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INFLUENCE OF TUBER SOAKING TIMES WITH SOME NUTRIENTS ON POTATO GROWTH AND PRODUCTIVITY

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ABSTRACT

Two field experiments were conducted at 2018 and 2019 seasons at private farm in Talkha, El-Dakahlia governorate, to evaluate the effect of soaking times of some nutrients and their interaction on vegetative growth characters, photosynthetic pigments, yield and tuber quality of potato. The experiment was arranged in split plot design in complete blocks randomized. This research included 15 treatments consist of three soaking times of nutrients (1 hour, 2 hours and 3 hours) and 4 nutrients application i.e., NPK, zinc (Zn), boron (B), Zn+B in addition control treatment (tap water). Obtained results cleared that soaking tubers pre planting 3 hours gave the maximum values of vegetative growth characters, photosynthetic pigments, yield and tuber quality. All nutrients application significantly increased measured parameters compared to the control treatment. NPK gave the highest values of vegetative growth characters, photosynthetic pigments, yield and tuber quality. Thus, It can be recommended that soaking tuber pre planting 3 hours with NPK enhanced potato growth, yield and quality.

***Keywords*:** Potato (*Solanum tuberosum* L.), growth and productivity

Introduction

Potato (*Solanum tuberosum* L.) considered the second important vegetable in economic value after tomato. The total production of potato 4.8 million tons/ year, inclusive 637, 434 ton for exportation that gave a great value of income. It is a inexpensive source of carbohydrates also plays an important role on human nutrition and starch manufacture. It contains energy, starch, protein, vitamins and mineral elements.

Nowadays, potato farming is confrontation many challenges to preserve and ameliorate production with high quality and quantity. In effect, there are several factors that can negatively influence this cultivation like environmental factors, mainly linked to climate change thus used pretreatments tubers before planting can decrease days to harvest (Abd El-Hady and Shehata, 2019) and reduce emergence stage and increase vegetative growth (Kandil *et al.*, 2012).

Potato requires macro and micro nutrients to obtain high and quality yield. Nitrogen considered constituent of proteins and affect on physiological and biochemical operations, vegetative growth, the formation of organs, phosphor enhances tubers quality by increasing starch contents, also it accelerates tuber growth, potassium has paramount function in the physiological processes ameliorates quality of tubers and it helps in keep the tubers at long time (Boskovic-Rakocevic *et al.*, 2018).

Zinc has important contributory in several physiological functions as it interpose in many enzymes structure and crebs cycle in plant (Alloway, 2004), utilized in the structure of carbohydrates and chlorophyll, transformation starch to sugar. It is serious in the formation of auxins by synthesis tryptophan that is precursor of IAA, that ameliorate stem elongation. The addition of nano silver in plant media has a significant effect on the status of nitrogen , phosphorous and potassium in tomato fruits compared with control. Nano silver at 20 ppm gave the greatest values (Abbas, 2020).

Root growth and other physiological and biochemical process were affected by boron by enhancing cell division as well formation of cell wall, in addition the movement of sugar, carbohydrate metabolization and IAA (Camacho *et al.*, 2008). Increase in the percentage of germination and root length root dry weight of eggplant when treated with aqueous extracts (myrtle, oranges, myrtle + oranges), and the highest rate of increase was due to the effect of extract (myrtle + orange) (Abbas and Hussain, 2020). Thus, the aim of this study was to evaluate the impact of soaking tubers periods with some mineral nutrients on vegetative growth characters, chemical composition, yield and quality of potato.

Material and Methods

Two field experiments were conducted at Talkha district, Dakahlia Governorate, Egypt during the two seasons of 2018 and 2019 to evaluate the impact of soaking times with some nutrient elements on potato (*Solanum tuberosum)* c.v Selani.

Some physical and chemical characters of the soil experiment in the two seasons are shown in Table 1 according to Chapman and Pratt (1971).

Table 1: The physical and chemical properties of the experiments soil in the first and the second season.

