Plant Archives Vol. 20, Supplement 1, 2020 pp. 416-419 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

THE IMPACT OF POTASSIUM LEVELS AND ITS EXTRACTION METHODS ON GROWTH AND YIELD OF POTATOES (*SOLANUM TUBEROSUM* L.)

Riyam J. Al-Mafraji, Turki M. Saad Hannoon and N.K. Al-Barakat
Department of Soil Science and Water Resources, College of Agriculture, Al-Muthanna University, Iraq.

Abstract

A field experiment was carried out at the Experimental Research Station (A'al Bandar) at the College of Agriculture, University of Al-Muthanna during Autumn season from 12 September 2018. The study aimed to determine the optimum level of potassium (K) on potato growth and yield (*Solanum tuberosum* L.). The field experiment included five potassium levels (0, 130, 260, 390 and 520) kg K/ha, which were symbolized as 0K, 1K, 2K, 3K and 4K respectively. The laboratory experiment was conducted at the soil labs of the college of Agriculture to determine the optimum extraction method of K. It included dissolved potassium in soil, soil: water (1: 1), ammonium acetate 1M, calcium chloride 0.5M, barium chloride 0.25M, sodium chloride 0.1M, sulfuric acid 0.01M and sulfuric acid 0.02 M. The results showed that the potassium levels significantly affected most growth and production characteristics of potatoes such as number of leaves. plant^{-1}, number of tillers, plant^{-1}, average number of marketable tubers. plant^{-1}, and total number of tubers^{-1}, total yield (ton.h^{-1}), marketable yield (ton.h^{-1}) and average weight of marketable tuber (gm), Significant correlation was obtained from available potassium extracted from soil with extracts of sodium chloride, sulfuric acid 0.02M, ammonium acetate, sulfuric acid 0.01M, calcium chloride and added potassium levels, and there was no significant difference between the addition levels and extraction methods of barium chloride and soil extract: water (1: 1) in the amount of potassium.

***Keyword*:** Potassium, Extraction methods, growth, yield, potatoes (*Solanum tuberosum* L.)

Introduction

Potato (*Solanum tuberosum* L) is considered as one of the most important crops all over the world due to its high nutrition value as a resource for carbohydrates and because of its storage capability, ease of use and various utilizations (Grzebisz *et al*., 2017). Potato is one of the most important vegetable crops and is affiliated to the Salanaceae family, and it is ranked as the fifth important world's crops following wheat, barley, rice and maize (Taha, 2007). It is also considered as one of the high productive crops and needs K in high rates, particularly during the critical growth period. It contains high rates of protein, starch, nutrient elements and vitamins (Al-Bahash, 2006). Due to high demand for potato and to achieve high yield production, suitable levels of soil nutrients, including K, need to be ensured as the plant needs K during its growth stages, hence, soil should be able to supply high levels of this nutrient element (Al-Battawi, 2007).

Potassium (K) is considered as one of the most essential macro nutrient elements which occupies top rankings in terms of its importance for many crops, especially for the tubercle and radical crops (Dhillon *et al*., 2019). It is a dynamic element inside the plant, and plants uptake it as an ion K^+. Potassium is existent in the soil in various amounts that are ranged between 5000 and 50000 ppm. This variation is attributed to the differentiation of original matter, weathering degree, climatic and other factors. Many studies that have been conducted about K have shown that the Iraqi soils are characterized by a relatively large amount of stored K as that in the dry and semi-dryland regions. However, speed of its release is relatively low and is insufficient for (or does not deliver) the requirements for many crops (Ali *et al*., 2014). But there are many various methods to extract the available K in the soil by chemical extractors which are considered as one of the most common methodology of its estimate. These methods, however, give too different results for the same soil.

Most important issue of the intensive cultivation is the imbalanced nutrients, especially of the macro nutrient elements such as K, which requires to study the behavior of that nutrient (particularly its threshold) in the soil in order to increase the productivity and to determine the optimum method to estimate the available K. Therefore, this study aimed to find out the best method to estimate K which reflects the plant growth indications with K concentration in the soil and to study the effect of best K level on the potato growth and production.

