Plant Archives Vol. 19, Supplement 1, 2019 pp. 1087-1096 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

IMPACT OF FERTIGATION OF NANO N P K FERTILIZERS, NUTRIENT USE EFFICIENCY AND DISTRIBUTION IN SOIL OF POTATO (*SOLANUM TUBEROSUM* L.)

Hayyawi W.A. Al-uthery and Qusay. M.N. Al-Shami
College of Agriculture, University of Al-Qadisiyah, Iraq
Emails : hayyawi.aljutheri@qu.edu.iq, Qusay.murad1983@gmail.com

Abstract

A field experiment was carried out in the autumn season of 2017 in one of the fields of the College of Agriculture - University of AL- Qadisiyah to study of impact fertigation of nano NPK fertilizers in WUE, NUE and nutrients distribution in soil of potato (*Solanum tuberosum* L.) cultivar Arizona, The experiment included 9 treatments of fertigation single Nano N, P, K, di combination nano (N+P), (N+K), (P+K), tri nano (N+P+K) and conventional fertilizers (NPK20:20:20) In addition to the control treatment, according to design of RCBD and one way simple treatments with 4 replicates.

Fertilizers was injected with levels of addition of 40L h^{-1} of nano nitrogen fertilizer 25%N, 10 kg h^{-1} of nano phosphorus fertilizer 25% P and 20 kg h^{-1} of nano potassium fertilizer 35% K and 300 kg h^{-1} traditional fertilizer Tron (NPK 20:20:20)) in four batches 10%, 20%, 30% and 40% of the quantities of fertilizers added to the first, second, third and fourth batch respectively. and for the study of water , nutrient use efficiency, agronomic efficiency and available nutrients distribution N, P and K forhorizontal and vertical dimensions of the emitters, soil samples of the horizontal dimension (0, 10, 20 and 30 cm) were taken from emitters and deep (10, 20, 30, 40 and 50 cm) by making a clip made of wood with circular holes of 20 slots distributed on the clamp representing the horizontal and vertical distribution of nutrients under the emitters for tri treatment of nano and traditional NPK fertilizers only and analyzed statistically according to the design of split plots to take the main plots source of fertilizers nano and traditional and sub plots depth of soil cm under emitters and sub plots horizontal dimension of emitters, The results of the statistical analysis for Duncan showed the fertigation of nano NPK fertilizers mixture treatment is superior of WUE, NUE, PUE and KUE(26.50AE Kg fresh tubers Kg^{-1} fertilizer, 97.43%, 98.11% and 97.03%) respectively compare to traditional NPK fertilizer (21.43 Kg fresh tubers Kg^{-1} fertilizer, 52.27%, 35.02% and 44.04%) respectively and LSD showed a significant difference between the horizontal and vertical distribution of the availability nutrients N, P and K emitted from the emitters, According to the fertilizers source and depth at the surface of the soil and the horizontal dimension of the emitters, and the superiority of the nano fertilizes in nutrient availability and homogeneity of movement.

***Key words*: ** N P K, nanofertilizers, availability, dimension, movement

Introduction

The utilization of mineral fertilizers development is a typical agricultural practice that gets satisfactory outcomes terms of yield (Al-Taey *et al*., 2018), nutrients balance in the soil and meet the basic requirements of plant nutrient elements throughout the growth stages. It also reduces the intensive needs of mineral fertilizers, Reduce the loss of nutrient elements forms (Al-Taey *et al*., 2015), climate change, declining arable land and low availability of water. However, we need to achieve sustainable growth in agriculture. At least 4% to meet food security challenges. To address some of these challenges, it is necessary to apply leading technologies such as nanotechnology to accurately detect how to provide the right amount of nutrients that enhance productivity while ensuring environmental safety and high nutrient efficiency (Subramanian *et al*., 2007) So that nano slow controlled fertilizers can be used as environmentally friendly to achieve sustainable, environment-friendly agriculture that operates with nanomaterials (1-100 nm) specifically for dimensions that have some characteristics that differ from those in their volumetric diameter (Ghorbanpour *et al*., 2017).

Nano fertilizers are more effective and efficient than traditional fertilizers because of their positive effects on the quality nutrition of crops and the reduction of stresses in plants and the lack of added quantities and costs for their rapid uptake by the roots and their penetration into cells and transport and representation within the plant tissues (Singh, 2017, Ali and Al -juthery, 2017). Drip irrigation proved to efficiently provide irrigation water and nutrients to the roots of plants, while maintaining high yield production. Modern drip irrigation has arguably become the world's most valued innovation in agriculture, which replaced flood irrigation. This is because high water application efficiencies are often possible with drip irrigation, since there is reduced surface evaporation, less surface runoff as well as minimal deep percolation (Shymaa *et al*., 2009; Al-Juthery, 2011)

Fertigation is one of the fertilizer application methods in which fertilizer is combined with irrigation water by modern sprinkler and drip irrigation systems. After dissolving the nutrient fertilizers in solution and injected with irrigation water that provides nutrients and water (Fanish and Muthukrishnan, 2013). Essential elements are then directly available to the active root zone, thus reducing nutrient fertilizers and increasing their efficiency to 60%, which ultimately helps to improve the yield and quality. Fertilizer use efficiency is increased from 80 to 90 per cent (Rachna Rana *et al*., 2014). Shedeed *et al*. (2009) pointed out that adding certain nutrient concentrations with irrigation water improves the consistent distribution of nutrients and improves the fertilizer use efficiency, as well as reducing nitrogen washing in the form of nitrate (NO_3^{-1}) and potassium to the root zone. Phosphorus at any level was more readily available relative to terrestrial addition. This is an efficient method of adding fertilizer (Segares, 2002, Fares and Abaas, 2009). This technique provides the right mineral nutrition. Allowing for increased nutrient efficiency. However, nutrient determinants when harvest is needed and adapted to its water needs are essential for accurate plant nutrition and high nutrient efficiency as a successful method of reducing pollution (Bres, 2009 and Al-Juthery, 2011). Potato (*Solanum tuberosum* L.) is one of the most important strategic food crops can absorb high amounts of special nutrients "NPK from the soil during the growth period to obtain high yields of tubers and good quality (White *et al*., 2007). Therefore, the current study aims to studying the role of fertigation of tri nano NPK fertilizers in availability and horizontal and vertical distribution of NPK nutrients under emitters.