Seasons	Mechanical analysis (%)				Texture class	OM (%)	SP	$CaCO_3$%	EC dS.m^{-1} 1:5	pH (1:2.5)	Available (ppm)		
	Clay Sand	Fine Sand	silt	clay							N	P	K
1st	3.2	27.4	36.8	32.6	Loamy	1.72	44.6	27.2	1.11	8.04	41.7	6.19	275
2nd	3.6	28.4	35.7	32.3	Loamy	1.76	45.4	31.1	1.18	7.95	42.4	5.75	283

The experimental design:

The experiment was done in split plot design with three replicates including 15 treatments that were the interaction between 3 soaking periods of potato tubers (1, 2 and 3 hours) which were assigned in main plots and 5 nutreint elements i.e, Tap water as control, nitrogen+ phosphor+potassium (NPK), zinc (Zn), boron (B), and zinc+boron (Zn+B) which were allocated in sup plots as follow:

A- First factor (soaking times):

1- One hour.

2- Two hours.

3- Three hours.

B- Second factor (nutreint elements):

1- Control (Tap water)

2- Nitrogen+phosphor+potassium (NPK).

3- Zinc (Zn).

4- Boron (B).

5- Zinc+boron (Zn+B).

Agricultural practices:

In middle October of both seasons, the field was cleaned, ploughed. Tubers of potato were sown on the 10th and 15th of November in first and second seasons, respectively. Plot area was 14.7 m^2 consisted of 3 rows. Each row was 70 cm width and 7 m long at 50 cm between each plant.

A commercial NPK (19:19:19) was used at 4 g/L, Zn as zinc chelates from EDTA was used at 100 mg/L, while B as boric acid was used at 50 mg/L.

All cultural practices were done according to the recommendations of the Egyptian Ministry of Agriculture in both seasons.

Data recorded:

A- Vegetative growth characters:

Five plants from each experimental plot were randomly taken after 80 days from transplanting and the following measurements were recorded:

1- Plant height (cm).

2- Number of leaves/plant.

3- Leaves fresh weight (g) and dry matter (%): leaves of five plants were weighed and dried in an oven at 70°C for 48 to 72 hours until constant weight.

B- Photosynthetic pigments:

1. Chlorophyll contents: were estimated according to Goodwine (1965).
2. Carotenoids were determined as described by Dubois *et al.* (1956).

C-Yield and its components:

After 100 days from sowing at the harvesting stage; plant yield, number of tubers and total yield were recorded.

D-Tuber quality:

- Starch%: was estimated according to Somogy (1952).
- Vitamin C (mg/100 g Fw): It was estimated as described in AOAC (2012).
- Total Soluble Solids (TSS) %: were estimated by using Refract meter according to A.O.A.C. (2012).
- Total sugars %: were estimated by the method described by Malik and Srivastava (1979).

Statistical analysis:

Data were subjected to the analysis of variance (ANOVA). The differences among means of data were compared by LSD as found by Gomez and Gomez (1984). The Statistical analyses were conducted according to the procedure outlined by (Sneddecor and Cochran, 1976).

Result

A- Vegetative growth parameters

Data in Table 2 revealed that enhancing soaking times of potato tubers from 1hour up to 3hours enhanced plant height, No. of leaves, fresh and dry weights. The highest values of these characters obtained from soaking tubers of potato 3 hours. This trend was true in both seasons.

As for the effect of nutrients application on vegetative growth characters, data in the same table cleared that all nutrients application significantly enhanced aforementioned characters as compared to the control treatment. The maximum values of vegetative growth characters were obtained from soaking tubers with NPK treatment, followed by soaking with Zn+B.

As regard to the interaction effect between soaking times with some nutrients, data shown in the same table illustrated that soaking potato tubers before sowing 3 hours with NPK gave the maximum values of plant height, No. of leaves, fresh and dry weights, followed by soaking tubers 2 hours with NPK. These results were obtained in both seasons.

