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Effect of NPK, Boron and Zinc Fertilizers on Growth and Tuber Yield of Potato

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ABSTRACT

This study was carried out at a Private Farm in Abou Hamad, Sharkia Governorate, Egypt during the two seasons of 2022/2023 and 2023/2024 to investigate the response of potato cv. Spunta to N P K application in the soil and different concentrations of foliar application of Zinc and Boron.

The layout of the experiment was laid out in randomized complete block design (RCBD) with three replicates.

The experiment included 10 treatments as follows:

1- Control.
2- N P K (100 – 200 – 100 kg/fed).
3- Foliar application with Boron at 2 ml/L.
4- Foliar application with Boron at 4 ml/L.
5- Foliar application with Zinc at 2 ml/L.
6- Foliar application with Zinc at 4 ml/L.
7- N P K + Foliar application with (2 ml/L B + 2 ml/L Z).
8- N P K + Foliar application with (4 ml/L B + 2 ml/L Z).
9- N P K + Foliar application with (4 ml/L B + 2 ml/L Z).
10- N P K + Foliar application with (4 ml/L B + 4 ml/L Z).

The obtained results are summarized as follows:

The obtained results indicate that all the treatments significantly increased vegetative growth ,tuber yield and its components , leaves and tubers constituents of potato cv Spunta . The treatment of N P K + 4 ml/L B + 4 ml/L Z, being the most effective on all the vegetative growth tuber yield and its components , leaves and tubers constituents of potato in both growing seasons. This treatment followed by the treatments of N P K + 4 ml/L B + 2 ml/L Zn and N P K + 2 ml/L B + 4 ml/L Zn, respectively compared to the other treatments and control.

Conclusion: The treatment of N P K + 4 ml/L B + 4 ml/L Z, being the most effective on all the vegetative growth, tuber yield and its components , leaves and tubers constituents of potato in both growing seasons. The lowest values of vegetative growth of potato plants were obtained from the control treatment.

Key words: N P K - Boron + Zinc – potato**.**

INTRODUCTION:

Potato (*Solanum tuberosum* L.) is classified under family Solanaceae and in terms of human consumption world is third most significant food crop after wheat and rice **(Tripathi *et al*., 2024)**.

Potato is one of the most important food crops and can be used in human nutrition as a low – cost energy source. Additionally, it is an affordable food with significant content of starch, minerals, vitamin C and B, and amino acids and is highly appreciated world wide **(Kumar and Kumar, 2020).**

Potatoes need many macro-nutrients (N , P and K) and macro-nutrients (Zinc and Boron) to for increasing growth, chemical contents and tuber yield Nitrogen, phosphorus and potassium are considered as the most significant macro-nutrients for potato crop. Nitrogen is the first limiting nutrient in potato production that greatly influence crop growth and tuber yield, in addition, Nitrogen is a component of protoplasm and it is helpful for chlorophyll synthesis. It has play predominant role for growth and development in potato. Nitrogen application can increase dry matter content, protein content of tubers and total tuber yield (**Marschner, 2018**). Phosphorus is the second most important macronutrient limiting plant growth after nitrogen. Phosphorus plays a crucial role in enhancing tuber yield and quality by influencing cell division, starch synthesis, and storage. It also increases concentrations of ascorbic acid, nitrogen and protein in tubers, thereby impacting their size and dry matter content (**Rosen *et al.*, 2014**). Moreover, potassium holds significant importance as a crucial macronutrient for vegetable crops. Potassium plays a vital role in photosynthesis by enhancing the translocation of photosynthates, increasing enzyme activities, and contributing to the synthesis of proteins, carbohydrates, and fats, thereby significantly (**Trankner *et al.*, 2018**).

The micronutrient elements are required in very small quantity like Zinc and Boron for healthy growth and optimum yield of potato. Zinc plays an important role in biosynthesis of indole acetic acid (IAA) and in initiation of primordial for reproductive parts and partitioning of photosynthates towards them resulting in better flowering and fruiting, and also acts as a metal component of many enzymes. Hence application of Zinc becomes essential to increase the productivity of potato (**Sharma *et al.,* 2024**). Boron plays a vital role in cell division sugar translocation, movement of growth regulators within the plant and lignin synthesis (**Aparna and Putaiah, 2012**).

