (%) in tuber roots of sweet potato during storage period of 2013 and 2014 seasons

Treatments		Decay (%)							
		Days from storage							
		30		60		90		120	
		2013 season	2014 season	2013 season	2014 season	2013 season	2014 season	2013 season	2014 season
Nitrogen rates		**Effect of nitrogen rates (kg N/fad.)**							
40 kg /fad.		0.00	0.00	1.59	1.60	5.59	6.36	8.46	9.91
60 kg /fad.		0.00	0.00	1.42	1.49	4.32	4.09	6.24	7.36
80 kg/fad.		0.00	0.00	1.56	1.67	5.56	7.15	9.37	10.31
LSD at 5 % level		--	--	NS	NS	0.12	0.24	0.35	0.43
Whey protein (%)		**Effect of whey protein rates (%)**							
0.0		0.00	0.00	1.74	1.72	6.06	6.85	9.81	10.78
0.05 (%)		0.00	0.00	1.51	1.63	5.43	6.42	8.21	9.59
0.10 (%)		0.00	0.00	1.48	1.50	4.79	5.51	7.32	8.75
0.15 (%)		0.00	0.00	1.37	1.49	4.33	4.69	6.74	7.65
LSD at 5% level		--	--	NS	NS	0.12	0.22	0.30	0.39
Nitrogen rates	**Whey protein**	**Effect of interaction treatments**							
40 kg /fad.	**0.0**	0.0	0.0	1.80	1.64	6.66	8.16	11.04	11.97
	0.05 (%)	0.0	0.0	1.55	1.66	5.71	6.79	9.13	10.40
	0.10 (%)	0.0	0.0	1.56	1.54	5.45	5.70	7.04	9.14
	0.15 (%)	0.0	0.0	1.44	1.54	4.53	4.80	6.63	8.14
60 kg /fad.	**0.0**	0.0	0.0	1.66	1.67	4.69	4.47	6.85	7.94
	0.05 (%)	0.00	0.00	1.44	1.52	4.76	4.73	6.48	8.25
	0.10 (%)	0.00	0.00	1.34	1.42	4.09	3.84	6.00	7.24
	0.15 (%)	0.00	0.00	1.23	1.35	3.73	3.33	5.62	6.01
80 kg /fad.	**0.0**	0.0	0.0	1.75	1.86	6.83	7.91	11.55	12.43
	0.05 (%)	0.0	0.0	1.54	1.71	5.83	7.74	9.02	10.11
	0.10 (%)	0.0	0.0	1.53	1.54	4.84	6.99	8.93	9.88
	0.15 (%)	0.0	0.0	1.43	1.58	4.73	5.94	7.98	8.80
LSD at 5% level		--	--	NS	NS	0.21	0.39	0.53	0.68

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تأثير التسميد النيتروجينى وبروتينات شرش اللبن المحللة بالإنزيمات على النمو، والإنتاجية ومضادات الأكسدة والقدرة التخزينية للبطاطا المزروعة في أرض رملية

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أجرى هذا البحث خلال موسمين صيفيين متتاليين لعامي ٢٠١٣، ٢٠١٤ تحت ظروف الأرض الرملية ونظام الرى بالتنقيط بمزرعة خضر خاصة بمنطقة الخطارة، محافظة الشرقية لدراسة تأثير المعدلات المختلفة من النتيروجين وتركيزات بروتينات شرش اللبن المحللة بالإنزيمات كإضافة رش على النمو، ومضادات الأكسدة والمحصول، وجودة الجذور المتدرنة، والقدرة التخزينية لنباتات البطاطا صنف بيورجارد، أوضحت النتائج أن تسميد نباتات البطاطا صنف بيورجارد النامى في الأرض الرملية بالسماد النتروجينى بمعدل ٦٠ كجم/فدان والرش ببروتينات شرش اللبن بتركيز ٠.١٥% أدى إلى زيادة كل من عدد الأفرع للنبات، ومساحة الورقة، والوزن الجاف للعرش، والممتص من النتروجين والبوتاسيوم بواسطة العرش، ومتوسط وزن الجذور المتدرنة، والمحصول الصالح للتسويق والمحصول الكلى، بينما أدى التسميد بمعدل ٦٠ كجم /فدان والرش ببروتينات شرش اللبن بتركيز ٠.١٠% إلى زيادة إنزيم الجلوتاثين اوكسيديز فى العرش، وكذلك محتوى الجذور المتدرنة من المواد الصلبة الكلية والسكريات الكلية، كما أدت إلى تحسين القدرة التخزينية للجذور المتدرنة للبطاطا، سجل تسميد النباتات بالسماد النيتروجيني بمعدل ٨٠ كجم /فدان والرش ببروتينات شرش اللبن بتركيز ٠.١٥% إلى زيادة كل من طول النبات، والكلوروفيل الكلى فى أنسجة الورقة، وتركيز انزيم البيروكسديز، ومضادات الأكسدة في عرش البطاطا، وكذلك محتوى الجذور المتدرنة من النشا، على جانب أخر فقد سجلت معاملة التفاعل بين تسميد النباتات بمعدل ٤٠ كجم نيتروجين/ فدان والرش ببروتينات شرش اللبن بتركيز ٠.١٥% أعلى تركيز لكل من أنزيم الجلوتاثين أوكسيديز فى العرش ومحتوى الكاروتين فى الجذور المتدرنة، وتوصى الدراسة باستخدام التسميد النيتروجيني بمعدل ٦٠ كجم/فدان والرش ببروتينات شرش اللبن بتركيز ٠.١٥% لزيادة محصول البطاطا النامية في الأراضي الرملية.

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