Polytechnic Journal

Polytechnic Journal

Volume 8 | Issue 3 Article 7

11-1-2018

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Arshad Abdulkhalq Yaseen
Horticulture department, College of Agriculture, Salahaddin University - Erbil, Iraq

Yahya Abdul-Munim Abd Sabry
Soil and water department, College of Agriculture, Salahaddin University, - Erbil, Iraq

Akram Othman Esmaiel
Soil and water department, College of Agriculture, Salahaddin University, - Erbil, Iraq

How to Cite This Article

Yaseen, Arshad Abdulkhalq; Abd Sabry, Yahya Abdul-Munim; and Esmaiel, Akram Othman (2018) "EFFECT OF APPLIED PHOSPHORUS AND POTASSIUM AND THEIR INTERACTIONS ON BROCCOLI (brassica oleracea var. italica) YIELD AND SOME LEAF CHARACTERISTICS," *Polytechnic Journal*: Vol. 8: Iss. 3, Article 7.
DOI: https://doi.org/10.25156/ptj.2018.8.3.241

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Abstract

This investigation was carried out during October 2016 to February 2017 at Grdarasha field ,College of Agriculture University of Salahaddin ,Erbil to study the effect of 5 water levels of triple super phosphate (TSP) (0,50,100,150 and 200 kg ha-1) and two levels of KCl (0,150 kg ha-1) which equivalent to (0 ,11.25,22.5, 33.75 and 45 g TSP plot-1), (0 and 33.75 g -1KCl) per plot respectively and their interaction on growth and yield of broccoli (Agassi F1 hybrid), using Randomized Complete Block Design (RCBD) with 4 replicates. The constant amount of urea (100 kg ha-1 which equivalent to 11.25 g) urea per experimental unit was added to each experimental unit. Significant differences were observed for all the studied traits. The highest yield (23.15 Mg ha-1 was recorded from P4 treatment, while the lowest was (14.50 Mg ha-1) obtained from control treatment (P0). Also, the application of potassium caused significant increase in broccoli yield; the lowest and highest values were (17.24 and 19.08 Mg ha-1) recorded from K0 and K1 treatments respectively. The highest values of interaction (74.3, 75.6 and 76.2) SPAD were recorded from K1, P3 and P3K0 respectively. Leaf contents of macro and micro nutrient were recorded a significant difference with interaction effect of both Potassium and Phosphorus, the highest level of concentration recorded was on P4 and K1 at (37.80, 3.98 and 2.25) for Nitrogen, Phosphorus and Potassium respectively.

Polytechnic Journal: Vol.8 No.3 (Aug 2018): Pp.: 121 -131
http://epu.edu.krd/ojs/index.php/Journal
https://doi.org/10.25156/ptj.2018.8.3.241

EFFECT OF APPLIED PHOSPHORUS AND POTASSIUM AND THEIR INTERACTIONS ON BROCCOLI (*brassica oleracea var. italica*) YIELD AND SOME LEAF CHARACTERISTICS

Arshad Abdulkhalq Yaseen[(1)], Yahya Abdul-Munim Abd Sabry[(2)], Akram Othman Esmaiel[(3)]

[(1)] Horticulture department, College of Agriculture, Salahaddin University - Erbil, Iraq
[(2), (3)] Soil and water department, College of Agriculture, Salahaddin University, - Erbil, Iraq

ABSTRACT

This investigation was carried out during October 2016 to February 2017 at Grdarasha field ,College of Agriculture University of Salahaddin ,Erbil to study the effect of 5 water levels of triple super phosphate (TSP) (0,50,100,150 and 200 kg ha^{-1}) and two levels of KCl (0,150 kg ha^{-1}) which equivalent to (0 ,11.25,22.5, 33.75 and 45 g TSP plot^{-1}), (0 and 33.75 g $^{-1}$KCl) per plot respectively and their interaction on growth and yield of broccoli (Agassi F1 hybrid), using Randomized Complete Block Design (RCBD) with 4 replicates. The constant amount of urea (100 kg ha^{-1} which equivalent to 11.25 g) urea per experimental unit was added to each experimental unit. Significant differences were observed for all the studied traits. The highest yield (23.15 Mg ha^{-1} was recorded from P4 treatment, while the lowest was (14.50 Mg ha^{-1}) obtained from control treatment (P0). Also, the application of potassium caused significant increase in broccoli yield; the lowest and highest values were (17.24 and 19.08 Mg ha^{-1}) recorded from K0 and K1 treatments respectively. The highest values of interaction (74.3, 75.6 and 76.2) SPAD were recorded from K1, P3 and P3K0 respectively. Leaf contents of macro and micro nutrient were recorded a significant difference with interaction effect of both Potassium and Phosphorus, the highest level of concentration recorded was on P4 and K1 at (37.80, 3.98 and 2.25) for Nitrogen, Phosphorus and Potassium respectively.

