Effect of cultivation distances and potassium fertilization on the growth and yield of broccoli (Broccoli Brassica oleracea var. italica Plenck)

*Abbas Latif Hashem Nawal M.H. Al-Bayaty Najla Jabr Mohamed
Department of Horticulture and Landscape Gardening, College of Agriculture, University of Basra, Basra province, Iraq.
Department of Soil and Water Resources, College of Agriculture, University of Basra, Basra province, Iraq.

ABSTRACT

The experiment was conducted during the winter season (2017 - 2018) in the Tomato Development Project belonging to the Directorate of Agriculture in Basra province, Khor Al-Zubair, in order to the effect of cultivation distances and potassium fertilization on the growth and yield of broccoli to determine the best cultivation distance and the best fertilizer dose causing the highest production. The experiment involved nine treatments which included the interaction between three cultivating distances of (40, 50, 60 cm) and three potassium levels of (0, 200, 300 $kg.ha^{-1}$). The Randomized Complete Block Design (RCBD) was used to a factorial experiment with a split-plot and three replications. The averages of the treatments were compared according to the test of the least significant difference at a probability level of 0.05. The results showed that the plants cultivated on the distance of 60 cm were significantly excelled in the curd content of total chlorophyll (mg. 100 g^{-1} fresh weight) and in the percentage of dry matter and potassium, while the plants that cultivated at distance (50 cm) was excelled in the percentage of nitrogen. Both distances were excelled in the total plant yield (kg), the plants that cultivated at a distance of 40 cm was excelled in total yield ($tons.ha^{-1}$). The plants fertilized with a level of (300 $kg.ha^{-1}$) had a significant superiority in the indicators of vegetative growth and the yield under study. Bi-interaction was significant for all traits in the experiment.

*Research paper from MSc thesis for the first author.

تأثير مسافات الزراعة و التسميد البوتاسي في نمو و حاصل البروكلي Broccoli *Brassica oleracea* var. *italica* Plenck.

عباس لطيف هاشم * نوال مهدي حمود نجلة جبر محمد
قسم البستنة وهندسة الحدائق, كلية الزراعة, جامعة البصرة, جمهورية العراق.
قسم علوم التربة والموارد المائية, كلية الزراعة, جامعة البصرة, جمهورية العراق.

الخلاصة

أجريت التجربة خلال الموسم الشتوي 2017 – 2018 في مشروع تنمية الطماطة التابع لمديرية زراعة البصرة في خور الزبير, بهدف دراسة تأثير مسافات الزراعة و التسميد البوتاسي في نمو و حاصل نبات البروكلي لتحديد افضل مسافة زراعية و افضل

ISSN 2072-3875

جرعة سمادية مسببة لاعلى انتاج. تضمنت التجربة تسعة معاملات عبارة عن التداخل بين ثلاث مسافات للزراعة بين النباتات هي 40 و 50 و60 سم وثلاثة مستويات من البوتاسيوم هي 0 و 200 و 300 كغم هكتار$^{-1}$. استعمل تصميم القطاعات العشوائية الكاملة لتجربة عامليه منشقة لمرة واحدة بثلاثة مكررات. قورنت متوسطات المعاملات وفق اختبار اقل فرق معنوي عند مستوى احتمال 0.05. بينت النتائج تفوق النباتات المزروعة على مسافة 60 سم معنويا في محتوى الاقراص الزهرية من الكلوروفيل الكلي (ملغم 100غم$^{-1}$ وزن طري) وفي النسبة المئوية للمادة الجافة والبوتاسيوم, في حين تفوقت نباتات المسافة 50 سم في النسبة المئوية للنتروجين, وتفوقت كلا المسافتين في حاصل النبات الواحد الكلي (كغم), وتفوقت النباتات المزروعة على مسافة 40 سم في الانتاجية الكلية (طن هكتار$^{-1}$). حققت النباتات المسمدة بالمستوى 300 كغم هكتار$^{-1}$ تفوقا معنويا في مؤشرات النمو الخضري والحاصل قيد الدراسة, وكان التداخل الثنائي معنويا لجميع الصفات في التجربة.

* مستل من رسالة ماجستير للباحث الاول.

