Available online at: http//bjas.bajas.edu.iq

College of Agriculture, University of Basrah

DOi:10.21276/basjas

Basrah Journal of Agricultural Sciences

ISSN 1814 – 5868 Basrah J. Agric. Sci., 32(Spec Issue): 90-97, 2019 E-ISSN: 2520-0860

Effect of Planting Depth and Zinc Sulphate Spraying on Growth and Yield of Potato (*Solanum tuberosum* L.)

Hussein J.M. Al-Bayati* & Karam R. Ali[2]

Department of Horticulture and Land scape Design, College of Agriculture and Forestry, University of Mosul, Iraq

***Corresponding author e-mail: al_bayati_1956@yahoo.com**

Received 15 March 2019; Accepted 8 June 2019; Available online 1 September 2019

Abstract: This study was conducted in one of the unheated plastic house at the Department of Horticulture and Landscape design, College of Agriculture and Forestry, University of Mosul during spring season 2018 to study the impact of two factors, the first: Tuber depth , 10 and 15 cm, the second: Zinc sulphate spraying on potato plants Actrice variety, 0, 150, 300 and 450 mg. l^{-1}, the experiment was designed in the Split Plot system within a Randomized Complete Block Design (RCBD) with three replicates. The results could be summarized as: Tuber planted at 15 cm depth and spraying with zinc sulphate 450 mg. l^{-1} increased plant higher, number of stems per plant, leaf area per plant, whole dry matter percentage, number of tubers per plant, plant yield and total mg. l^{-1} .

Keywords: Tuber Depth, Zinc, Sulphate, Potato.

Introduction

Potato (*Solanum tuberosum* L.) an important crop after rice, yellow corn and wheat in source of nutrition. one of the world's vegetable crops, belonging to Solanaceae family (Matlob *et al.*, 1989). Potato tubers have a high nutritional value. They contain proteins, carbohydrates, vitamins, fiber, fats, minerals such as phosphorus, potassium, iron, calcium, magnesium ascorbic acid. It provides the body with calories, their tubers also rich in amino acids. It contains 18 amino acids, particularly lysine, which lacks to it grain crops, giving them high nutritional value (Hassan, 1999). The production of this crop is affected by many factors, including the appropriate cultivar, size of the seeds, environmental factors and the agricultural service operations, which in turn affects the photosynthetic products, the quantity and quality of the crop (Hassan *et al.*, 2002). Deep cultivation of potato tubers causes slow tuber germination. While surface cultivars expose tubers to light and low or high temperatures by season of cultivation.

These are the most important problems of growing potatoes. The cultivation of tubers deep in the soil reduces vegetative growth and works on reduce the strength (Vigor) of the

tuber and the survival of these seedlings (Hawkes, 1990).

Alsadon *et al.* (1993) planted tubers of two potato varieties in the spring season at a depth 12 and 20 cm, found increased the total yield of tubers when planting at 20 cm. Al-Doghachi (2008) observed when cultivating the potato tubers in the Basrah plant at the depth of 5, 7.5 and 10 cm significantly increase the plant height at planting 5 cm depth, while planting at depth 7.5 cm caused a significant increase in the number of tubers per plant, plant yield and the total yield of tubers, while significant increase average of tuber weight when planting at 10 cm, while no significant differences found in the number of stems per plant.

Chehaibi *et al.* (2013) explained that the planted tubers at 15 cm significantly increase dry weight of vegetative growth and total tubers yield, compared with 10 cm planted depth. Fanos *et al.* (2015) found that planted tubers 12 cm depth significantly increased plant height, number of stems per plant, number of tubers per plant, average weight of tuber and total yield of tubers and decreased green tubers percentage. Kumar *et al.* (2015) observed that planted tubers at 15 cm depth caused significant increase in plant height, number of stems per plant, number of tubers per plant and total yield of tubers compared with 10 and 20 cm planted depth.

` A study of nutrient behavior such as zinc is of no less important than major nutrients such as nitrogen, phosphorus and potassium, because zinc is a necessary nutrient essential to plant growth. As it enters into many vital processes in the plant, including the stimulation of oxidation processes in plant cells and it is necessary for the formation of amino acid Tryptophan which is made up of oxin (IAA) as it is observed that plants that lack zinc suffer from low elongation of the stem and low activity of oxin and a few contents of the amino acid Tryptophan (Tsui, 1984).