B- Photosynthetic pigments

Data in Table 3 cleared that photosynthetic pigments (chlorophyll a, chlorophyll b, chlorophyll a+b and carotenoids) increased with increasing tubers soaking times. In this concern, soaking times potato tubers 3 hours before sowing gave the maximum values of aforementioned pigments.

Concerning the effect of application with nutrients before sowing, data in the same table illustrated that all nutrients enhanced significantly photosynthetic pigments of potato leaves compared to control treatments. Application with NPK before sowing gave the highest values of

aforementioned pigments, followed by application with Zn+B. This trend was obtained in both seasons.

As for interaction effect between soaking times with some nutrients, data in the same table cleared that soaking tubers 3 hours before sowing with NPK gave the highest values of leaves pigments, followed by soaking tubers 3 hours before sowing with Zn+B. The lowest values were obtained from soaking tubers 1 hour before sowing with tap water.

C-Yield and its components:

It was cleared from Table 4 that showed there were a significant differences between soaking times before sowing on average tuber weight, No of tubers/plant and total tuber yield/fed., the maximum values of average tuber weight, No of tubers/plant and total tuber yield/fed. were when soaking tubers 3 hours before sowing, followed by soaking tubers 2 hours.

Tabulated data in the same table illustrated that application with nutrients significantly increased average tuber weight, No of tubers/plant and total tuber yield/fed. compared to the control, the maximum values were obtained from application tubers with NPK before sowing, followed by application with Zn+B.

Data presented in the same tables cleared that the interaction between soaking tubers 3 hours with NPK before sowing gave the highest values of average tuber weight, No of tubers/plant and total tuber yield/fed. These results were true in 2017 and 2018 seasons.

D-Tuber quality:

Data presented in Table 5 cleared that soaking tubers 3 hours before sowing significantly enhanced potato quality (TSS, vitamin C, starch, and total sugar). The maximum values of these contents obtained from soaking tubers 3 hours before sowing.

It was cleared from the same tables that there were significant differences between applications with nutrients before sowing. Application tubers with NPK before sowing gave the highest values of aforementioned contents. As for data presented in the same table there were significant differences between soaking times with nutrients on tuber quality. In this concern, the interaction between soaking tubers 3 hours before sowing with NPK gave the maximum values of aforementioned contents.

Table 2: Vegetative growth characters of potato as affected by soaking times of some nutrients during 2018 and 2019 seasons.

Characters / Treatments		Plant height (cm)		No. of leaves/ plant		Fresh weight (g)		Dry weight (g)	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd
A- Soaking times:									
1 Hour		42.60	40.18	18.13	18.26	224.03	303.69	23.61	23.74
2 Hours		45.15	42.33	20.13	20.06	244.49	322.29	25.70	25.84
3 Hours		47.11	44.44	22.33	22.13	263.86	346.21	27.63	28.43
LSD at 5 %		**0.11**	**0.14**	**0.41**	**0.51**	**0.97**	**14.65**	**0.02**	**0.31**
B- Nutrients:									
Control		42.26	40.34	16.66	16.11	224.17	293.58	23.45	23.58
NPK		49.12	46.43	24.88	25.11	283.35	367.76	29.55	29.79
Zn		44.43	41.58	19.77	19.88	237.32	326.54	25.06	25.47
B		43.75	40.81	18.88	19.00	230.08	307.39	24.33	24.84
Zn+B		45.19	42.42	20.77	20.66	245.70	325.05	25.85	26.35
LSD at 5%		**0.22**	**0.08**	**0.72**	**0.83**	**1.81**	**14.52**	**0.14**	**0.22**
C- Interaction:									
1 Hour	**Control**	37.81	37.62	14.66	14.33	202.33	254.93	20.50	20.30
	NPK	48.39	45.64	23.66	24.33	275.14	359.19	28.82	29.00
	Zn	42.27	39.18	17.33	17.66	213.55	323.46	22.91	23.09
	B	41.62	38.35	16.66	16.66	206.50	281.86	22.17	22.43
	Zn+B	42.89	40.10	18.33	18.33	222.63	299.02	23.65	23.91
2 Hours	**Control**	43.59	40.48	16.66	16.33	224.60	297.48	23.98	23.78
	NPK	49.15	46.43	25.00	24.66	283.11	368.16	29.52	29.70
	Zn	44.27	41.53	19.66	20.00	237.99	314.11	24.95	25.13
	B	43.60	40.82	18.66	19.00	230.64	306.76	24.28	24.54
	Zn+B	45.12	42.42	20.66	20.33	246.11	324.97	25.77	26.03
3 Hours	**Control**	45.39	42.92	18.66	17.66	245.59	328.32	25.87	26.67
	NPK	49.83	47.21	26.00	26.33	291.81	375.93	30.30	30.66
	Zn	46.75	44.04	22.33	22.00	260.42	342.07	27.31	28.18
	B	46.02	43.28	21.33	21.33	253.10	333.56	26.53	27.54
	Zn+B	47.56	44.74	23.33	23.33	268.36	351.16	28.13	29.12
LSD at 5%		**0.38**	**0.15**	**NS**	**NS**	**3.14**	**25.14**	**0.25**	**0.38**