1. INTRODUCTION

Broccoli (Brassica oleracea var. Italica Plenck) is considered one of the winter vegetables, it belongs to the Brassicaceae family, It is an annual herbaceous plant similar morphology of cauliflower plant, it is considered one of the few plants in Iraq, it ranks 31 globally in terms of production, which is from a crops of cold season cultivated throughout the year in cold regions, It needs a temperate atmosphere that tends to warm during the vegetative growth stage (at the beginning of its life) and a cool atmosphere during the formation of the heads and the best production between January and March, withstand the rise and decrease in temperatures more than cauliflower, it is cultivated for its edible inflorescences in the phase of vegetative and flower buds with its thick stalks (7). It is also a vegetable rich in chemical compounds that have shown anti-cancer properties, where it was noted that eating more than one meal during the week reduces the risk of this disease with a ratio of (45%), It also helps prevent eye diseases (13, 25), In nutrient terms, it is rich in vitamin A and C, protein, carbohydrates and minerals such as calcium, iron, phosphorus, potassium, and sodium (17). The right basis for cultivation begins by choosing the appropriate cultivating distance, which determines the extent to which plants benefit from various environmental factors of temperature, lighting, nutrition, humidity, ventilation, etc., thus obtaining their needs from these factors, which are reflected in the growth rate, increase yield and facilitate the Crop service operations as well as disease and insect control (4). Potassium is considered the third major nutrient needed by the plant in high quantities, it has a role in stimulating more than 65 enzymes related to many of the bio-activities, including helping the plant to raise the efficiency of the process of carbon fixation by the formation of ATP and protein composition through its importance in Absorption of

ISSN 2072-3875

nitrogen (14). Despite the presence of potassium in large quantities in the soil, a small percentage of it is available for absorption and this demonstrates the need to add potassium fertilizers to the soil. The choice of the type of fertilizer depends on the image of the nutrient element, its degree of solubility and economic cost and from the sources of used potassium fertilizer (potassium sulphate fertilizer), which contains 41% potassium and 18% sulfur, which is expensive for the high costs of industry, but it is a good source for sulfur (5), Therefore, this study aims to achieve the best cultivating distance between plants and the best level of potassium which achieves the highest production and quality for this crop.

1. MATERIALS AND METHODS

The experiment was conducted during the winter season (2017 - 2018) in the Tomato Development Project belonging to the Directorate of Agriculture in Basra province, Khor Al-Zubair. Random samples were taken from field soil before cultivating to determine some of their physical and chemical traits as shown in Table (1). The experiment involved two factors treatments which are the interaction between three cultivating distances of (40, 50, 60 cm) and three levels of potassium fertilizer (0, 200, 300 kg.ha-1), potassium sulfate (50% K_2O). It was added in three batches, the first batch was added to the soil after 15 days from the seedling (30/10/2017), the second batch was added to the soil after a month from the first batch and the third one after a month from the second batch by feeding method. The Randomized Complete Block Design (RCBD) was used to a factorial experiment with a split-plot. The cultivation distances were considered the main plots and the levels of potassium were sub-plots. Thus, the number of treatments is nine factorial treatments, with three replicates to be the number of units 27 experimental units. The results of averages were statistically analyzed using the Genstat software, and the least significant difference test (L.S.D.) was used to compare the averages at a probability level of 0.05 (2).

ISSN 2072-3875

Table 1: Physical and chemical traits for the soil of the experiment.

Traits	pH	Ec (dS.m^{-1})	Organic matter (%)	Nitrogen availability (ppm)	phosphorus availability (ppm)	Potassium availability (ppm)	Clay (g.kg^{-1})	Silt (g.kg^{-1})	Sand (g.kg^{-1})	Soil texture
Values	7.31	11.11	0.64	154	6.9	102	134	36	830	Sandy clay