The Iraqi soil has a high content of lime up to 30%, and pH diagonal to alkaline and has low content organic matter all these factors helped to reduce the availability of micronutrients including zinc in soil solution, leaves nutrition is an effective method for addressing micronutrient deficiency, including zinc in plants, as it provides the nutrients requirements of these nutrients during the growth stages, which may be unable to provide roots due to the determinants of absorption by the roots and the soil conditions inappropriate (Martin, 2002). The reduced of this element leads to small leaf size and determines plant growth (Alloway, 2004).

Mousavi *et al*. (2007) found zinc spraying on potato plants increases vegetative and quantitative. Ahmed *et al.* (2011) found that spraying zinc sulphate for potato plants Valor variety with the concentration 300 mg.l^{-1} caused a significant increase in plant length, number of stems per plant, leaf area of plant, dry weight of vegetative growth, plant yield and total yield of tubers. Mahmoud (2013) said spraying zinc sulfate to potato plants Argos variety with a concentration of 60 mg. l^{-1} caused a significant increase plant yield, average weight of tuber and total yield of tubers. Al-Fadhly (2016) found that the zinc spraying to potato plants a concentration 60 mg. l^{-1} caused a significant increase in average weight of tuber, plant yield and total yield of tubers compared with control treatment. Assi (2017) observed that the spraying zinc sulphate on potato plants at 50 ml. l^{-1} caused a significant increase in plant length, leaf area per plant, number of tubers

per plant, tuber weight and total yield of tubers compared with control treatment. Manea *et al*. (2019) found that spraying zinc sulphate for potato plants Sylvana variety at 400 mg. l^{-1} concentration caused a significant increase in plant length, leaf area per plant, number of tubers per plant, plant yield, total yield of tubers, compared with control treatment.

The aims of study to find out the most suitable depth for the cultivation of potato tubers in the spring season, and the best concentration of zinc sulphate to improve the growth and the quality, and increase yield.

Materials & Methods:

The experiment was conducted in the vegetative field, Department of Horticulture and Landscape, College of Agriculture and Forestry, University of Mosul, during spring season 2018. Soil samples were taken from the surface layer at a depth of 30 cm to study some physical and chemical traits of the soil before the cultivation starting as shown in Table (1).

Table (1): Physical and chemical traits of field soil.

pH	EC ($ds.m^{-1}$)	Organic matter (%)	N ($mg.kg^{-1}$)	P ($mg.kg^{-1}$)	K ($mg.kg^{-1}$)	Sand g. kg^{-1}	Loam g. kg^{-1}	Clay g. kg^{-1}	Soil texture
1.7	0.75	18.45	23.15	14.75	125.55	648.1	228.8	123.1	Silty loam

The soil was prepared for cultivation by plowing with the mound board plough trio by plowing it two perpendicular plowing, and then the soil was smoothed and settled. A (18-46-0) NPK with rate of 400 $kg.ha^{-1}$ (Al-Obaydi, 2005) was added to the soil 10 days before tubers planting, the compost was mixed with soil, and the experiment of ground was divided into three sectors. The tubers were treated with a fungicide (Pentanol) at a concentration of (1 g $.l^{-1}$ water) to protect the tubers from fungal infections before planting. Tubers of Sylvana variety were planted on 8th February 2018 in the furrows, the distance between each furrow is 75 cm and 25 cm between tubers. Experimental unit included 3 furrows with a length of 2 m and a width of 2.25 m, the experimental unit area was 4.5 m^2. The number of planted tubers in furrows each 8 tuber, experimental unit contained 24 tubers. The agricultural service operations were conducted in a similar manner to all the experimental units, from fertilizing, weeding and, control diseases, insects, grubbing, controlling the thicket and incubation, as is the case of the commercial fields. Irrigation method was Dropping method. The study included two factors. Nitrogen fertilizer (Urea) added after tubers germination at 100 kg. ha^{-1} (Al-Obaydi, 2005) in two times. To summarize the research, we include only two factors:

The first factor: planting tubers on two depth:

1-10 cm, 2- 15 cm

The second factor: spraying the plants with zinc sulphate three concentrations in addition of water only:

2-150 mg. l^{-1}, 2- 300 mg. l^{-1}, 3- 450 mg. l^{-1}.

All this concentration sprayed on vegetative whole at three times:

-After tubers germination is completed at (43 days of cultivated).

-During the formation of the tubers after (15 days from the first spraying).

-Tuber growth period after (15 days from the second spraying).

The number of treatments in each replicate were 8 treatments (2×4), the total experimental units were 24 experimental units. The experiment was conducted within the split-plot system according to the Randomized Complete Block Design (RCBD), with three replicates. The tubers planted depth (first factor) were placed in the main plots and the spraying zinc sulphate (second factor) in the sub plots.