Materials and Methods

A field experiment was conducted in one of the fields of Horticulture and Garden Engineering Faculty of Agriculture - University of Al-Qadisiyah in the soil of a sandy loam with the properties shown in table 1. For the study of the effect of fertigation of nano NPK fertilizers in horizontal and vertical distribution of nano NPK nutrients under drip irrigation system of the potato (*Solanum tuberosum* L.) cultivar Arizona. The experiment included nine compatibility treatments for fertigation of N, P and K nano fertilizers and their different combinations were added in four unequal increments to match the growth stages of the crop by the amount of fertilizer, the number of injection times and the mixing ratios shown in Table 2. In a simple experiment using RCBD And four replicates, On 20/9/2017, potato tubers were planted Arizona cultivar 0.2 m between tuber and others, From the top of the furrow and along the line. Irrigation was done using a drip irrigation system prepared for this purpose and was operated with a consistency coefficient of 94.33%,Fertilizers was added by fertilization process by dissolving the required amount of fertilizer in each addition of plastic suspension bottles prepared for this purpose with a diameter of 0.15 m and a size of 6 liters and contain a valve to control the descent of the mixture fertilizer for each transaction and 2 valve at the ends, The treatment line 3 m contain 15 emitters to ensure no leakage between the treatments, The process of injecting the mixture after 5 minutes from the start of the irrigation process then close the valves between the treatments and open the valves of the bottles to allow the mixture of fertilizer into the emitters and after the completion of fertigation process add an equivalent amount of water 6 liters to wash the bottles and falling pipes and then open the valves to complete Irrigation process and according to water consumption for that day. After the plant reached maturity, the tubers were harvested on 15 January 2018 after harvesting the vegetative parts.

Table 1: Some soil properties

Property	Value	Estimated Methods
Particle size distribution (gm kg^{-1}soil)		
Clay Silt Sand	379.2 436.9 183.9	
Texture	Loamy Sand	Kilmer and Alexander,1949
CEC C mol_c kg^{-1}Soil	22.5	Salim and Ali,2017
OMgm kg^{-1}Soil	12.0	Salim and Ali,2017
Calcite gm kg^{-1}Soil	177	Salim and Ali,2017
pH	7.5	Salim and Ali,2017
EC(1:1) (dS m^{-1})	2.1	Salim and Ali,2017
Available macronutrients (mg kg^{-1}soil) N P K	 22 15 177	Salim and Ali,2017 Salim and Ali,2017 Landon,1984
Bulk density Mg m^{-3}	1.37	Landon,1984

Table 2 : Shows the experiment treatments, quantities of fertilizers and number of injections

Tr. No	Treatments of spraying	10% of fertilizer	20% of fertilizer	30% of fertilizer	40% of fertilizer
T1	control	0	0	0	0
T2	Nano Nitrogen*25%N	4	8	12	16
T3	Nano phosphorus**25%P	1	2	3	4
T4	Nano Potassium*** 35%K	2	4	6	8
T5	Nano(N+P)	1+4	2+8	3+12	4+16
T6	Nano (N+K)	2+4	4+8	6+12	8+16
T7	Nano (P+K)	2+1	4+2	6+3	8+4
T8	Nano (N+P+K)	2+1+4	4+2+8	6+3+12	8+4+16
T9	Traditional (20:20:20NPK)****	30	60	90	120

40Liter of Nano Nitrogen fertilizer ha^{-1} ** 10Kg Nano Phosphorus fertilizer ha^{-1} *** 20 Liter of Nano Potassium ha^{-1} **** 300 Kg (20:20:20) traditional ha^{-1}

Water use efficiency (WUE) or water productivity was calculated as the ratio of potato yield (Y) to total crop water use (WU) (Howell, 2000). Nutrient Use Efficiency or recovery efficiency for each element % = uptake of the treated fertilizer - uptake in treatment \ quantity of element added × 100. (Ali, 2011). Available nutrients distribution N, P and K for horizontal and vertical dimensions of the emitters, soil samples of the horizontal dimension (0, 10, 20 and 30 cm) were taken from emitters and deep (10, 20, 30, 40 and 50 cm) by making a clip made of wood with circular holes of 20 slots distributed on the clamp representing the horizontal and vertical distribution of nutrients under the emitters for tri treatment of nano and traditional NPK fertilizers only and analyzed statistically according to the design of split split plots to take the main plots source of fertilizers nano and traditional and sub plots depth of soil cm under emitters and sub plots horizontal dimension of emitters

Soil analyses were conducted before trial using methods mentioned at (Table 1) for physical and chemical soil properties.

Duncan’s multiple range test at $p \leq 0.05$ (1955) after analyzing the data by Genstat program. Statistical analysis of collected data was performed by using LSD test (Al Sahuki and Whaib, 1990) of Genstat program. Statistical differences were considered significant at $p<0.05$.