In the experiment, the hybrid seeds of the broccoli (Paraiso) produced by Syngenta company (Australia origin) were used in the year 2013 with 85% germination ratio and purity of 99%, the import of Dabaneh for Modern Agriculture Co. Ltd. for 2016. The seeds were cultivated on 1/9/2017 in cork dishes with a rate of one seed for each pit in a house covered with green saran cover to reduce sunlight. All the operations were conducted symmetrically for all treatments, where seedlings were sprayed three times after two weeks of germination with high phosphorus fertilizer (10-30-10) every three days at a rate of (1 g.L^{-1}). after three weeks, it sprayed with neutral N. P. K fertilizer (20:20:20), three spraying every seven days, with a rate of (2 g.L^{-1}), it was then transferred to the field after 45 days of cultivating on 15/10/2017, the seedling contains (5 - 7 leaves) with a height of (5 - 8 cm). The soil of the field was plowed, smoothed and settled and divided into lines with a length of (24 m), the width of (40 cm), depth of (15 cm) and distance of (80 cm) between one line and another. Each line represents an experimental unit (nine lines per replicate). The cultivating was conducted at three distances (40, 50, 60 cm) between one plant and another to be the number of plants in the line is (60, 48, 40 plants), with a density of (27500, 22000, 18333 plant.ha^{-1}), respectively. Agricultural operations were conducted according to the recommendations followed in broccoli cultivation, where triple superphosphate (TSP) fertilizer was added with the rate of (120 kg P_2O_5.ha^{-1}) for all treatments in one batch before cultivating. The seedling was conducted after irrigating the field with standard irrigation while placing part of the peat moss around the roots during seedling to maintain soil moisture. The subsurface drip irrigation system (T-Tape type, from French origin), which contained drippings, 15 cm a distance between each another, was used to irrigate plants using artesian wells. The insecticide (Diffuse) was used at a

ISSN 2072-3875

concentration of (50 ml 100 L^{-1}) to control worms and rodent larvae, Weeding process was conducted to get rid of the thickets whenever needed. Five plants were randomly taken to measure the vegetative growth indicators represented by plant height (cm) and leaf area (dm^2). The total plant yield (kg) (from the weight of the peripheral curd with the weight of the lateral curd in plant per experimental unit and divided by the number of plants), and the total yield ($tons.ha^{-1}$) (from the total plant yield (kg) × plant density per distance), The curd content of chlorophyll (mg. 100 g^{-1} fresh weight) was calculated according to (6) and the Percentage of dry matter, nitrogen and potassium were estimated as indicated in (16).

1. RESULTS AND DISCUSSION

Tables (2, 3) show that there are no significant differences between cultivating distances in plant height and leaf area. Both levels (300, 200 $kg.dunum^{-1}$) have excelled in these two traits compared to the plants of the non-fertilized control treatment. Bi-interaction treatment between cultivating distances and potassium fertilization showed a significant excelling, where the cultivated plants at a distance of (60 cm) that fertilized with a level of (300 $kg.dunum^{-1}$) were significantly excelled in plant height and leaf area which amounted to (66 cm, 51.02 dm^2) compared to plants cultivated at a distance of (40 cm) which amounted to (58.33 cm, 41.19 dm^2), respectively. Table (4) shows that the cultivating distance has a significant effect on the total plant yield. where the plants cultivated at a distance of (60, 50 cm) excelled with a non-significant difference between them in this trait on the plants cultivated at a distance of (40 cm), with an increase of (21, 16%), respectively. The results also showed that the plants fertilized with potassium at the level of (300 $kg.ha^{-1}$) have excelled with an increase of (14, 18 %) on the plants fertilized with potassium at the level of (200 $kg.ha^{-1}$) and non-fertilized control plants, respectively, which did not differ significantly between them. The interaction showed that the plants cultivated at a distance of (60 cm) and fertilized with potassium at the level of (300 $kg.ha^{-1}$) were significantly excelled in the total plant yield which amounted to (1.12 $kg.ha^{-1}$) compared to the lowest yield for the control treatment that cultivated at a distance of (40 cm) which amounted to (0.75 $kg.ha^{-1}$).

ISSN 2072-3875

Table 2: Effect of cultivating distance and Potassium Fertilization and their interaction on Plant Height (cm) for Hybrid Broccoli (Paraiso).