Material and Methods

Two experiments (one field and one lab) were performed at the Research Station and Labs of the College of Agriculture, University of Al-Muthanna. The field trial was conducted during the autumn season 12/09/2018 to determine the effect of the optimum K level and its threshold on the potato growth and production. Table (1) shows the chemical and physical characteristics of the soil. The K fertilizer was applied to the soil as K sulfate (41% K) with four levels as well as the control treatment (0, 130, 260, 390 and 520) kg K/ha. The fertilizer levels were splitted into 5 applications and were added at different stages. The first application was 10% of the total fertilizer level was added about 2 weeks after sowing. The other 4 applications were 15, 20, 25 and 30% of the total K fertilizer level and were added at about 4, 6, 8 and 10 weeks after sowing respectively. The nitrogen (N) fertilizer was applied as urea (46% N) once only for all plots with 240 kg N/ha. The phosphorus (P) fertilizer was applied as di-ammonium phosphate (18% N and 20% P) with amount of 120 kg P/ha as P resource for all plots. The P fertilizer was squashed and dissolved in combination with N fertilizer and the combined fertilizer was applied at the same time with K fertilization.

The lab experiment included soil samples that have been taken from the field trial plots after the harvest from up to 30 cm soil depth using Auger. The soil was dried, squashed and sieved with 2 mm diameter sieve. The dissolved K was estimated using 1:1 soil:water extraction

(Richards 1954), whereas the available K was estimated using various methods such as ammonium acetates (1M NH_4OAC) according to Page *et al.* (1982), potassium chloride (0.5M $H_2O_2CaCl_2$) according to Sparks and Martin (1983), Barium Chloride (0.25M $BaCl_2$), Sodium Chloride (0.1M NaCl), light Sulfuric acid (0.1M H_2SO_4) and light Sulfuric acid (0.2M H_2SO_4).

Table 1 : Physical and chemical properties of the soil before planting.

Properties	Values	Units
PH	7.6	
EC 1:1	6.1	$dS.m^{-1}$
OM	1.2	$g.kg^{-1}$
Lime	9.5	%
Available nitrogen	31.5	$Mg.kg^{-1}$soil
Available phosphorus	8.0	
Available potassium	136	
Soil separations		
Sand	722	$g.kg^{-1}$soil
Silty	112	
Clay	166	
Texture	Sandy Loam	

Plant height was measured from the first node, where its connection to the soil, to the stem terminal of the plant, the number of tillers and the number of leaves were also counted for 5 randomly selected plants. After their maturity, the potato tubers were cleaned from the soil and were weighed the tubers yield for each plot. The marketable tubers yield (weighed 25 g and over) was separated from the non-marketable yield (weighed 25 g and below), which is tainted and/or distorted (Rebertson and Pascal, 1977). Five plants from each plot have been harvested to estimate the yield per plot, the yield per plant and the average yield per hectare, and the final yield was estimated as tons per hectare excluding the tubers weighed 25 g each and below.

Results and Discussion

Effect of potassium fertilizer levels on the number of leaves, tillers and plant height

As shown in Table (2), the results indicated that K levels have significantly affected the number of plant leaves where treatment of 3K produced the largest number of leaves about 46.78 leaves/plant followed by 2K about 32.90 leaves/plant. The other treatments of 0K, 1K and 4K did not differ significantly from each other.

From Table (2), there are significant differences in the number of tillers, where treatment of 3K had a significantly greater number of tillers (about 5.18 tillers/plant) than 1K and 2K, which had 4.10 and 3.40 tillers/plant respectively, but it did not differ significantly from 0K and 4K. This may be attributed to the direct effect of potassium on the major nutrients, especially nitrogen and phosphorus, which then positively reflected on vegetative growth represented by the number of leaves and the number of tillers of the potato plants Kumar et al (2007).