Results

Water use efficiency (WUE) kg m^{-3}: The results indicate the effect of fertigation nano NPK fertilizers in (WUE) or Water productivity shown in Table 3. The combination of tri nano (NPK)As an effect "common" The highest WUE (26.50 kg m^{-3}) was significantly higher on all treatments including the combination of tri conventional fertilizer (NPK) treatment (21.43 kg m^{-3})compared to the control treatment of 16.85 kg m^{-3}, It is noted that the treatments of the di combinations of nano (NP), nano (NK) and nano (PK) (25.64, 24.54 and 22.44 kg m^{-3}) respectively, the highest values were recorded from the single nano (P) and (K) (20.51 and 21.61 kg m^{-3}) and did not reach the significantly level fertigation of nano (PK) (22.44 kg m^{-3}) compare to single nano-nitrogen (23.32 kg m^{-3}).

Agronomic efficiency(AE)or fertilizer productivity kg fresh tubers kg^{-1} fertilizer:The results of the statistical analysis are shown in Table (3) Fertigation of nano-NPK fertilizers with their different combinations have significantly affected (AE)The single fertigation nano (P) achieved the highest agronomic efficiency (666.70 kg kg^{-1}) compare to control (0 kg kg^{-1})Followed by single fertigation nano (K) (433.35 kg kg^{-1})and the lowest (AE) of the single fertigation treatments was at nano (N) (294.44 kgkg^{-1}) and significant difference between them, Di nano combinations treatments showed higher nano (PK) treatment (338.85 kg kg^{-1})Followed by the treatment of nano (NP) (319.97 kg kg^{-1}) and the lowest in the treatment of nano (NK) (233.28 kg kg^{-1}) but not the significantly between them, the lowest field efficiency in conventional mixed fertilizer (NPK) was achieved (27.77 kgkg^{-1}).

Table 3 : Effect of fertigation nano fertilizers NPK in water use efficiency and agronomic efficiency and element use efficiency

Tr. N^O	WUE Kg m^{-3} water	AE Kg fresh tubers Kg^{-1} fertilizer	NUE %	PUE %	KUE %
T_1	16.85 g	0.00 d	0	0	0
T_2	23.32 cd	294.44 bc	85.30	0	0
T_3	20.51 f	666.7 a	0	94.34	0
T_4	21.61 ef	433.35 b	0	0	94.06
T_5	25.64 ab	319.97 bc	96.35	97.51	0
T_6	24.54 bc	233.28 c	92.52	0	95.42
T_7	22.44 de	338.85 bc	0	95.56	95.77
T8	26.50 a	250.78 c	97.43	98.11	97.03
T9	21.43 ef	27.77 d	52.27	35.02	44.04

AE agronomic efficiency, WUE, NUE, PUE and KUE water, nitrogen, phosphorus and potassium use efficiency

Element Use Efficiency (EUE)%: Note from the results of table (3) that the highest uptake efficiency of the element is achieved when the nano NPK combined NUE, PUE, and KUE (97.43, 98.11 and 97.03%) respectively compared to conventional compound fertilizer NPK which recorded the lowest values of NUE, PUE and KUE (52.27, 35.02 and 44.04%) While the di combination achieved the highest NUE to treatments nano (NP) and nano (NK) compared to single nano N fertilizers (96.35, 92.52 and 85.30%) respectively. PUE is also used for the dual and individual combinations of the same direction and different values (97.51, 95.56 and 94.34%) and KUE (95.42, 95.77 and 94.06%) respectively.

Distribution of available nitrogen in soil by fertilizer source and vertical and horizontal dimension of emitter: From table (4) the results showed that the nano nitrogen source in the nitrogen content of the soil is higher than that of the traditional source (30.85 and 22.18 mg N kg^{-1} soil) respectively. The highest nitrogen content at depth (20 cm) and the lowest at the depth of the latter (50 cm) (31.96 and 22.56 mg N kg^{-1} soil) respectively. The effect of the horizontal distance from point (C) was the highest content of the prepared nitrogen at the dimension 0 cm and the lowest content at dimension 30 (29.24 and 20.86 mg N kg -1 soil). The interaction between fertilizer source and soil depth (AB)) has a "significant" effect on the content of the available nitrogen if the highest content of this interaction (35.19 mg N kg^{-1} soil) at depth (30) for nano fertilizer compared to conventional fertilizer 28.72 mg N kg^{-1} soil (depth 20 cm) and significant differences. The interaction between the source of the fertilizer and the horizontal distance from the emitter (AC) indicates from the same table that the nitrogen content of the nano source is significantly higher "(35.69 mg N-kg^{-1} soil) at the nano source and the horizontal distance 0 compared to" the traditional source and the horizontal dimension 10 cm (24.33 mg N kg^{-1} soil). The results show that the soil depth and horizontal distance from the emitter BC showed the highest content of available nitrogen at the first horizontal distance (0cm) with soil depth (30 cm) (39.36 mg N kg^{-1} soil) compare with horizontal distance (30 cm) at the last depth (50 cm), which recorded the lowest content of ready nitrogen (17.98 mg N kg^{-1} soil) and a significant difference. (ABC) between the source of fertilizer and the depth of the soil and the horizontal distance from the emitter was limited to the minimum (15.11 mg N kg^{-1} soil) when the interaction traditional fertilizer with the depth of the soil (50 cm) and the horizontal dimension of the emitter (30 cm), The maximum (43.28 mg N kg^{-1} soil) was from the interaction of the nano fertilizer at the third depth (30 cm) and the first dimension (0 cm) from the horizontal distance from the emitter.