Table 3: Photosynthetic pigments of potato leaves as affected by soaking times of some nutrients during 2018 and 2019 seasons.

Characters / Treatments		Chlorophyll a (mg/g FW)		Chlorophyll b (mg/g FW)		Chlorophyll a+b (mg/g FW)		Carotenoids (mg/g FW)	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd
A- Soaking times:									
1 Hour		0.697	0.657	0.390	0.368	1.087	1.026	0.373	0.360
2 Hours		0.728	0.587	0.408	0.386	1.136	0.974	0.391	0.376
3 Hours		0.747	0.707	0.417	0.395	1.165	1.103	0.404	0.388
LSD at 5 %		**0.002**	**0.002**	**0.005**	**0.002**	**0.007**	**0.003**	**0.003**	**0.003**
B- Nutrients:									
Control		0.660	0.553	0.376	0.349	1.037	0.903	0.349	0.340
NPK		0.769	0.735	0.430	0.412	1.199	1.147	0.419	0.402
Zn		0.738	0.602	0.411	0.391	1.150	0.994	0.399	0.381
B		0.693	0.644	0.386	0.359	1.080	1.004	0.366	0.352
Zn+B		0.758	0.720	0.423	0.405	1.181	1.125	0.413	0.398
LSD at 5%		**0.004**	**0.003**	**0.002**	**0.003**	**0.004**	**0.004**	**0.003**	**0.004**
C- Interaction:									
1 Hour	**Control**	0.627	0.623	0.367	0.342	0.994	0.966	0.335	0.331
	NPK	0.734	0.687	0.408	0.389	1.143	1.077	0.398	0.379
	Zn	0.716	0.667	0.397	0.375	1.113	1.042	0.383	0.365
	B	0.681	0.633	0.379	0.352	1.060	0.986	0.356	0.344
	Zn+B	0.724	0.677	0.401	0.382	1.125	1.060	0.393	0.381
2 Hours	**Control**	0.659	0.403	0.376	0.351	1.036	0.754	0.347	0.336
	NPK	0.775	0.746	0.436	0.417	1.211	1.163	0.423	0.407
	Zn	0.744	0.422	0.414	0.395	1.159	0.818	0.404	0.385
	B	0.696	0.645	0.386	0.359	1.082	1.004	0.367	0.352
	Zn+B	0.764	0.722	0.429	0.410	1.194	1.133	0.417	0.400
3 Hours	**Control**	0.693	0.635	0.384	0.355	1.081	0.990	0.364	0.353
	NPK	0.798	0.771	0.446	0.429	1.244	1.201	0.438	0.422
	Zn	0.755	0.717	0.423	0.405	1.179	1.122	0.411	0.392
	B	0.704	0.655	0.393	0.367	1.097	1.022	0.376	0.360
	Zn+B	0.785	0.759	0.439	0.422	1.224	1.182	0.431	0.414
LSD at 5%		**0.006**	**0.005**	**0.004**	**0.005**	**0.007**	**0.008**	**0.004**	**0.007**

Table 4: Yield of potato as affected by soaking times of some nutrients during 2018 and 2019 seasons.