The levels of potassium fertilizer did not affect this characteristic statistically, and this is consistent with Al-Jumaili and Al-Jumaili (2012) and Kumar et al (2007). The treatment 0K had the highest rate about 36.3 cm, whereas the treatment 1K had the shortest plants about 32.1 cm.

Table 2 : Effect of potassium fertilizer levels on the number of leaves, tillers and plant height

Treatment	Number of leaves. Plant $^{-1}$	Number of tillers Plant^{-1}	Plant length (cm)
K0	39.35	4.408	36.3
K1	39.05	4.100	32.1
K2	32.90	3.400	35.0
K3	46.78	5.175	35.9
K4	40.89	4.138	32.9
L.S.D.$_{0.05}$	8.17	1.046	n.s.

Effect of potassium fertilizer levels on the invalid yield, suitable for marketing, and the total yield

The results of the statistical analysis in Table (3) showed that there were significant differences in the total yield, where the treatment 3K was significantly superior than all other treatments, about 33.55 t/ha. In contrast, there were no significant differences between the levels 0K, 1K, 2K and 4K, which reached (20.18, 26.87, 26.26 and 26.74) t/ha respectively. It was stated that the addition of potassium might lead to encouraging the growth of tubers through increasing the efficiency of the leaves in terms of photosynthesis process, the increase of the transfer of the produced materials to the tubers and to the role that potassium plays in the movement of Carbohydrates from their formation sites to their storage sites (Havlin *et al.*, 2005). The tubers that come from the contribution of potassium may return to the fact that the nitrogen prepared for the plants may be consumed well in the field of increasing vegetative growth and production when the amount of potassium added is appropriate (Mengel and Kirkby, 1982).

On the other hand, the K fertilizer levels, as shown in Table (3), did not significantly affect the quantity of non-marketable yield, where treatment 3K was superior by giving the highest amount of non-marketable yield up to 2.3 t/ha, whereas treatment of 1K had the lowest amount of non-marketable yield about 1.1 t/ha.

The results also showed that there were significant differences in the quantity of the marketable yield, where treatment of 3K was significantly superior compared with the control treatment about 31.256 t/ha. In contrast, the control treatment produced only about 18.739 t/ha. There were no significant differences between treatments 3K, 1K, 2K, and 4K. The dryland areas suffer from shortage or limitation of N nutrient since K might has contributed to the release of the ammonium that could be necessary for the crop plants, which may be reflected positively on the yield (Standford and Pierre, 1947).

Table 3 : Effect of potassium fertilizer levels on the invalid yield, suitable for marketing, and the total yield

Treatment	total yield (tons. h^{-1})	non-marketable yield (ton. h^{-1})	The marketable yield (ton. h^{-1})
K0	20.18	1.4	18.739
K1	26.87	1.1	25.789
K2	26.26	1.6	24.627
K3	33.55	2.3	31.256
K4	26.74	1.8	24.915
L.S.D.$_{0.05}$	6.95	n.s.	6.301

The effect of potassium fertilization levels on the average weight of marketable and non-marketable tuber. It is noted from the results in Table (4) that the K levels did not significantly affect the average weight of the non- marketable tuber, where treatment 4K gave the highest rate about 10.7 g, whereas treatment 1K gave the lowest rate 7.7 g.

The results also showed that there were significant differences in the average weight of the marketable tuber. The treatment of 2K reached up to approximately 99.37 g and was significantly superior to 0K, 1K and 3K which had 72.45, 81.28 and 80.59 g, respectively. There were significant differences between treatment 2K and 4K may be due to the role of potassium in the various vital activities in the plant through increasing the amount of materials resulting from the photosynthesis process in addition to increasing the efficiency of the process of transferring and storing the materials produced to the places stored in the tubers (Al-Alousi, 2013).