Distribution of available phosphorus in soil by fertilizer source and vertical and horizontal dimension of emitter: Table results indicate (5) showed significant superiority of phosphorus content in the soil to the source of the nano fertilizer compared to the traditional source (A) (15.13 and 13.53 mg P kg^{-1} soil) respectively. The effect of soil depth (B) on the concentration of phosphorus. The results showed that the highest phosphorus content was achieved at the second depth (20 cm) (18.45 mg P kg^{-1} soil) compared to the last depth (50 cm), which recorded the lowest content of phosphorus ready (8.58 mg P kg^{-1} soil) and a significant difference, the horizontal distance from the emitter was significant. The highest phosphorus content in the soil was achieved at (0 cm) (18.14 mg P kg^{-1} soil) while the (30 cm) distance from the emitter had the lowest phosphorus content (7.71 mg P kg^{-1} soil).From the same table, we observe that the effect of the interaction between the fertilizer source and soil depth (AB) of the available phosphorus content of the nano fertilizer in range (9.04 - 19.13 mg P kg^{-1} soil) at 50 and 20 cm respectively compared to the conventional source ranged from (8.12 - 17.76 mg P kg^{-1} Soil) at depth 50 and 20 respectively.

and a significant difference, as for interaction between the source of fertilizer and the horizontal distance from the emitter (AC), the nano fertilizer obtained the highest phosphorus content at 0 cm (19.42 mg P kg^{-1} soil) relative to the traditional source which recorded the highest phosphorus content at (0 cm) of the emitter (16.86 mg P kg^{-1} soil) and significantly different. As shown in Table (2), the interaction between the depth of the soil and the horizontal distance from the emitter (BC) showed the highest phosphorus content at horizontal distance (0 cm) in depth (20 cm) (24.74 mg P kg^{-1} soil) while the horizontal distance (30 cm) in the last depth (50 cm) of (6.19 mg P kg^{-1} soil) has the lowest content of available phosphorus and significant difference. There was a significant effect of the three interaction (ABC) of the three factors in the phosphorus content, which had the lowest value of the available phosphorus content (5.59 mg P kg^{-1} soil) and was the result of the traditional fertilizer interaction at depth (50 cm) with the first dimension (0cm) from the horizontal distance of the emitter, while the highest value of phosphorus content (26.06 mg P kg^{-1}soil) was obtained from the interaction of the nano fertilizer at depth (20 cm) with the first dimension (0 cm) from the horizontal distance of the emitter.

Distribution of available potassium in soil by fertilizer Source and vertical and horizontal dimension of emitter: Note from table 6. Effect fertigation of nano and convential NPK Fertilizer vertical and horizontal distance from emitter in available potassium content in soil mg Kg^{-1}soil, The results showed significant superiority Potassium content in the soil for the nano fertilizer (173.69 mg K kg^{-1} soil) compared with the conventional source (144.12 mg K Kg^{-1} soil). The soil depth effect (B) in the concentration of the available potassium and the highest concentration was in the first and second depths (10 and 20 cm) (182.06 and 188.29 mg K kg^{-1} soil) respectively, Then began to decline in other depths, especially the last depth (50 cm), and the horizontal distance (C) from the emitter had a "significant" effect with the highest increase in the potassium content at the dimension 10 cm (185.33 mg K kg^{-1} soil) 30 cm) from the emitter on the lowest content of available potassium (102.90 mg K kg^{-1} soil).From the same table, we observe that the effect of the interaction between the source of fertilizer and soil depth (AB) of the potassium content of nano fertilizers ranged from (197.46-110.24 kg K^{-1} soil) and the depth (50 and 20 cm) compared to the traditional source where it ranged from (84.44 171.66 mg K kg^{-1} soil) and the same depths and a significant difference, as well as the interaction between the source of fertilizer and the horizontal distance from the emitter (AC), the effect of the other was significant "in the content of available potassium where the highest of available potassium content for the nano fertilizer (203.44 mg K Kg^{-1} soil) at the dimension (10 cm) compared to the traditional source which recorded a higher content of potassium ready (168.37 mg K Kg^{-1} soil) dimension (0 cm) and a significant difference,The table showed that the interaction between the depth of the soil and the horizontal distance from the emitter (BC) achieved the highest content of the available potassium when interaction the horizontal distance (10 cm) with the depth (20 cm) (217.10 mg K kg^{-1} soil) while record the horizontal distance (40 cm) In the last depth (50 cm) of (69.62 mg K kg^{-1} soil) the lowest content of available potassium and a significant difference, the results of the same table showed that the treatment of the triple interaction (ABC) was significantly higher in available potassium content (234.43 mg K kg^{-1} soil), which was the result of nano fertilizer interaction at soil depth 20 cm and the horizontal distance 10 cm compared to the triple interaction potassium is less available (63.21 mg K Kg^{-1} soil) than result interaction the conventional fertilizer at 50 cm depth and the horizontal distance 30 cm.