Cultivating distance (cm)	Potassium Fertilization ($kg.ha^{-1}$)			Average of cultivating distance
	0	**200**	**300**	
40	58.33	61.00	62.33	60.55
50	59.67	60.67	63.00	61.11
60	59.00	62.67	66.00	62.56
Average of Potassium fertilization	59.00	61.45	63.78	
The least significant difference (LSD) at a significant level (0.05)				
Cultivating distance	Potassium fertilization			Cultivating distance × Potassium fertilization
NS	**1.11**			**3.14**

Table 3: Effect of cultivating distance and Potassium Fertilization and their interaction on leaf area (dm^2) for Hybrid Broccoli (Paraiso).

Cultivating distance (cm)	Potassium Fertilization ($kg.ha^{-1}$)			Average of cultivating distance
	0	**200**	**300**	
40	41.19	43.30	49.08	44.53
50	39.24	43.49	47.11	43.28
60	42.56	45.05	51.02	46.21
Average of Potassium fertilization	41.00	43.95	49.07	
The least significant difference (LSD) at a significant level (0.05)				
Cultivating distance	Potassium fertilization			Cultivating distance × Potassium fertilization
NS	**2.57**			**9.90**

Table 4: Effect of cultivating distance and Potassium Fertilization and their interaction on leaf area (dm^2) for Hybrid Broccoli (Paraiso).

Cultivating distance (cm)	Potassium Fertilization ($kg.ha^{-1}$)			Average of cultivating distance
	0	**200**	**300**	
40	0.75	0.84	0.85	0.81
50	0.88	0.90	1.03	0.94
60	0.91	0.91	1.12	0.98
Average of Potassium fertilization	0.85	0.88	1.00	
The least significant difference (LSD) at a significant level (0.05)				
Cultivating distance	Potassium fertilization			Cultivating distance × Potassium fertilization
0.06	**0.05**			**0.09**

ISSN 2072-3875

Table (5) indicates a significant increase in the total yield of curd whenever the cultivating distance decreases, where the plants cultivated at a distance of (40 cm) were significantly excelled in the total yield for the curd on those cultivated at a distance of (50, 60 cm), with significant difference between them by an increase of (8, 24 %) for each, respectively. As for the effect of potassium fertilizer, It was observed excelling the plants fertilized with potassium at the level of (300 $kg.ha^{-1}$) on those fertilized at the level of (200 $kg.ha^{-1}$) and non-fertilized control plants, which did not significantly differ between them with an increase amounted to (12, 18%), respectively. Bi-interaction showed excelling the plants cultivated at a distance of (40 cm) and fertilized at a level of (300 $kg.ha^{-1}$), which recorded a value amounted to (23.43 $tons.ha^{-1}$) compared to the lowest total yield obtained from the interaction of the plants cultivated at a distance of (60 cm) and fertilized with potassium at the level of (200 $kg.ha^{-1}$), which amounted to (16.62 $tons.ha^{-1}$). Table (6) shows that there are significant differences between the cultivating distances in the curd content of total chlorophyll, where plants cultivated at a distance of (60 cm) was excelled on the distances of (50, 40 cm), The plants that fertilized at the level of (300 $kg.dunum^{-1}$) followed and with significant difference the plants fertilized at the level of (200 $kg.dunum^{-1}$) and then the plants of control treatment that gave the lowest curd content of chlorophyll. As for the effect of interaction between the cultivating distances and potassium fertilization, the plants cultivated at a distance of (60 cm) and fertilized at the level of (300 $kg.dunum^{-1}$) which gave a value amounted to (5.15 mg.100 g^{-1} fresh weight), and the lowest content found in plants cultivated at a distance of (40 cm) for the control plants, where it amounted to (3.30 mg.100 g^{-1} fresh weight). Table (7) shows the plants cultivated at a distance of (60 cm) was excelled in the percentage of dry matter in curd compared to the lowest percentage observed in the plants cultivated at a distance of (40 cm). The results showed that there was no significant difference between the plants cultivated at a distance of (60 cm) and those cultivated at a distance of (50 cm) which in turn did not differ significantly from the plants cultivated at a distance of (40 cm). The plants fertilized with Potassium for both levels were excelled and with non-significant differences between them on the non-fertilized control plants. Bi-interaction between the cultivating distance and potassium fertilization showed excelling the plants cultivated at the distance of (60 cm) and fertilized with potassium at a level of (300 $kg.ha^{-1}$) where recorded a percentage amounted to (15.73%) compared to the lowest percentage

ISSN 2072-3875

of (13.01%) found in the control plants that cultivated at a distance of (50 cm).