Keywords*: Broccoli, Phosphorus and potassium, total yield, N, P, K*

1. INTRODUCTION

Broccoli (*Brassica oleracea var. italica*) is an important member in the family of Brassicacea which is considered to be the first to originate from wild cabbage ie *Brassica oleracea var oleracea* (*syn sylvestris*), it is found growing wild along the Mediterranean Sea (Dev, 2012). In the last few centuries the worldwide production of broccoli has increased strongly. It is a recently introduced to Iraq, however; the production of the plant has increased rapidly in the last few years due to the demand on it (Arshad and Ahmed**,** 2017).

Commercially, the consumed part of broccoli plant is its inflorescence which is harvested before the flower buds begin to open, and often including about 10 cm of the crisp fleshy stem. The inflorescence is rich in chlorophyll so that it is a dark green when it is fully matured. The plant produces lateral heads as well it forms inflorescences as well, lateral shoots will develop about two to three weeks after the main shoot has been harvested, in modern hybrid cultivars the main shoot is large and dominating the lateral heads. Broccoli can be stored cold for a period of two weeks only (Vågen, 2005).

Broccoli is well grown in clay soil with well supplied with organic matter, besides it can be grown on a wide range of soil types, ranging from light sand to heavy loam (Katayal, 1994). For successfully produce broccoli there are many factors such as environmental and fertilizer management should be considered.

Broccoli growth and curd initiation is impacted by applied Phosphorus. Demchak and smith (1990) stated that phosphorus was the most responsible element for the increased yield of broccoli. Potassium also has an important role in balancing physiological activities. Different levels of potassium influence the growth and yield of broccoli (Zaki *et al*., 2015). Ying *et al*., (1997) observed that potassium was the most important element for yield and dry weight of broccoli. Since there are little studies in Kurdistan region on the role of fertilization in growth and yield of broccoli for this reason this investigation was conducted to study the effect of different levels of phosphorus, potassium and their interactions on yield and quality of broccoli.

2. MATERIALS AND METHODS

This investigation was carried out during mid of August 2016 to 10 February 2017 at Grdarasha field ,College of Agriculture University of Salahaddin ,Erbil with GPS reading of (N =360 06' 49'' E=440 00 ' 47'' and Elevation 407m) to study the effect of 5 water levels of triple super phosphate(TSP) (0,50,100,150 and 200 kg ha^{-1}) and two levels of KCl (0 and 150 kg ha^{-1}) which equivalent to (0 ,11.25,22.5, 33.75 and 45 g TSP $plot^{-1}$) ,(0 and 33.75 g $^{-1}$KCl) plot respectively and their interactions on growth and yield of broccoli (Agassi F1 hybrid cultivar), using Randomized Complete Block Design (RCBD) with 4 replicates. The mean values of the treatments were compared using revised LSD. at the level of 0.05. The area of experimental unit was (1.5 *1.5) m^2, the space between blocks was 1m, while the space between experimental units was 0.75 m. The seeds were sown in plastic trays then after they reached to 4 true leaves the seedlings were transplanted on 11 October 2016. The space between plants was 50 cm which was 4 plants per experimental units. The constant amount of urea 100 kg ha^{-1} was added (which equivalent to 11.25 g per each experiment). Drip irrigation was conducted whenever using needed. Weed control was done mechanically. The soil was plowed horizontally and vertically, then soften by using rotavator, table (1) shows some chemical and physical properties of the experiment.

The crop harvesting (cutting the main flower heads) was started on 20 January 2017 (main heads) and the last harvest was on 10 February 2017.

The total yield was determined by harvesting in two different times, the first one all the main heads from each experiment were collected and weighted while they reached to the standard head size then the second harvest was done around 20 days after the main head cutting by harvesting the lateral heads.

2.1. Soil Analysis:

The chemical and physical properties of the soil were analyzed according to Rowell (1996).

2.2. Plant analysis:

The chlorophyll content was determined using chlorophyll meter (SPAD).

The plant leaves were digested using 1:1 H_2SO4:H_2O_2, then the concentration of N, P and K were determined according to Gupa (2006).