Table 4 : Effect of fertigation nano and conventional NPK fertilizers and the vertical and horizontal distance from emitter in the distribution of available nitrogen in soils mg N kg^{-1} Soil

A Source of fertilizer	**B Soil depth (cm)**	**C Horizontal distance from emitter cm**				**AB**
		0	**10**	**20**	**30**	
Nano NPK	10	20.88	34.58	29.42	19.95	26.21
	20	39.24	40.73	35.61	25.18	35.19
	30	43.28	39.41	30	27.61	35.08
	40	38.25	28.86	26.57	24.91	29.65
	50	36.78	30.31	24.43	20.86	28.10
Average AC		35.69	34.78	29.21	23.70	30.85
Traditional NPK	10	16.60	24.84	20.06	19.43	20.23
	20	30.10	30.81	33.32	20.64	28.72
	30	35.44	27.33	20.84	18.33	25.49
	40	20.00	21.46	19.67	16.55	19.42
	50	18.77	17.23	17.00	15.11	17.03
Average AC		24.18	24.33	22.18	18.01	22.18
C		29.94	29.54	25.69	20.86	B
BC	10	18.75	29.71	24.74	19.69	23.22
	20	34.67	35.79	34.46	22.91	31.96
	30	39.36	33.29	25.42	22.97	30.26
	40	29.13	25.16	23.12	20.73	24.54
	50	27.78	23.77	20.72	17.98	22.56

L.S.D 0.05	A	B	C	AB	AC	BC	ABC
	0.0958	0.1774	0.1262	0.2317	0.1663	0.2976	0.4108

Table 5 : Effect of fertigation nano and conventional NPK fertilizers and the vertical and horizontal distance from emitter in the distribution of available phosphorus in soils P kg^{-1} Soil

A Source of fertilizers	**B Soil depth cm**	**C Horizontal distance from emitter cm**				**AB**
		0	**10**	**20**	**30**	
Nano NPK	10	16.73	20.44	18.74	10.35	16.56
	20	26.06	23.45	18.03	8.99	19.13
	30	23.51	21.68	15.20	7.51	16.97
	40	19.31	16.17	12.55	7.73	13.94
	50	11.49	9.32	8.56	6.80	9.04
Average AC		19.42	18.21	14.61	8.28	15.13
Traditional NPK	10	15.17	18.86	17.39	7.91	14.83
	20	23.42	22.17	17.03	8.43	17.76
	30	21.66	20.64	14.66	6.92	15.97
	40	13.97	12.34	10.76	6.89	10.99
	50	10.07	9.22	7.60	5.59	8.12
Average AC		16.86	16.65	13.49	7.15	13.53
C		18.14	17.43	14.05	7.71	B
B*C	10	15.95	19.65	18.07	9.13	15.70
	20	24.74	22.81	17.54	8.71	18.45
	30	22.59	21.16	14.93	7.21	16.47
	40	16.64	14.26	11.66	7.31	12.47
	50	10.78	9.27	8.08	6.19	8.58

L.S.D 0.05	A	B	C	AB	AC	BC	ABC
	0.0564	0.1338	0.0926	0.1725	0.1189	0.2204	0.3027

Table 6 : Effect of fertigation nano and conventional NPK fertilizers and the vertical and horizontal distance from emitter in the distribution of available potassium in soils K kg^{-1} Soil

A Source of fertilizers	B Soil depth cm	C Horizontal distance from emitter cm				AB
		0	10	20	30	
Nano NPK	10	206.65	220.31	205.28	157.58	197.46
	20	232.41	234.43	221.33	131.50	204.92
	30	223.59	219.18	190.45	102.68	183.98
	40	211.14	211.03	172.90	92.36	171.86
	50	128.09	132.25	104.59	76.02	110.24
Average AC		200.38	203.44	178.91	112.03	173.69
Traditional NPK	10	175.51	188.86	171.59	130.79	166.69
	20	198.44	199.76	176.37	112.05	171.66
	30	191.07	186.07	156.43	85.16	154.68
	40	178.21	172.10	144.53	77.69	143.13
	50	98.62	89.24	86.68	63.21	84.44
Average AC		168.37	167.21	147.12	93.78	144.12
C		184.37	185.33	163.01	102.90	B
BC	10	191.08	204.58	188.43	144.18	182.06
	20	215.43	217.10	198.85	121.77	188.29
	30	207.33	202.63	173.44	93.92	169.33
	40	194.68	191.57	158.72	85.03	157.50
	50	113.35	110.79	95.63	69.62	97.35

L.S.D 0.05	A	B	C	AB	AC	BC	ABC
	0.1379	0.1572	0.1211	0.2170	0.1750	0.2785	0.3914

Discussion

It is possible to manage optimal nutrient management in arid and semi-arid areas by following one of the modern farming techniques as a combination of "slow release fertilizers and drip irrigation (Janmohammadi *et al*., 2016). Note when comparing the productivity or water use efficiency (WUE) with the nano fertilizers of NPK with fertigation of traditional fertilizers, there has been an increase of up to 23.66% despite the high amount of traditional fertilizers added and this is required in the conditions of water governance and scarcity (Goyal, 2015 and Feng *et al*., 2017) As well as "improving the quality of the product. That water management is the determining factor in potato production through irrigation programs scheduled during the crop growth period of crop growth (Panigrahi *et al*., 2011). Matovic *et al.* (2016) also pointed out that the use of drip irrigation and fertigation of nutrients has increased potato productivity by 70% compared with other irrigation methods this is confirmed (Al-Juthery, 2011 and PetrElzner *et al*., 2018). Nutrients fertigation enhances the plant's ability to adapt to biotic and abiotic stresses. this provides water use efficient and optimal yield production (Darwish *et al*., 2011). The results showed the lowest significant decrease in agronomic efficiency in the treatment of traditional NPK and 88.93% reduction compare with nano NPK fertilizer. This confirms the effective role of nano fertilizers despite the low added quantities in efficiency of absorption, transport and metabolism, Which has been reflected in stimulating growth and increase as well as the agronomic efficiency (AE) for nano fertilizers, especially nano phosphorus, Using nano phosphate fertilizers as an alternative to conventional fertilizers with methods of addition with irrigation water can promote and improve agronomic efficiency (AE) and nutrients use efficient such as phosphorus (PUE) and reduce the nutrient eutrophication (Kumar, 2017). This is due to the fact that the fertilizer added through the drip irrigation system, which is the most effective system and promising strategies to improve the efficiency of nutrient use in agricultural systems with the possibility of providing nutrients at a low rate and high repetition, improves nutrient availability in the root zone and absorbs it more easily and quickly. Provide an opportunity for washing, stabilization and nutrient availability in the root zone, leading to reduced nutrient loss risk (Incrocci *et al*., 2017).