Table 5: Effect of cultivating distance and Potassium Fertilization and their interaction on total yield (tons.ha^{-1}) for Hybrid Broccoli (Paraiso).

Cultivating distance (cm)	Potassium Fertilization (kg.ha^{-1})			Average of cultivating distance
	0	**200**	**300**	
40	20.57	22.96	23.43	22.32
50	19.36	19.76	22.73	20.62
60	16.69	16.62	20.51	17.94
Average of Potassium fertilization	18.87	19.78	22.23	
The least significant difference (LSD) at a significant level (0.05)				
Cultivating distance	Potassium fertilization			Cultivating distance × Potassium fertilization
1.08	**1.29**			**1.96**

Table 6: Effect of cultivating distance and Potassium Fertilization and their interaction on the curd content of total chlorophyll (mg.100 g^{-1} fresh weight) for Hybrid Broccoli (Paraiso).

Cultivating distance (cm)	Potassium Fertilization (kg.ha^{-1})			Average of cultivating distance
	0	**200**	**300**	
40	3.30	3.48	3.80	3.53
50	3.45	3.81	4.25	3.84
60	3.57	4.09	5.15	4.27
Average of Potassium fertilization	3.44	3.79	4.40	
The least significant difference (LSD) at a significant level (0.05)				
Cultivating distance	Potassium fertilization			Cultivating distance × Potassium fertilization
0.57	**0.33**			**0.64**

Table 7: Effect of cultivating distance and Potassium Fertilization and their interaction on the percentage of dry matter in curd (%) for Hybrid Broccoli (Paraiso).

Cultivating distance (cm)	Potassium Fertilization (kg.ha^{-1})			Average of cultivating distance
	0	**200**	**300**	
40	13.60	13.72	13.39	13.57
50	13.01	14.37	14.62	14.00
60	13.31	14.80	15.73	14.61
Average of Potassium fertilization	13.31	14.30	14.58	
The least significant difference (LSD) at a significant level (0.05)				
Cultivating distance	Potassium fertilization			Cultivating distance × Potassium fertilization
0.64	**0.53**			**0.88**

ISSN 2072-3875

Table (8) shows that the plants cultivated at a distance of (50 cm) were significantly excelled in the percentage of nitrogen in the curd, followed by and with a significant difference the plants cultivated at a distance of (60 cm) and the lowest percentage appeared in the plants cultivated at a distance of (40 cm) which did not differ significantly from the plants cultivated at a distance of (60 cm). As for the effect of potassium fertilization, the results showed that there was a significant increase in the percentage of nitrogen in the curd by increasing the level of potassium fertilizer added to the soil. As for the effect of interaction between cultivating distances and potassium fertilization, the plants cultivated at a distance of (50 cm) and fertilized at the level of (300 $kg.dunum^{-1}$) which amounted to (3.79 %) compared to the lowest percentage recorded for the control plants compared cultivated at a distance of (40 cm) which amounted to (2.91%). Table (9) shows that there is a significant increase in the percentage of potassium with the increase of cultivating distance between plants. The results also showed that the plants fertilized with potassium fertilizer at the level of (300 $kg.ha^{-1}$) in this percentage, which did not differ significantly from the plants fertilized with potassium fertilizer at the level of (200 $kg.ha^{-1}$). The lowest percentage appeared in the plants of the control treatment which did not differ significantly from the plants fertilized at the level of (200 $kg.ha^{-1}$). The interaction between the two study factors showed excelling the plants cultivated at a distance of (60 cm) and the plants fertilized with potassium fertilizer at the level of (300 $kg.ha^{-1}$) by giving them the highest percentage of potassium in the curd amounted to (1.66%) and the lowest percentage found in the plants of the control treatment cultivated at a distance of (40 cm) which amounted to (1.16%). The increase in the total plant yield as shown in Table (4) with the increase in cultivating distances may be due to the fact that the spaced distances led to the plant obtaining the largest amount of light as well as the lack of competition between plants on nutrients and the water availability. This has led to increase the photosynthesis process and nutrients accumulation in the curd, which facilitates the growth and development of the curd (8, 10, 19), which is also reflected in the increase in the curd content from chlorophyll as shown in Table (6), dry matter as shown in Table (7), and increasing the nutrients absorption as shown in Tables (8, 9). These results agree with (12). As for the increase in total yield as shown in Table (5) with reducing the cultivating distances may be due to the fact that agriculture at close distances has led to an increase in the number of cultivated plants, thus an increase in the number of formed curd, which led to an increase in yield, these results