Table 4 : The effect of potassium fertilization levels on the average weight of marketable and non-marketable tuber

Treatment	average weight of the non- marketable tuber(g)	average weight of the marketable tuber(g)
K0	8.9	72.45
K1	7.7	81.28
K2	9.8	99.37
K3	8.6	80.59
K4	10.7	86.09
L.S.D.$_{0.05}$	n.s.	15.04

Lab Experiment

Potassium Extraction Methods

The results of the statistical analysis through Table (5) showed that there is a significant increase in the values of available potassium extracted from the soil with chemical extracts which are sodium chloride and sulfuric acid (0.02 M), ammonium acetate and sulfuric acid (0.01M) and calcium chloride with increased levels of added potassium fertilizer While extracts that did not give significant differences by increasing the levels of potassium are barium chloride and 1:1 extract, this is consistent with Asaad and Abd al-Rasoul (2017) and Abd al-Rasul (2007) except for treatment 4K. It appears that the superiority of barium chloride extract over all extracts by giving the highest amount available Potassium followed by sodium chloride, sulfuric acid extract (0.02M), ammonium acetate, sulfuric acid (0.01m) and calcium chloride. The 1:1 extract is ranked as last in terms of extractive capacity.

Perhaps the reason for the difference in the ability of the chemical extracts used to extract available potassium from the soil is that each chemical possesses properties that distinguish it from another chemical, as the substitution of positive potassium ions occurs with the positive ions of the used chemicals (Ba^{+2}, Na^{+1} and H^{+1}, $NH4^{+1}$ and Ca^{+2}) as Ali et al. (2014) mentioned, the adsorption or release of the positive ion depends on the positive ion charge, which is directly proportional to the adsorption strength except for the hydrogen ion due to its very small size and high charge density, as well as the size of the coating Water, in other words, the largest ion in diameter has an aqueous shell Smaller and thus increases its adsorption strength in the colloidal body.

Table 5 : Potassium extraction methods

Treatment	$BaCl_2$	$NaCl_2$	H_2SO_4 0.02M	NH_4OAC	H_2SO_4 0.01M	$CaCl_2$	1:1
K0	3.1	1.0211	0.7347	0.5863	0.5838	0.3414	0.06
K1	3.3	1.1714	0.8465	0.7270	0.7129	0.3689	0.08
K2	3.5	1.3728	0.9904	0.8593	0.8632	0.4220	0.11
K3	4.1	1.8018	1.3983	1.2129	1.2078	0.5153	0.19
K4	3.7	1.5077	1.2244	1.0205	1.0467	0.4648	0.16
L.S.D$_{0.05}$	N.S.	0.4834	0.4377	0.3987	0.3933	0.1133	n. s

Methods of analysis of potassium and the amount of potassium absorbed by the plant

The results of the statistical analysis showed in Table (6) that the best method that responded with the amount of potassium absorbed by the plant is a 1: 1 method that did not give significant differences between them as it averaged 195 kg K. H^{-1}, while the method NH_4OAC and H_2SO_4 excelled 0.02M and H_2SO_4 0.01

In addition, $NaCl_2$, $BaCl_2$ and $CaCl_2$ were significant with the amount of potassium absorbed by the plant as it reached (1407, 1658, 1415, 2183, 5599 and 671) kg. K e-1 Consecutively, perhaps the reason is that the irrigation water dissolves the soluble potassium and reaches the soil solution and is absorbed by the plant while the methods Other chemicals prepare photos that are not ready for absorption by the plant.

Table 6 : Methods of analysis of potassium and the amount of potassium absorbed by the plant

treatment	Total potassium in the plant kg K. h^{-1}	NH_4OAC kg K. h^{-1}	1:1 kg K .h^{-1}	H_2SO_4 0.02M kg K .h^{-1}	H_2SO_4 0.01M kg K .h^{-1}	$NaCl_2$ kg K .h^{-1}	$BaCl_2$ kg K .h^{-1}	$CaCl_2$ kg K .h^{-1}
K0	86	917	90	1149	913	1597	4809	534
K1	101	1137	122	1324	1115	1832	5213	577
K2	123	1344	174	1549	1350	2147	5471	660
K3	152	1897	304	2187	1889	2818	6402	806
K4	104	1741	287	2079	1809	2523	6099	777
the average	113	1407	195	1658	1415	2183	5599	671
L.S.D 0.05	294.2							

References

Abdul Rassoul, K.J. (2007). Evaluation influence of organic & mineral fertilization (NK) on potassium status, release & uptake by potato plants productivity of tubers (*Solanum tuberosum* L.). D thesis. Soil & water science-College of Agriculture-University of Baghdad.