The distribution of nitrogen in the soil can be explained by the fact that nitrogen fertilizer has been added in a fertigation manner and is considered to be the most economical and most ideal for nitrogen fertilizers, reducing the risk of nitrogen loss in the soil. "Nitrogen is also an element of soil mobility, Especially moderate irrigation can maintain a good distribution of nitrogen within the soil range (Abyaneh *et al*., 2014 and Rajonee *et al*., 2016).The increase in the content of the available nitrogen in the soil can be attributed nano fertilizer to the traditional source as nano fertilizers have unique chemical and physical properties that are slower to release and have more delivery rules and are more available to meet the demand for plant roots more efficiently than conventional fertilizers through a process Ion exchange and absorption (Jyothi and Hebsur, 2017, Qureshi *et al*., 2018 and Al-juthery *et al*., 2018). Manikadan and Subramanian (2014) confirmed that nano fertilizers were capable of releasing nitrogen for 40 days, which coincided closely with the crop growth stages regardless of the soil texture variation. The effect of the soil depth showed that the available nitrogen was more available at depth (20 cm) The maximum content of the nitrogen at the dimension (0 cm) and the minimum content at the dimension (30 cm) was due to the addition of fertilizers with the irrigation water to the homogeneity and distribution of the added nitrogen in the wet soil area (Fanish and Muthukrishnan, 2014). It is also noted that the di interaction (AB),(AC) and (BC), Note that there is a good and consistent distribution of nitrogen in soil layers (10, 20 and 30 cm)The real decline was in the deep (40 and 50 cm) (Mahgoub *et al*., 2017) "This distribution is good," especially for crops with shallow roots such as potatoes and the superiority of the nano fertilizers source significantly in all di and tri interactions compared to "the traditional source. This is due to the fact that the nanoparticle used in fertilization do not move far" Emissions (emitters) ie moving close to near the root, so when you ignore the water, air and living organisms live in the movement of soil factors can increase the distance and the rate of mobility (Rajonee *et al*., 2016 and Rajonee *et al*., 2017). Nano materials maintain nutrients availability and minimize external effects, which reduce nitrogen losses by nitrification associated with temperature variability through slow release according to plant need. Fujinuma and Balster (2010) detected a slow release of nitrogen from nano fertilizes although pH was different (5.2, 4.2 and 7) compared with conventional fertilizers, with harmonious release with crop growth 60 days compatible with conventional fertilizers and was released at a shorter time. The results also showed a "significant" superiority of available phosphorus content from nano compared to "traditional fertilizers source" (Subramanian and Thirunavukkarasu, 2017). The phosphorus movement in the soil is very slowly and phosphate is often deposited in the corresponding positive ions such as calcium, magnesium.These sedimentation and adsorption processes can be controlled by phosphate encapsulation in a nano-matrix or with chelates, and low phosphorus content is observed in depth. The reason for this decrease can be attributed to the physico-chemical reactions of phosphorus in calcareous soils which reduces movement with depth (Al-juthery, 2011 and Mahgoub *et al*., 2017). The horizontal distance from the emitters had a "significant" effect .Al-Ansari et al (2014) found that the movement of phosphorus in the soil depends on the amount of irrigation water as the movement increases with the increase of the amount of water added. This explains the increase of available phosphorus in the first dimension of the horizontal distance from the emitter and decrease in the last dimension of the emitter. The effect of the interaction between fertilizer source and soil depth (AB) can be attributed to the phosphorus content and significantly superior to the "nano-source" compared to the conventional source, this has been confirmed Abyaneh and Maryam (2014). The irrigation system is characterized by the movement of vertical and horizontal water in the effective roots area compared to other irrigation methods. It increases the amount of water stored in the root zone, where 95% water efficiency and the water movement and its active role in the phosphorus-ready movement in the soil (Alansari *et al*., 2014 and Goyal, 2015). The results indicated that there is a significant superiority in the concentration of available potassium in the soil for the source of nano fertilizer compared to conventional fertilizers. It can be attributed to the fact that the used chelate nano fertilizes are slow release with high surface and high solubility and targeting (Rajonee *et al*., 2017; Ghorbanpour *et al*., 2017). The decrease in potassium with depth and also with the horizontal distance from the emitters may be due to the low levels of moisture in the soil leading to the formation of thin and non-continuous water membranes around soil minutes so that the diffusion of potassium to the roots of plants is more tortuous and the potassium is subject to exchange interactions with other positive ions in soil such as calcium, magnesium, sodium and hydrogen, which affects movement and distribution of potassium (Fulton *et al*., 2010).While nano fertilizers are characterized by their slow release, fine targeting, absorption speed by roots and penetration of living membranes, as well as protection from adsorption and sedimentation reactions (AbouZeid *et al*., 2017; Rajonee *et al*., 2017 and Qureshi *et al*., 2018). The consistency of the distribution of potassium in the soil came in harmony with the results of both (Singh *et al*., 2002; Rivera *et al*., 2006; Badr, 2007; Abyane *et al*., 2014 and Mahgoub *et al*., 2017).