Experimental measurements:

First: Vegetative growth traits: vegetative growth traits of plants were measured after 10 days of last spraying of zinc sulphate which included:

1-Plant height (cm)

2-Number of aerial stems per plant.(stem.plant^{-1})

3-Plant leaf area(cm^2.plant^{-1})

4-Whole dry matter percentage.

Second: Quantitative yield traits : Tubers were harvested after 120 days of cultivation, which included:

1-Number of tuber per plant (tuber. plant^{-1}).

2-Average weight of tuber (g).

3-Plant yield (g.plant^{-1}).

4-Total yield of tubers.(t. ha^{-1}).

5-Green tubers percentage.

After the finishing of data collection, statistical analysis was conducted using SAS, 2001 program and Duncan Multiple Range test at a probability level 0.05 (Al-Rawi & Kallaf Allah, 2000).

Results & Discussion:

Vegetative growth traits:

Table (2) showed that tubers planted at 15 cm was significantly increased plant height which amounted for 55.50 cm, number of aerial stems per plant 3.27 stem.plant^{-1}, leaf area per plant 1862 cm^2. Plant^{-1}, dry matter percentage of whole vegetative 14.00% , while there is no significant between tubers planted depth on chlorophyll in the leaves.

Table (2): Effect of planted tuber depth and zinc sulphate spraying on vegetative growth traits.

Tuber depth	Plant height (cm)	Nu. of stems per plant	Leaf area (cm^2.plant^{-1})	Whole dry matter (%)	Chlorophyll SPAD
10 cm	54.08 b	2.86 b	1547 b	12.90 b	61.49 a
15 cm	55.50 a	3.27 a	1862 a	14.00 a	62.45 a
Zinc sulphate concentrations (mg. l^{-1}):					
0	53.00 b	2.98 a	1897 b	13.08 b	58.79 c
150	54.85 ab	3.04 a	1909 ab	13.22 ab	61.07 bc
300	55.30 ab	3.05 a	1928 ab	13.58 ab	62.73 b
450	56.05 a	3.18 a	2130 a	13.90 a	65.28 a

Averages with same letter for each factor was no-significant according Duncan's multiple Range of 0.05 test.

Results of zinc sulphate spraying observed that sprayed 450 mg. l^{-1} was significantly increased plant height 56.05 cm, leaf area per plant 2130 cm^2. $Plant^{-1}$, dry matter percentage of the whole vegetative, 13.90% and chlorophyll in leaves 65.28 compared with control treatment, but there is no significant differences between zinc sulphate spraying on number of aerial stems per plant. No significant differences were observed between concentration of zinc sulphate in these characteristics.

The interaction between planted tubers at 15 cm and spraying zinc sulphate 150 , 300 and 450 $mg.l^{-1}$ gave the highest of plant higher, number of aerial stems per plant, leaf area per plant, highest dry matter percentage of whole vegetative and chlorophyll in the leaves which amounted 57.06 cm, 3.37 $stem.plant^{-1}$, 1994 cm^2. $Plant^{-1}$, 14.44% and 65.95 respectively (Table 3).

Table (3): Effect of interaction between planted tuber depth and zinc sulphate spraying on vegetative growth traits.

Tuber depth	Zinc sulphate (mg. l^{-1})	Plant higher (cm)	Nu. of stems per plant	Leaf area ($cm^2.plant^{-1}$)	Whole dry matter (%)	Chlorophyll SPAD
10 cm	0	51.97 b	2.75 b	1358 c	12.54 c	58.20 c
	150	54.07 ab	2.83 b	1595 b	12.69 bc	60.88 bc
	300	55.26 ab	2.87 b	1617 b	13.01 abc	62.26 ab
	450	55.03 ab	2.98 b	1616 b	13.35 abc	64.62 ab
15 cm	0	54.00 ab	3.20 ab	1800 ab	13.62 ab	59.38 bc
	150	55.63 ab	3.25 ab	1815 ab	13.75 ab	61.25 b
	300	55.33 ab	3.23 ab	1836 ab	14.15 ab	63.20 ab
	450	57.06 a	3.37 a	1994 a	14.44 a	65.95 a

Averages with same letter for each factor was no-significant according Duncan's Multiple Range test of 0.05.