Abdulrasol, K.J. and Asaad, S.A. (2018). Evaluation study for some available soil potassium extraction methods and its relationship with absorbed potassium by barley crop. Iraqi J. of Agricultural Science, 48(6): 1697-1704.

AL-Aloosy, Y.A. (2013). Effect of soil and Foliar Potassium Application and Foliar Organic Extract on Growth and Yield of Potato. Journal of Kufa for agricultural sciences. 5(1).

Al-Bahash, N.A. (2006). Instructions for producing potatoes. Ministry Of Agriculture. Guidance leaflet.

Al-Batawi, B.M.A. (2007). The comparison between potassium sulphate and potassium chloride fertilizers as related to balanced fertilization and cucumber productivity in plastic house. Ph.D. thesis." Soil & water science-College of Agriculture-University of Baghdad.

Ali, N.S.; Rahi, H.S. and Shaker, A.A. (2014). Soil fertility book. Scientific Books House for printing, publishing and distribution Amman- Jordan.307.

AL-Jumally, A.W.; Mohammed, A. and AL-Jumally, O. (2012). Effect of humic acid foliar application and potassium fertilizer on growth and yield of potato (*Solanum tubersum* L.) under drip irrigation system. Diyala Journal of Agricultural Sciences. 4(1): 205-219.

Dhillon, J.S.; Eickhoff, E.M.; Mullen, R.W. and Raun, W.R. (2019). World Potassium Use Efficiency in Cereal Crops. Agron. J. 111: 889–896.

Grzebisz, W.; Čermak, P.; Rroco, E.; Szczepaniak, W.; Potarzycki, J. and Fuleky, G. (2017). Potassium impact on nitrogen use efficiency in potato– a case study from the Central-East Europe. 63(9): 422-427.

Havlin, J.L.; Beaton, J.D.; Tisdale, S.L. and Nelson, W.L. (2005). Soil fertility & fertilizers: 7th Ed. An introduction to nutrient management. Upper Saddle River, New Jersey.

Kumar, P. and Pandey, S.K.; Singh, B.P. and Dinesh, S.V.S. (2007). influence of source and time of potassium application on Potato growth, yield economics and crisp quality. potato Research, 50: 1-13.

Martin, H.W. and Sparks, D.L. (1983). Kinetics of non-exchangeable potassium release from two coastal plain soils. S.S.S. Am. J., 47: 883-887.

Mengel, K. and Kirkby, E.A. (1982). Principles of Plant Nutrition 3rd edition International Potash Institute. Warblaufen-Bern Switzerland.

Page, A.L.; Miller, R.H. and Keeney, D.R. (1982). Methods of soil analysis. Part 2. 2nd edition. Chemical & Microbiological properties. Am. Soc. of Agr., S.S.S. Am. Inc., Madison, Wisconsin, USA.

Pascal, B. and Robertson, T.P. (1977). Yield effects of regularly and Irregularly spaced potato tuber Exp. Husb. 32: 25-33.

Richards, L.A. (1954). Diagnosis & improvement of saline & alkaline soils. USDA Hand book60. USDA, Washington DC.

Stanford, G. and Pierre, W.H. (1947). S.S.S.Am.Proc.11:155-160.

Taha, F.A.A. (2007). The effect of potassium fertilizer and soil cover on three varieties of potatoes (*Solanum tuberosum* L.) planted in Basra Governorate. D thesis." Soil & water science-College of Agriculture-University of Basrah.