Conclusion

It can be concluded that good potato productivity can be achieved through adoption of fertigation combined of nano N, P and K fertilizers and good irrigation management with drip irrigation, high WUE, AE and EUE as well as a consistent distribution of nutrients in the soil.

References

Abouzeid, S.T. and Amal, A.A.E. (2017). Evaluation of Potassium Sources and Rates on the Yield and Quality of Fertigated Potato Grown in Sandy Soil. Egypt. J. Soil Sci. 57(1): 15- 21.

Abyaneh, H.Z and Maryam, B.V. (2014).The effect of nanofertilizers on nitrate leaching and its distribution in soil profile with an emphasis on potato yield. NSNTAIJ. 8(6): 198-207.

Al-Ansari, A.M.A; Nedawi, D.R; Al-Gasim, A.sh. B (2014). Effect of level and methods of irrigation on vertical or horizontal movement of available phosphorus in marshes soil. Basrah J. Agric. Sci., 27(2):112-124.

Al-Hussaini, A.K.A. (2010). Genetics and development of horizons accumulation some of soil in northern Iraq. Ph.D. thesis college agriculture. University of Baghdad.

Ali, N.S. and Al-Juthery, H.W.A. (2017). The application of nanotechnology for micronutrient in agricultural production (review article). The Iraqi Journal of Agricultural Sciences. (9)48: 489-441.

Ali, N.S. (2011). Fertilizers technologies and uses. Baghdad University. College of Agriculture.

Al-juthery, H.W.A. and Saadoun, S.F. (2018). Impact of foliar application of micronutrients nanofertilizers on growth and yield of Jerusalem artichoke .TIJAS. http://TIJAS.2018 .

Al-juthery, H.W.A.; Ali, N.S.; Al-Taey, D.KA. and Ali, E.A.H.M. (2018). The impact of foliar application of nano fertilizer, seaweed and hypertonic on yield of potato. Plant Archevs.18 (2): http://www.scimagojr.com

Al-juthery, H.W.A. (2011). Effect of Different Fertilizers Sources and Rates and Irrigation Methods on Growth and Yield of Potato (*Solanum tuberosum* L.) Ph.D. thesis college agriculture. University of Baghdad.

Al-juthery, H.W.; Abdul Kareem, H.H.; Radhi, F.M. and Sahan, S.A.H. (2018). Maximize Growth and Yield of Wheat by Foliar application of Complete Nano-fertilizer and Some of Bio stimulators. Res. on Crops 19(3): 387-393.

Al-Sahuki, M. and Whaib, K.M. (1990). Applications in the design and analysis of experiments. Baghdad university. Ministry of higher education and scientific research.

Al-Taey, D.K.A.; al-Janabi, A.H. and Rachid, A.M. (2015) Effect of irrigation water quality and organic and mineral fertilization on the availability of some nutrient elements and cabbage yield (*Brassica oleracea var. capitat*e L.). Euphrates Journal of Agriculture Science 4(7): 235- 247.

AL-Taey, D.K.A.; AL-Azawi, S.S.M.; AL-Shareefi, M.J.H. and AL-Tawaha, A.R. (2018). Effect of saline water, NPK and organic fertilizers on soil properties and growth, antioxidant enzymes in leaves and yield of lettuce (*Lactuca sativa* var. Parris Island) *Res. Crops* 19 : 441-449.

Badr, M.A. (2007). Spatial Distribution of Water and Nutrients in Root Zone under Surface and Subsurface Drip Irrigation and Cantaloupe Yield. World Journal of Agricultural Sciences, 3:747-756.

Bres, W. (2009). Estimation of nutrient losses from Open Fertigation Systems to Soil during Horticultural Plant Cultivation. Polish J. of Environ. Stud. 18(3): 341-345

Darwish, T.; Atallah, T.; Khatib, N. and Karam, F. (2011). Fertigation and conventional Potassium application to field grown Potato in Lebanon: Perspective to enhance Eefficiency. National council for scientific research. P.O. Box: 11-8281. Beirut, Lebanon

Duncan, D. (1955). Multiple Range and Multiple F Tests. Biometrics 11: 1-42.

Fanish, S.A. and Muthukrishnan, P. (2013). Nutrient Distribution under Drip Fertigation Systems. World Journal of Agricultural Sciences, 9: 277-283.

FAO. (2013). FAO STAT Agriculture Database http://faostat.fao.org/DesktopDefault.spx.

Fares, A. and Abbas, F. (2009). Irrigation Systems and Nutrient Sources for Fertigation. Soil and Crop Management. SCM-25.132.

Feng, Z.; Shuqin, W.; Yaohu, K. and Shiping, L. (2017). Drip fertigation regime for potato on sandy soil. Emirates Journal of Food and Agriculture. 29(6): 476-484

Fujinuma, R. and Balster, N.J. (2010). Controlled-release nitrogen in tree nurseries. Res Commun 2: 123-12.

Fulton, A.; Advisor, F.; Colusa, T.G. and Shasta, C. (2010). Primary Plant Nutrients: Nitrogen, Phosphorus and Potassium. 1-3.

Ghorbanpour, M.; Manika, K. and Varma, A. (2017). Nano-science and Plant– Soil Systems. Springer International Publishing.

Goyal, M.R. (2015). Management, Performance, and Applications of Micro Irrigation Systems. CRC Press, Boca Raton.

Howell, T.A. (2000). Irrigation's role in enhancing water use efficiency, in: R.G. Evans, B.L. Benham, T.P. Trooien (Eds.), Proceedings of the

4th Decennial Natl. Irrig. Symp., ASAE, St. Joseph, MI., 66-80.