This work aims to study the effect of N P K application and Zinc and boron foliar with different concentration on growth, and yield of potato cv. Spunta.

MATERIALS AND METHODS

This study was carried out at a Private Farm in Abou Hamad, Sharkia Governorate, Egypt during the two seasons of 2022/2023 and 2023/2024 to investigate the response of potato cv. Spunta to N P K application with the soil and different concentrations of foliar application of Zinc and Boron.

The physical and chemical analysis of soil samples were executed according to **Chapman and Pratt (1978)** are presented in Table (1).

The physical and chemical properties of the soil are presented in Table (1). The system of irrigation was surface irrigation the chemical content of irrigation water are presented in Table (2).

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

Content	Value	
	2022/2023	2023/2024
Physical properties:		
Sand (%)	85.77	86.69
Silt (%)	6.75	5.89
Clay (%)	7.58	7.42
Soil texture	Sandy	Sandy
Chemical properties:		
Organic matter (%)	0.04	0.06
Available P (ppm)	5.3	5.7
Available K (ppm)	5.8	6.3
Calcium carbonate (%)	53	61
pH	7.9	8.1

Table (2): The analysis of irrigation water for the experimental soil.

Characters	Value
Soluble cations	
K^{+} (meq/ L):	1.19
Ca^{++}	9.7

Mg^{++}	12.59
Na^{+}	38.6
Soluble anions (meq/ L):	
$NCO3^{-}$	9.33
$SO_4^{=}$	14.8
Cl^{-}	38.9
pH	7.3
EC (dSm^{-1})	2.46

The layout of the experiment was laid out in randomized complete block design (RCBD) with three replicates. Seeds (tubers) were bring from seeds Management of Agricultural Research center, Giza, Egypt.

The plot area was 9.6 m^2 (4 rows, 4 m length and 0.6 width). Seeds cv. Spunta were sown at 20 and 22 September 2022 and 2023, respectively.

The experiment included 10 treatments as follows:

1. Control.
2. N P K (100 – 200 – 100 kg/fed).
3. Foliar application with Boron at 2 ml/L.
4. Foliar application with Boron at 4 ml/L.
5. Foliar application with Zinc at 2 ml/L.
6. Foliar application with Zinc at 4 ml/L.
7. N P K + Foliar application with (2 ml/L B + 2 ml/L Z).
8. N P K + Foliar application with (4 ml/L B + 2 ml/L Z).
9. N P K + Foliar application with (4 ml/L B + 2 ml/L Z).
10. N P K + Foliar application with (4 ml/L B + 4 ml/L Z).

As recommended by the Ministry of Agriculture and land Reclamation (MALR, Egypt). Chemical fertilizers were added at the rate of 100 – 200 100 N-P-K kg/fed. The sources of N P K (nitrogen in the form of ammonium sulplate (20.5% N), Calcium superphosphate (15.5 P_2O_5) and potassium sulplate (48% K^2O). Nitrogen and Potassium were added at two equal portion, at 30 and 60 days from sowing and phosphorus fertilizer at two equal portion at during the preparation of the soil and one month sowing.

Zinc in the form of zinc chloride ($Zncl_2$) and boric anhydride in the form of boric acid (B_2O_3) were purchased from sigma chemical Co. (St. Louis, Mo, USA).

Zinc and Boron were added as foliar application three times at one month from sowing date and 20 days intervals, i.e. 10/11 and 12/11 (the second spray) and 30/11 and 2/12 (the third spray) in the first and the second seasons, respectively.

Data recorded

The following data was recorded at 8 weeks age as follows:

Vegetative growth characters:

1- Plant height (cm).
2- Number of stems/plant.
3- Number of leaves/plant.
4- Shoot fresh weight (g).
5- Shoot dry weight (g).

Yield and its components:

At harvest time, data were recorded as follows:

1 - Number of tubers / plant

2 - Average tuber weight (g)

3 - Tubers weight / plant (g)

4 - Tubers yield / feddan (ton)

Statistical analysis:

All data were statistically analysis according to SAS software program **(SAS, 2007)**. The least significant difference (LSD) at (0.05) level of probability was used compare the means of treatments values according to **Snedecor and Cochran (1989)**.