Table 1: Some chemical and physical properties of the soil used in the study.

pH	EC dS.m^{-1}	ECACO$_3$	Ca^{2+}	Mg^{2+}	Na^{+}	SO$_4$-2	HCO$_3$-	Cl-	CO$_3$-2	K	P
										available	
		Mg. kg^{-1}	mmol l^{-1}							Mg. kg $^{-1}$soil	
7.55	0.70	240	4.50	2.10	0.50	1.15	4.80	2.01	0.0	119	2.99
Sand	Silt	clay	Textural name			Moisture at field capacity (F.C.)		Moisture at Wilting point(W.P.)			
mg kg^{-1}						%					
329	330	341	Clay loam			25.50		15.78			

3. RESULTS AND DISCUSSION

3.1. The yield of broccoli (kg. ha^{-1})

Table (2) shows the significant effect of levels of applied P, K and their interactions on broccoli yield.

The levels of applied P affected significantly on broccoli yield, the highest value (75.6 kg ha^{-1} was recorded from P3 treatment, while the lowest value was obtained from control treatment (72.0 kg ha^{-1}). It means that increasing in the levels of applied P caused increasing in the total yield since the soil contains low amount of available P (2.99mg kg^{-1}soil)as shown from table(1.) There are critical values for available phosphorus in calcareous soil 7.00mg kg^{-1}soil (Esmail and Kazin, 2018).

In the same table, the application of potassium caused significant increase in broccoli yield the lowest and highest values (74.3 and 70.6 kg ha^{-1}) were recorded from K0 and K1 treatments respectively. This may be due to low available potassium content of the soil(less than 119 mg kg^{-1} soil) (Hassan, 1976) as shown from table (1).This results disagree with those recorded by Saleh (2016) since the soil used by him contains large amount of available potassium (340 mg kg $^{-1}$ soil).

The interaction treatments also affected significantly on the yield the highest value (76.20 kg ha^{-1})was obtained from P0K0, while the lowest value (68.0 kg ha-1) was recorded from interaction treatment P3K0 .This may be due to the single effect of both nutrients since the concentration of both of in the studied soil is low as mentioned before or not sufficient for

normal plant growth and yield, for this reason application of them and their interaction caused (59.65 ,10.67 and 95) % increase in yield respectively comparing with control treatment. It is appear that role of phosphorus in increasing broccoli yield is 5.6 times more than the role of potassium application. The significant correlation coefficient (r =099**) explains the role of phosphorus fertilization in increasing broccoli yield.

Table 2: interaction effect of levels of applied Phosphorus, potassium and their interaction on broccoli yield (kg ha-1).

Applied phosphorus (kg ha^{-1})	**Applied potassium (kg ha^{-1})**		
	0.0	**150**	**Mean effect for P**
0	68	74	72.0
50	70	74	72.0
100	72	76	74.0
150	76.2	75	75.6
200	73	74	73.5
Mean effect for K	70.8	74.3	
$LSD_{.01}$ for P = 1.90	$LSD_{.01}$ for K = 1.34		$LSD_{.01}$ for P K = 1.20

3.2.. Chlorophyll content in the leaves:

Table (3) shows that the levels of applied potassium, Phosphorus and their interactions affected significantly on Chlorophyll content in the broccoli leaves. The highest values (19.08, 23.15 and 22.50) SPAD were recorded from K1, P4 and P4K1 respectively. This may be due to the role of each of P and K in plant growth and activity since the concentration of them in the studied soil is below the critical level of P (7mg kg^{-1} soil) and K (180mg kg^{-1} soil) as shown from table(1).

Table (3) shows that the levels of applied potassium , Phosphorus and their interactions affected significantly at level of 0.01 on SPAD values of broccoli . The highest values (23.80, 22.50 and 20.00) SPAD were recorded from K1, P3 and P3K0 respectively. This may be due to the role of each of P and K in plant growth and activity since the concentration of them in the studied soil is below the critical level of P (7mg kg^{-1} soil) and K (180mg kg^{-1} soil) as shown from table (1).Or may due to the role of P in root growth then increase in root

depletion zone which caused increase in nutrient uptake and increase in chlorophyll content similar results were obtained by Saleh (2016).

Table 3: Interaction effect of levels of applied Phosphorus and potassium on chlorophyll content (SPAD value) during the study.