Incrocci, L.; Daniele, M. and Alberto, P. (2017). New trends in the fertigation management of irrigated vegetable Crops. horticulture.

Janmohammadi, M.; Pornour, N.; Javanmard, A. and Sabaghnia, N. (2016). Effects of bio-organic, conventional and nanofertilizers on growth, yield and quality of potato in cold steppe. Bot. Lith. 22(2): 133–144

Jyothi, T.V. and Hebsur, N.S. (2017). Effect of nanofertilizers on growth and yield of selected cereals - A review. Agricultural Research Communication Centre 38 (2): 112-120.

Kilmer, V.J. and Alexander, L.T. (1949). Methods making mechanical analysis of soils. Soil. Sci. 68: 15-24.

Kumar, D. (2017). Agronomic evaluation of enhanced efficiency N fertilizers in lowland rice. Division of Agronomy, ICAR-Indian Agricultural Research Institute, New Delhi 110012, INDIA.

Landon, L.R. (1984). Tropical Soil Manual. Booker Agriculture international Limited. 450 pp.

Mahgoub, N.A.; Mohamed, A.I.; El-Sikharyand, E.S.M. and Ali, O.M. (2017). Roots and Nutrient Distribution under Drip Irrigation and Yield of Faba Bean and Onion. Open Journal of Soil.

Manikandan, A. and Subramanian, K.S. (2014). Fabrication and characterisation of nanoporous zeolite based N fertilizer. Afr J AgrRes.9:276-284.

Matovic, G.; Zorah, B.; Sonja, D.; Enik, G. and Pusko, G. (2016). Profitability assessment of Patato production applying different irrigation methods. Irrigation and Drainage/Volume 65(4).

Panigrahi, B.; Panda, S.N. and Raghuwanshi, N.S. (2011). Potato water use and yield under furrow irrigation. Irrigation Science. 20: 155-163

PetrElzner; Miroslay, J. and Miroslay, J. (2018). Effect of drip irrigation and complementary nutrition with nitrogen on potato quality and yield. acta unversitatis agriculture brunensis silviculturae. 66(1): 149-153

Qureshi1, A.; Singh, D.K. and Dwivedi, S. (2018). Nano-fertilizers: a novel way for enhancing nutrient use efficiency and crop productivity. Int. J. Curr. Microbiol. App. Sci. 7(2): 3325-3335.

Rachna, R.; Ramesh, K.S. and Guleria, G. (2014). Fertigation: a tool for efficient fertilizer and water management 2(1): (January-March).

Rajonee, A.A.; Nigar, F.; Ahmed, S. and ImamulHuq, S.M. (2016). Synthesis of Nitrogen Nano Fertilizer and Its Efficacy. Canadian Journal of Pure and Applied Sciences, 10: 3913-3919.

Rajonee, A.A.; Shurovi, R.Z. and Shah, M.I.H. (2017). Preparation, Characterization and Evaluation of Efficacy of Phosphorus and Potassium Incorporated Nano Fertilizer. Advances in Nanoparticles. 6: 62-74.

Rivera, R.N.; Duarte, S.N.; Miranda, J.H.D. and Botrel, T.A. (2006). Potassium Modeling Dynamics in the Soil under Drip Irrigation: Model Validation. Engenharia Agrícola, 26: 388-394.

Safavi, F.G (2016). Effect of nano potassium fertilizer on some parchment pumpkin (*Cucurbitapepo*) morphological and physiological characteristics under drought conditions. International Journal of Farming and Allied Sciences IJFAS Journal-367-371/ 30 June.

Salim, S.Ch and Ali, N.Sh. (2017). Guide For Chemical Analyses of Soil, Water, Plant and Fertilizers. University of Baghdad-College of Agriculture. pp: 279.

Segars, B. (2002). Efficient fertilizer use-fertigation. Section for fertilizers for injection into irrigation.

Shedeed, S.I.; Zaghloul, S.M. and Yassen, A.A. (2009). Effect of method and rate of fertilizer application under drip irrigation on yield and nutrient uptake by tomato. Ozean Journal of Applied Sciences. 2(2): 139-147

Shymaa, I.S.; Zaghloul, S.M. and Yassen, A.A. (2009). Effect of Method and Rate of Fertilizer Application under Drip Irrigation on Yield and Nutrient Uptake by Tomato. Ozean Journal of Applied Science, 2: 139-147.

Singh, A.K.; Chakraborty, D.; Mishra, P. and Singh, D.K. (2002). Nitrogen and Potassium Dynamics in Fertigation Systems. 17th World Congress of Soil Science, Bangkok, 14-21.

Singh, M.D.; Gautam, C.; Patidar, O.P.; Meena, H.M.; Prakasha, G. and Vishwajith (2017). Nano-Fertilizers is a new way to increase nutrients use efficiency in crop production. international journal of agriculture. review article. International Journal of Agriculture Sciences. 9(7): 3831-3833.

Subramanian, K.S.; Paulraj, C. and Natarajan, S. (2007). Plant nutrient management through nano fertilizers. in application of nanotechnology in agriculture, Tamilnadu Agricultural University, Coimbatore, India

Subramanian, K.S. and Thirunavukkarasu, M. (2017). Nano fertilizers and nutrient transformations in soil department of nano Science & technology, Tamilnadu Agricultural University, Coimbatore 641003, Tamilnadu, India.

White, P.J.; Wheatley, R.E.; Hammond, J.P. and Hang, K. (2007). Minerals, soils and roots. In: vreugdenhil D (ed) Potato biology and biotechnology, advances and perspectives. Elsevier, Amsterdam, 739–752.