RESULTS AND DISCUSSION

Vegetative growth characters:

Data presented in Tables (3 and 4) study the effect of N P K, Zinc and Boron and their combined effect on vegetative growth of potato cv. Spunta, i.e. plant height, number of leaves plant number of stems /plant and shoot fresh weight and shoot dry weight. The obtained results indicate that all the treatments significantly increased vegetative growth of potato.

The treatment of N P K + 4 ml/L B + 4 ml/L Z, being the most effective on all the vegetative growth of potato in both growing seasons, This treatment followed by the treatments of N P K + 4 ml/L B + 2 ml/L Zn and N P K + 2 ml/L B + 4 ml/L Zn, respectively compared to the other treatments and control.

The lowest values of vegetative growth of potato plants were obtained from the control treatment. These results are true in both growing seasons. Regarding the important role of N P K, Boron and Zine on growth parameters of potato, **Marschner(2002)** demonstrated that nitrogen is the first limiting nutrient in potato plant that greatly influence growth as well as, nitrogen is a component of protoplasm, and has play predominant role for growth and development in potato. In addition, **Rosen *et al.* (2014)** repented that phosphorus is the second most important macronutrient limiting plant growth after nitrogen, as well as, it plays a crucial role in enhancing cell division and increases dry matter content.

Moreover, **Trankner *et al.* (2018)** illustrated that potassium plays an important role in water balance and transpiration and translocate the elements and enzymes for increasing plant growth Regarding the important role of Zinc and Boron to increase the plant growth parameters, **Aparnaand Puttaiah (2012)** found that Zinc plays an important role in bio synthesis of indole acetic acid (IAA) which has an important role in increasing plant growth.

Moreover, **Aparna and Putaiah (2012)** stated that Boron plays a vital role in cell division and movement of growth hormones in plant which increase plant growth.

These results are in close agreement with those reported by **Ali *et al.* (2021)** and **Sai and Paswan (2024), Neupane *et al.* (2025)**, who worked with N P K, Boron and Zinc, respectively.

As well as, **Bari *et al.* (2001)**, **Mahmoud *et al.* (2019)**, **Kohar *et al.* (2023)** and **Naz *et al.* (2024)**, who worked with Zinc and Boron on growth of potato plants.

Yield and its components:

Data in Table (5a and 5b) revealed that all the treatments of N P K, Boron and Zinc and their combination significantly increased in tuber yield and its components, i.e. number of tubers/plant, average tuber weight, tubers weight/plant and tuber yield/feddan.

Results obtained that the treatment of N P K + 4 ml/L B + 4 ml/L Zinc, being the most effective treatment in tuber yield and its components, followed by the treatments of N P K + 4 ml/L B + 2 ml/L Zinc, N P K + 2 ml/L B + 4 ml/L Zn, respectively.

Regarding the important role of N P K, B and Zn in increasing potato tuber yield, **Marshner (2018)** concluded that nitrogen significantly influences two critical quality attributes: specific gravity (dry matter content) and reducing sugar content (glucose), both of which affect tuber quality and yield and varying nitrogen levels have diverse effects on tuber yield and quality.

Moreover, **Rosen *et al.* (2014)** illustrated that phosphorus plays a crucial role in enhancing tuber yield and quality by influencing cell division, starch Synthesis, and storage, it also increases concentrations of ascorbic acid, nitrogen, and protein in tubers, thereby impacting their size and dry matter content.

Table (3): Effect of N P K, Boron, Zinc and their combined effect on vegetative growth of potato during 2022/2023 and 2023/2024 seasons.