Quantities yield traits:

Table (4) indicated that tubers planted at 15 cm was significantly increased tuber number 12.60 $tuber.plant^{-1}$, average tuber weight 127.64 g, plant yield 1143 g, total tubers yield 58.963 $t.h^{-1}$, but significantly decreased the greening percentage of tubers 5.44%. Results of zinc sulphate spraying in same table indicate the significant superiority of the concentration 450 mg. l^{-1} in number of tubers 12.68 $tuber. plant^{-1}$, average tuber weight 131.58 g, plant yield 1147 g, total tubers yield 58.743 t. ha^{-1} compared with control treatment, but no significant found in greening percentage of tubers. The interaction between the tuber depth planted and zinc

sulphate spraying (Table 5) showed that the interaction between planted tubers at 15 cm and spraying zinc sulphate at a concentrations 150, 300 and 450 mg. l^{-1} was significantly increased in all studied quantitative traits, tuber number per plant 13.75, average weight of tuber 136.95 g, plant yield 1205 g and total yield of tubers 62.420 $t.ha^{-1}$, while this treatment significantly decreased the greening percentage of tubers 3.77% .

Table (4): Effect of planted tuber depth and zinc sulphate spraying on vegetative growth traits.

Tuber depth	Nu. of tubers per plant	Average weight of tuber (g)	Plant yield (g)	Total yield of tubers ($t. ha^{-1}$)	Green tubers %
10 cm	11.08 b	118.92 b	1058 b	54.020 b	9.22 a
15 cm	12.60 a	127.64 a	1143 a	58.963 a	5.44 b
			Zinc sulphate concentrations (mg. l^{-1}):		
0	11.01 b	117.58 b	1045 b	54.668 b	7.91 a
150	11.40 b	120.89 b	1092 b	55.451 b	7.94 a
300	12.24 ab	123.04 ab	1116 ab	57.071 ab	7.47 a
450	12.68 a	131.58 a	1147 a	58.743 a	6.48 a

Averages with same letter for each factor was no-significant according Duncan's Multiple Range of test 0.05.

Table (5): Effect of interaction between planted tuber depth and zinc sulphate spraying on vegetative growth traits.

Tuber depth	Zinc sulphate (mg. l^{-1})	Nu. of tubers per plant	Average weight of tuber (g)	Plant yield (g)	Total yield ($t.ha^{-1}$)	Green tubers %
10 cm	0	10.29 c	112.19 c	1025 c	52.828 c	9.49 a
	150	10.59 bc	118.28 bc	1050 bc	53.872 bc	9.84 a
	300	11.80 bc	118.97 bc	1067 abc	54.311 bc	9.35 a
	450	11.61 bc	126.21 abc	1089 abc	55.066 abc	9.19 ab
15 cm	0	11.73 b	122.97 bc	1065 abc	56.507 abc	6.34 bc
	150	12.21 ab	123.50 bc	1134 ab	57.091 abc	6.04 bc
	300	12.68 ab	127.11 ab	1166 ab	59.831 ab	5.60 bcd
	450	13.75 a	136.95 a	1205 a	62.420 a	3.77 d

Averages with same letter for each factor was no-significant according Duncan's Multiple Range of 0.05.

The results indicated that tubers planted at 15 cm depth significantly increased plant higher, number of aerial stem per plant, due to that in light textured soil planting deeper allows the crops to get more food reserves and water (McEwan, 2012), encouraging development and increasing fresh weight, and this indicators reflected to increase the leaf area per plants and percentage of dry matter of whole.

It appears that is considerable interaction between the level of release of tubers in the soil and yield of the plant. In deed a major planting deepest germinates more slowly but their roots grow best laterally and at depth and make the most of available water and nutrients. By contrast, at shallower planting depths, plant biomass was relatively lees developed leading to a lower tuber yield. Tuber weight depends primarily on the operating time of the leaf canopy (Snapp & Kravchenko, 2010).

Conclusions

At the end of this experimental work aimed to study the effect of planting depth and zinc sulphate spraying on potato plants, it appears that planting potatoes at 15 cm and spraying zinc sulphate 150, 300 and 450 $mg.l^{-1}$ promoted better development of both below and above ground plant components.

Acknowledgements

We thank the College of Agriculture, University of Basrah, and the organizers of the conference for their efforts before and during the conference.

Conflict of interest: The authors declare that they have no conflict of interest.

References

Ahmed, A.A.; Abd-Baky, M. M.H.; Zaki, M.F & Abd EL-Aal, F.S. (2011). Effect of Active yeast extract and zinc on growth, yield and quality of potato plant (*Solanum tuberosum* L.). J. Appl. Sci. Res., 7(12): 2479 -2488.