Applied Phosphorus (kg ha^{-1})	Levels of applied Potassium (kg ha^{-1})		Mean effect for P
	0.00	150	
0	12.20	16.80	14.50
50	14.90	16.00	15.25
100	17.00	18.80	17.90
150	19.60	20.00	19.90
200	22.50	23.80	23.15
Mean effect for K	17.24	19.08	
R LSD$_{.01}$ for P = 2.11	RLSD$_{.01}$ for K = 1.50	R LSD$_{.01}$ for P K = 2.90	

3.3. N, P and K levels in the leaves:

As shown from table (4) the increase in levels of applied phosphorus caused significant increase in concentration of N ,P and K in the leaves , the highest values (36.86 ,3.74 and 1.82 mg g^{-1} dry weight respectively) were recorded from 200 kg. ha^{-1} treatment, while the lowest values (22.03 ,1.96 and 1.38 mg g^{-1} dry weight) were recorded from control treatment.

The result agrees with those recorded by Mohammad (2006). The results of statistical analysis explains these results since the highly significant correlation coefficient was recorded between levels of applied P and concentration of N, P and K in the leaves with the correlation coefficient values of (r= 0.98** , 099** and 098**) respectively.

Table 4: Effect of levels of phosphorus on concentration of N, P and K in broccoli leaves.

Applied Phosphorus (kg ha^{-1})	Concentration (mg g^{-1} dry weight)		
	Nitrogen	Phosphorus	Potassium
0	22.03	1.96	1.38
50	24.76	2.53	1.45
100	29.60	3.04	1.52
150	31.40	3.37	1.58
200	36.86	3.74	1.82
RLSD$_{.01}$	1.92	0.63	0.35

3.4. Effect of levels of potassium on concentration of N, P and K in broccoli of leaves:

The statistical analyses refers to significant effect of potassium application on concentration of N ,P and K in the leaves ,the highest values of them(37.80,30.14 ,3.00 and 1.86 mg g^{-1} dry weight) were recorded from treatment K, while the lowest values (27.73 ,2.85 and 1.24 mg g^{-1} dry weight respectively) were recorded from control treatment. (Table, 5). It means the plant not responded to potassium fertilization this may be due to the low available potassium concentration of the studied soil as mentioned before similar results were obtained by Saleh (2016).

Table 5: Effect of levels of potassium on concentration of N, P and K of broccoli leaves.

Levels of potassium	Concentration (mg g^{-1}dry matter)		
	Nitrogen	Phosphorus	Potassium
K0	27.73	2.85	1.24
K1	30.14	3.00	1.86
$RLSD_{.01}$	1.20	0.22	0.17

3.5. Interaction effect of levels of applied Phosphorus and potassium on N, P and K concentration in broccoli leaves:

The statistical analyses in table (6) explains the significant effect of interaction treatments on concentration of N ,P and K in the leaves, the highest values (37.80, 3.98 and 2.25 mg g^{-1} dry weight) were recorded from interaction treatment P200 and K150,while the lowest values (20.30 ,1.92 and 1.10 mg g^{-1} dry weight) were recorded from control. It means the plant responded to combination effect of both fertilizers this may be due to the low available phosphorus and potassium concentration of the studied soil as mentioned before (1). Or the combination between them might have created the best or suitable condition for plant growth.

It appears from the results of this study that the higher level of Phosphorus and potassium is necessary to obtain the higher yield and the amount of available phosphorus and potassium in the studied soil is below the critical level or not sufficient for the economical yield of broccoli.

Table 6: Interaction effects of phosphorus and potassium levels on concentration of N, P and K in broccoli leaves.

		Concentration of nutrients in plant leaves (mg g^{-1})/plant		
Applied Phosphorus (kg ha^{-1})	**Applied Potassium (kg ha^{-1})**	**Nitrogen**	**Phosphorus**	**Potassium**
0	0	20.30	1.92	1.10
	150	23.78	2.00	1.65
50	0	23.61	2.50	1.20
	150	25.90	2.56	1.69
100	0	28.80	3.00	1.24
	150	30.40	3.07	1.80
150	0	30.00	3.33	1.25
	150	32.80	3.40	1.90
200	0	35.92	3.50	1.39
	150	37.80	3.98	2.25
$RLSD_{.01}$		2.58	1.02	0.65

4. CONCLUSION

Results of the present study revealed that both potassium and phosphorus increases yield of broccoli as well as dry weight of leaf content (macro and micro) nutrients. It shown that with increase the level of applied P and K the yield has essentially increased. Also, their interaction has positively influenced both yield and of broccoli.

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