Treatments	Plant height (cm)		No. of leaves/plant		No. of Stoms/plant	
	2022/2023	2023/2024	2022/2023	2023/2024	2022/2023	2023/2024
Control	41.32	42.35	25.31	24.46	2.10	2.15
N P K (100 – 200 – 100)	54.36	55.39	33.59	33.82	2.89	2.60
Boron at 2ml/L	45.43	47.74	29.21	28.85	2.27	2.29
Boron at 4ml/L	50.33	49.75	31.12	31.22	2.33	2.29
Zinc at 2ml/L	51.11	50.39	32.33	32.52	2.51	2.44
Zinc at 4ml/L	52.21	54.56	32.55	32.43	2.62	2.59
N P K +(Boron 2 mi/L + Zinc 2 ml/L)	55.01	56.43	34.19	34.33	2.66	2.64
N P K +(Boron 2 mi/L + Zinc 4 ml/L)	55.67	57.43	35.67	35.81	2.72	2.62
N P K +(Boron 4 mi/L + Zinc 2 ml/L)	57.33	57.17	37.15	37.67	2.75	2.77
N P K +(Boron 4 mi/L + Zinc 4 ml/L)	58.67	59.67	38.97	38.15	2.82	2.86
LSD (0.05)	0.41	0.63	0,54	0.44	0.04	0.05

Table (4): Effect of N P K, Boron, Zinc and their combined effect on shoot fresh and dry weight of potato plants during 2022/2023 and 2023/2024 seasons.

Treatments	Shoot fresh weight(g)		Shoot dry weight(g)	
	2022/2023	2023/2024	2022/2023	2023/2024
Control	223.45	224.47	52.56	51.27
N P K (100 – 200 – 100)	248.31	247.33	59.07	57.09
Boron at 2ml/L	237.42	238.17	50.43	51.19
Boron at 4ml/L	235.51	235.82	54.18	53.33
Zinc at 2ml/L	240.13	241.09	56.55	56.81
Zinc at 4ml/L	241.17	242.22	58.28	58.12
N P K +(Boron 2 mi/L + Zinc 2 ml/L)	249.73	249.66	59.11	58.13
N P K +(Boron 2 mi/L + Zinc 4 ml/L)	253.31	252.33	60.47	61.11
N P K +(Boron 4 mi/L + Zinc 2 ml/L)	259.81	258.26	63.42	64.49
N P K +(Boron 4 mi/L + Zinc 4 ml/L)	263.53	264.11	65.59	66.17
LSD (0.05)	3.56	4.21	2.42	2.17

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Table (5a): Effect of N P K, Boron, Zinc and their combined effect on tuber yield of potato tubers during 2022/2023 and 2023/2024 seasons.

Yield and its components	Number of tubers (g)		Tuber fresh weight (9)		Tuber dry weight (g)	
	2022/2023	2023/2024	2022/2023	2023/2024	2022/2023	2023/2024
Control	3.87	3.91	109.96	115.13	58.33	59.11
N P K (100 – 200 – 100)	5.25	5.17	129.66	129.73	69.50	69.57
Boron at 2ml/L	4.17	4.11	113.61	113.75	60.17	60.22
Boron at 4ml/L	4.22	4.25	119.12	120.11	61.15	61.01
Zinc at 2ml/L	4.47	4.53	126.13	126.22	65.33	65.27
Zinc at 4ml/L	4.65	4.71	128.55	127.42	68.55	68.43
N P K +(Boron 2 mi/L + Zinc 2 ml/L)	5.29	5.33	129.75	130.21	69.51	70.22
N P K +(Boron 2 mi/L + Zinc 4 ml/L)	5.47	5.41	135.33	135.61	70.62	70.57
N P K +(Boron 4 mi/L + Zinc 2 ml/L)	5.51	5.47	135.71	136.17	71.91	71.85
N P K +(Boron 4 mi/L + Zinc 4 ml/L)	5.63	5.61	144.17	145.11	73.71	73.81
LSD (0.05)	0.11	0.11	2.63	2.49	1.18	1.06

Table (5b): Effect of N P K, Boron, Zinc and their combined effect on tuber yield of potato tubers during 2022/2023 and 2023/2024 seasons.