Al-Doghachi, E.H. (2008). Effect of tuber spacing and depth on growth and yield of potato *Solanum tuberosum* L. cultivated at Basrah city southern of Iraq. Basrah J. Agric. Sci., 21(Spec. Issue): 76-90.

Al-Fadhly, J.T.M. (2016). Response of Potato (*Solanum tuberosum* L.) to foliar application of zinc and manganese which fertilized by organic fertilizer. J. Agric. Vet. Sci., 9(4): 87- 91.

Alloway, B.J. (2004). Zinc in soils and crop nutrition. International Zinc Association (IZA). www. zincworld. Org.

Al-Obaydi, A.M.S.K. (2005). Physiological studies to improved growth and yield and seed production and water stress of potato (*Solanum tuberosum* L.). Ph. D. Thesis, Coll. Agric. Forestry, Univ. Mosul. (In Arabic).

Al-Rawi, K.M. & Khalaf-Allah, A.M. (2000). Design and Analysis of Agricultural Experiments. Foundation of Dar Al-Ktob. Univ. Mosul, Min. High. Educ. Sci. Res., Iraq: 488pp. (In Arabic).

AlSadon, A.A.; Wahdan, H.M. & Wahby, M.F. (1993). Yield and physical properties of potato tuber as influenced by planting depth. J. King Saud Univ. Agric. Sci., 5(2): 227-235.

Assi, S.L. (2017). Response of potato plant *Solanum tuberosum* L. desiree variety to application with foliar agro leaf fertilizer and zinc element. Euphrates Agric. Sci., 9(4): 70-85.

Chehaibi, S.; Hamdi, W. & Abrougui, K. (2013). Effect of planting depth on agronomic performance of two potato

varieties grown in the Sahel region of Tunisia. Global J. Arable Crop Prod., 1(1): 50-54.

Fanos, T.; Belew, D. & Nebiyu, A. (2015). Effect of Planting Depth and Time of Earthing- up on Potato (*Solanum tuberosum* L.) yield and yield components at Jimma Univ. Coll. Agriculture Vet. Med., South West Ethiopia. Int. J. Afr. Asian Stud., 15: 61-78.

Hassan, A.A.M. (2003). Potatoes Production. Dar Al-Arabiya Pub. Cairo: 446pp.

Hassan, M.A.O.; Gargees, M.M. & Hamdi, A.W. (2002). Effect of planting date on growth and yield of potato in Al-Garbia and Al-Sharquia area. Ebaa J. Agric. Res., 12(1): 112- 114.

Hawkes, J.G. (1990). The potato evolution, biodiversity and genetic resources. Belhaven. Pr., London: 360pp.

Kumar, P.; Singh, S.; Kumar, R.; Rawal, S. & Singh, B.P. (2015). Effect of tuber planting depth on yield, quality and profitability of potato (*Solanum tuberosum*) processing varieties. Indian J. Agron., 60(1): 139-144.

Mahmoud, J.T. (2013). Effect of foliar application of Iron and zinc on some parameter yield of potato fertilized with organic matter. Euphrates Agric. Sci., 5(2): 38-46.

Manea, A.I.; Al-Bayati, H.J.M. & Al-Taey, D.K.N. (2019). Impact of yeast extract, zinc sulphate and organic fertilizer spraying on potato growth and yield. Res. Crops, 20(1): 95-100.

Martin, P. (2002). Micro nutrient deficiency in Asia and the Pacific-Borax Europe Limited, UK, A.T., IFA. Reg. Conf. Asia on the Pacific Singapore, 18- 20 November 2019.

Matlob, A.N.; Sultan, E. & Abdul, K.S. (1989). Vegetable Production. Part 1. Dar AL-Kutub Publ.. Univ. Mosul, Iraq. 680pp.

McEwan, G. (2012). Flooding Means Losses for Many Potato Growers. Hort. Week: 36pp.

Mousavi, S.R.; Galavi, M. & Ahmadvand, G. (2007). Effect of zinc and manganese foliar application on yield, quality and enrichment on potato (*Solanum tuberosum* L.). Asian J. Plant Sci., 6(8): 1256-1260 .

SAS, (2001). Statistical Analysis System. SAS Institute. Inc. Cary Nc. 27511.

Snapp, E. & Kravchenko, A. (2010). Potato Yield Variability across the Land scape. Agron. J., 102(3): 885- 892.

Tsui, C. (1984). The role of zinc in auxin synthesis in the tomato plant. American Journal Botany, 35: 172- 179.