Characters / Treatments		Average tuber weight/plant (g)		No. of tubers/ plant		Total tuber yield (ton/fed.)	
		1st	2nd	1st	2nd	1st	2nd
A- Soaking times:							
1 Hour		130.36	122.55	3.80	4.06	6.06	6.07
2 Hours		141.14	132.41	4.66	4.66	7.98	7.50
3 Hours		149.37	141.72	5.40	5.33	9.73	9.11
LSD at 5 %		**0.75**	**1.01**	**0.57**	**0.79**	**0.95**	**1.18**
B- Nutrients:							
Control		129.46	122.51	3.66	3.77	5.73	5.57
NPK		157.65	150.49	5.88	5.77	11.15	10.44
Zn		137.93	129.51	4.55	4.77	7.63	7.49
B		134.91	125.80	4.22	4.33	6.92	6.61
Zn+B		141.51	132.84	4.77	4.77	8.19	7.69
LSD at 5 %		**0.82**	**0.65**	**0.57**	**0.53**	**0.95**	**0.82**
C- Interaction:							
1 Hour	**Control**	114.02	109.16	3.33	3.66	4.56	4.81
	NPK	154.28	146.59	5.33	5.33	9.87	9.38
	Zn	127.85	119.29	3.33	4.00	5.11	5.72
	B	124.16	115.36	3.33	3.66	4.96	5.07
	Zn+B	131.52	122.37	3.66	3.66	5.79	5.39
2 Hours	**Control**	132.56	123.84	3.66	3.66	5.83	5.45
	NPK	157.82	150.54	6.00	6.00	11.36	10.84
	Zn	138.08	129.58	4.66	4.66	7.73	7.25
	B	135.84	125.46	4.00	4.00	6.53	6.01
	Zn+B	141.43	132.62	5.00	5.00	8.48	7.95
3 Hours	**Control**	141.81	134.52	4.00	4.00	6.80	6.45
	NPK	160.87	154.33	6.33	6.00	12.22	11.11
	Zn	147.86	139.65	5.66	5.66	10.06	9.49
	B	144.73	136.58	5.33	5.33	9.26	8.74
	Zn+B	151.58	143.53	5.66	5.66	10.30	9.75
LSD at 5%		**1.42**	**1.12**	**NS**	**NS**	**NS**	**NS**

Table 5: Tuber quality of potato as affected by soaking times of some nutrients during 2018 and 2019 seasons.