Yield and its components	Total yield/plant (g)		Total yield/fed (Ton)	
	2022/2023	2023/2024	2022/2023	2023/2024
Control	425.5452	450.1583	7.41	7.47
N P K (100 – 200 – 100)	680.715	670.7041	12.73	12.75
Boron at 2ml/L	473.7537	467.5125	8.17	8.07
Boron at 4ml/L	502.6864	510.4675	8.33	8.41
Zinc at 2ml/L	563.8011	571.7766	9.01	9.15
Zinc at 4ml/L	597.7575	600.1482	10.31	10.26
N P K +(Boron 2 mi/L + Zinc 2 ml/L)	686.3775	694.0193	12.87	12.81
N P K +(Boron 2 mi/L + Zinc 4 ml/L)	740.2551	733.6501	13.12	13.21
N P K +(Boron 4 mi/L + Zinc 2 ml/L)	747.7621	744.8499	13.89	14.17
N P K +(Boron 4 mi/L + Zinc 4 ml/L)	811.6771	825.6759	15.17	15.22
LSD (0.05)	8.121	6.275	1.15	1.02

In addition, **Bhattarai (2016)** and **Nazli *et al.* (2018)** demonstrated that potassium plays a vital role in photo synthesis by enhancing the translocation of photo synthates, increasing enzyme activities, and contributing to the synthesis of proteins, carbohydrates, and fats, thereby significantly boosting overall crop productivity.

As well as, **Rai *et al.* (2021)** stated that the micronutrients play a vital role in crop production, where adequate supply of Boron and Zinc can improve the structural indignity and permeability of cell membrane, and have occupied a unique position in enhancing the yield of potato.

Moreover, Zn helps to increase the rate of photo synthesis and the translocation of photo syntheates leading to increased size and number of tubers, in addition, Boron plays avital role in cell division, sugar translocation, movement of growth regulators within the plant and lignin synthesis, and then increased the plant yield **(Aparna and Puttaiah, 2012)**.

These results are in concurrence with those recorded by **Ali *et al.* (2021)**, **Parganiha *et al.* (2022)** and **Sai and Paswan (2024)**, who worked with N P K fertilizer or potato plants, as well as, **Bari *et al.* (2001)**, **Mahmoud *et al.* (2019)**, **Rashid *et al.* (2022)**, **Hasan *et al.* (2023)** and **Sharma *et al.* (2024)**, who worked with Boron and Zinc on potato.

REFERENCES:

1. Ali, Maha M.E. , Spyridon A. Petropoulos , Daila AbdelFattah Fattah H. Selim , Mohssen Elbagory , Maha M. Othman , Alaa El-Dein Omara and Mostafa H. Mohamed (2021). Plant growth, yield and quality of potato crop in relation to potassium fertilization. Agronomy, 11, 675;1016.
2. Aparna, H. and E. T. Puttaiah (2012). Residual effect of zinc and boron on growth and yield of french bean (*Phaseolus vulgaris* L.) -rice (Oryza sativa l.) cropping system. International Journal of Environmental Sciences, 3(1): 167-171.
3. Bari, M. S., M. G. Rabbani, M. Sq. Rahman, M. J. Islam and A. T. M. R. Hoque (2001). Effect of Zinc, Boron, Sulphur and Magnesium on the growth and yield of potato. Pakistan Journal of Biological Sciences, 4(9): 1090-1093.
4. Bhattarai, B.m S. K.C, (2016). Effect of potassium on quality and yield of potato tubers – a review, International Journal of Agriculture & Environmental Science 3 (6): 7–12. https://www.internationaljournalssrg.org/IJAES/paper-details?Id=17.
5. Chapman, H. D. and P. E. Pratt (1978). Methods of analysis for soil and waters. University of California. Dep. of Agric. Sci. USA, pp. 1-309.
6. Hasan, Shimaa Kh.H.; Neama M. Marzouk and Doaa M.R. Abo-Basha (2023). Effect of Foliar Spray with Zinc, Boron, Calcium and Potassium on Growth, Yield, and Tuber Root Quality of Sweet Potato. Horticulture Research Journal, 1(4), 19:27, Dec. 2023.
7. Kohar Dhaniraj , Akash Gupta, Prem Prasad Siwakoti , Sandeep Gouli , Prajwol Shrestha and Rajan Sah (2023). Effect of zinc and boron on the performance of rainy season local potato variety “Sete” (Solanum tuberosum L.) at Rukumkot, Rukum East, Nepal. Archives of Agriculture and Environmental Science 8(2): 157-161 (2023).
8. Kumar, K., & Kumar, M. (2020). Effect of foliar micronutrients application on potato cultivation. Just Agriculture, 1(3), 1.
9. Mahmoud, S. H., Hanaa A. Abd-Alrahman, Neama M. Marzouk and A. M. M. EL-Tanahy (2019). Effect of zinc and boron foliar spray on growth, yield,quality and nutritional value of broccoli heads. Plant Archives Vol. 19 No. 2, 2019 pp. 2138-2142.
10. Marschner, H. (2013). Mineral nutrition of higher plants. 3rd Ed. Academic Press, Harcourt Brace and Company, Publishers. London, New York, Tokyo, pp 864

11. Naz , Raja Mohib Muazzam , Muhammad Umar , Qandeela Nigar , Haider Ali , Muhammad Hanif , Waqas Ahmed Dogar , Mushtaq Ahmed , Aish Muhammad , and Khalid Farooq (2024). Understanding the impact of Zinc and Boron applications on growth and yield attributes in potato. J. Appl. Res Plant Sci. Vol. 5(2), 297-304, 2024.
12. Nazli, F. ,M. Mazhar Iqbal, F. Bibi, M. Ramzan Kashif, M. Ahmad, Modeling the potassium requirements of potato crop for yield and quality optimization, Asian J Agri & Biol 6 (2) (2018) 169–180. https://www.researchgate.net/publication/326413345.
13. Neupane Prajina, Sandesh Bhatta, Arjun Kafle and Madhusudhan Adhikari (2025). Evaluation of foliar application of zinc at different doses on potato (Solanum tuberosum L.) growth, yield, and economic feasibility in Dolpa of Nepal. Technology in Horticulture2025, 5: e011.
14. Parganiha Shaurya, Pravin Kumar Sharma, Vandana Yadav, Vinay Kumar Samadhiya and Sweta Parganiha(2022). Effect of NPK on growth, yield and quality of potato (*Solanum tuberosum* L.) under Chhattisgarh plain. The Pharma Innovation Journal 2022; 11(8): 2214-2217.
15. Rai Ragniee, Raj Kumar, Devesh Pathak and Krishna Kumar Patel (2021). Effect of zinc and Boron on potato yield and quality, nutrient uptake and soil health. The Pharma Innovation Journal 2021; 10(11): 1020-1022.
16. Rashid MHA*, Islam MR and Hossain MM (2022). Effects of micronutrients on growth and yield of potato. Journal of Agriculture, Food and Environment (JAFE), Vol 3 No 3 September 2022 Pages 70-76.
17. Rosen, C.J., K.A. Kelling, J.C. Stark, G.A. Porter, Optimizing phosphorus fertilizer management in potato production, Am. J. Potato Res. 91 (2014) 145–160. Available from: https://link.springer.com/article/10.1007/s12230-014-9371-2
18. Sai , wan and Shobha Paswan (2024). Influence of higher levels of NPK fertilizers on growth, yield, and profitability of three potato varieties in Surma, Bajhang, Nepal. Heliyon 10 (2024) e34601.
19. Sai, Rijwan and Shobha Paswan (2024). Influence of higher levels of NPK fertilizers on growth, yield, and profitability of three potato varieties in Surma, Bajhang, Nepal. Heliyon 10 (2024) e34601.
20. SAS Institute, Inc (2007) . Statistical analysis system. SAS institute Inc., Cary, NC. USA
21. Sharma, Reena * , Keshab Raj Pande , Kalika Upadhyay and Yam Kanta Gaihre (2024). Responses of potato to different methods of zinc and boron application in midhills of Nepal. Archives of Agriculture and Environmental Science 9(4): 800-804.
22. Snedecor, G. W. and W. G. Cochran (1982). Statistical Methods. 7 th ed. Iowa State Univ. Press, Iowa, U.S.A.
23. Tripathi, B. P., Timsina, J., Vista, S. P., Gaihre, Y. K., & Sapkota, B. R. (2022). Improving soil health and soil security for food and nutrition security in Nepal. In J. Timsina, T. N. Maraseni, D. Gauchan, J. Adhikari, & H. Ojha (Eds.), Agriculture, natural resources and food security (Sustainable Development Goals Series). Springer, Cham. https://doi.org/10.1007/978-3-031-09555-9_8