Characters / Treatments		TSS %		Vitamin C mg/100 g		Starch %		Total sugar %	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd
A- Soaking times:									
1 Hour		6.84	6.51	20.44	19.70	18.34	18.24	6.17	5.77
2 Hours		7.20	6.93	21.59	21.02	19.58	19.27	6.61	6.23
3 Hours		7.58	7.29	22.68	22.07	20.72	20.19	6.99	6.69
LSD at 5 %		**0.02**	**0.03**	**0.20**	**0.03**	**0.07**	**0.02**	**0.03**	**0.02**
B- Nutrients:									
Control		6.55	6.51	20.12	19.47	18.13	18.14	5.98	5.70
NPK		8.01	7.68	23.75	23.21	21.75	21.10	7.46	7.14
Zn		7.15	6.79	21.31	20.65	19.24	18.98	6.51	6.11
B		7.00	6.64	20.95	20.26	18.89	18.62	6.33	5.93
Zn+B		7.29	6.94	21.71	21.08	19.70	19.33	6.65	6.27
LSD at 5%		**0.04**	**0.03**	**0.14**	**0.04**	**0.11**	**0.03**	**0.04**	**0.03**
C- Interaction:									
1 Hour	**Control**	6.17	6.04	18.48	17.71	16.20	16.62	5.51	5.16
	NPK	7.88	7.52	23.36	22.77	21.34	20.74	7.33	6.96
	Zn	6.69	6.35	20.14	19.34	18.05	17.96	6.02	5.59
	B	6.56	6.19	19.75	18.93	17.64	17.58	5.85	5.42
	Zn+B	6.87	6.48	20.45	19.77	18.46	18.32	6.13	5.76
2 Hours	**Control**	6.57	6.54	20.26	19.87	18.27	18.35	6.04	5.68
	NPK	7.99	7.68	23.73	23.22	21.73	21.08	7.45	7.15
	Zn	7.15	6.80	21.27	20.65	19.24	18.96	6.54	6.11
	B	6.99	6.67	20.95	20.23	18.92	18.63	6.32	5.92
	Zn+B	7.27	6.95	21.74	21.14	19.71	19.33	6.70	6.28
3 Hours	**Control**	6.91	6.95	21.62	20.83	19.92	19.46	6.39	6.28
	NPK	8.16	7.84	24.15	23.64	22.17	21.48	7.62	7.32
	Zn	7.61	7.22	22.54	21.96	20.44	20.01	6.98	6.64
	B	7.46	7.08	22.16	21.61	20.12	19.65	6.84	6.45
	Zn+B	7.73	7.39	22.92	22.32	20.92	20.35	7.12	6.78
LSD at 5%		**0.08**	**0.05**	**0.25**	**0.08**	**0.18**	**0.05**	**0.08**	**0.06**

Discussion

The results of this study cleared that enhancing soaking times of nutrients significantly promote potato growth, photosynthetic pigments, tuber yield and quality. These results indices may be due that potato tuber grown in moderate moisture and prevent irrigation about one month even plant emergence over the soil surface to prevent tubers rotting thus tubers need optimal level of moisture to stimulate sprout for emergence and commence process of cell division that leading to enhance vegetative growth (Table 2) hence increasing chlorophyll contents (Table 3) thus increased photosynthesis and translocation from leaves to tubers therefore raising potato yield (Table 4). These results are in compatible with those obtained by Sabongari and Aliero (2004) on tomato, Kandil *et al.* (2012), Abd El-Hady and Shehata (2019) on potato and Abbas (2020) on tomato.

The increment of vegetative growth, photosynthetic pigments, tuber yield and quality of potato with NPK application may be attributed to the enhancing utilization of carbon and subsequent synthesis of assimilation (Lawal, 2000). Increasing all evaluated parameters (number of leaves, fresh weight, dry weight, plant height, yield/plant and total yield) in response to NPK may be due to take nutrients up by plant and utilize in cell division, amino acid synthesis (Eifediyi and Remison, 2010) and several metabolic process which reflected positively on formation of photoassiilates that translocated to various sinks (tubers) and therefore increased vegetative growth this led to enhance yield and quality in plant tissues. This observation agrees with the reports of Abd El-Hady and Abd-Elhamied (2018) on cucumber, Rakocevic *et al.* (2018) and Eid *et al.* (2020) on potato.

The positive effect on all parameters allied with Zn and B may be attributed to its role in building up IAA that promote cell division and cell elongation (El-Tohamy and El-Greadly, 2007) and affect on meristematic growth which enhance plant growth with enhancing chlorophyll formation by effect on enzymatic role thus led to increase synthesis of carbohydrates and protein and their transport to storage tuber hence increase potato yield and quality. These findings are in agreement with Singh and Tiwari (2013) on tomato, Puzina (2004), Farouk (2015) on potato, Fouda and Abd-Elhamied (2017) on cowpea and Verma *et al.* (2017) on chickpea.

Conclusion

This study cleared that it is possible to enhance growth, yield and quality of potato plants cultivated under similar condition at Dakahlia governorate by soaking tubers 3 hours before sowing with NPK.

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