ISSN 2072-3875

agree with (22). The increase in vegetative growth indicators which represented by plant height as shown in Table (2) and leaf area as shown in Table (3) with increasing the concentration of potassium may be attributed to its role in the action of the enzymes responsible for the Structural construction for cells involved in the synthesizing plant structure and also its role in hormonal balance and increasing the efficiency of the work of plant growth regulators that increase the indicators of vegetative growth as well as its role in increasing the cells size, its speed of division, in reducing the Osmotic potential and increase the efficiency of carbon fixation, thus increasing the manufacture of nutrients, which affects the increase in the number and length of Internodes and reflecting this role in the plant height (11) and In increasing the surface area for the leaves, which is reflected in the increase of the leaf area for the plant (3). These results agree with (23). Increasing the level of added potassium may increase potassium availability and increase its concentration within the plant. This plays a major role in the regulation of photosynthesis process and transport of metabolic components, which ultimately leads to increase plant yields (9, 15), as well as its role in activating enzymes and its effect on the construction and composition of chlorophyll (18, 20). The reason for increasing the concentration of nitrogen and potassium in curd with increasing levels of potassium fertilizer may be due to the fact that potassium works to increase the physiological activity for the plant and encouraging the roots to absorb it, which improves the vegetative growth of the plant (24), which is reflected in increasing the absorption of nitrogen and potassium availability from the soil and increasing the dry matter as a result of increasing its concentration in the leaves (21) and then increase it in the curd as considering that the leaves are the main supplier for the curd (3).

Table 8: Effect of cultivating distance and Potassium Fertilization and their interaction on the percentage of nitrogen in the curd (%) for Hybrid Broccoli (Paraiso).

Cultivating distance (cm)	Potassium Fertilization (kg.ha^{-1})			Average of cultivating distance
	0	**200**	**300**	
40	2.91	3.01	3.46	3.13
50	3.17	3.41	3.79	3.46
60	2.92	3.37	3.39	3.23
Average of Potassium fertilization	3.00	3.26	3.55	
The least significant difference (LSD) at a significant level (0.05)				
Cultivating distance	Potassium fertilization	Cultivating distance × Potassium fertilization		
0.18	**0.19**	**0.29**		

ISSN 2072-3875

Table 9: Effect of cultivating distance and Potassium Fertilization and their interaction on the percentage of potassium in the curd (%) for Hybrid Broccoli (Paraiso).

Cultivating distance (cm)	Potassium Fertilization ($kg.ha^{-1}$)			Average of cultivating distance
	0	**200**	**300**	
40	1.16	1.21	1.27	1.21
50	1.29	1.36	1.41	1.35
60	1.47	1.55	1.66	1.56
Average of Potassium fertilization	1.30	1.38	1.44	

The least significant difference (LSD) at a significant level (0.05)		
Cultivating distance	Potassium fertilization	Cultivating distance × Potassium fertilization
0.12	**0.10**	**0.17**

REFERENCES

1- Al-Jebory, Razzaq Kadhim Rahman. 2014. Effect of organic fertilizer and potassium on levels vegetative growth and yield of tomato plant Lycopersicon esculentum Mill. in unheated conditions growth in sandy soil. Kufa Journal for Agricultural Sciences 5 (1): 286 331.

2- Al-Rawi, Khasha Mahmood and Khalaf Allah, Abdul Aziz Mohammed Khalaf. 1980. Design and analysis of agricultural experiments. Dar Al-Kutub for Printing and Publishing, University of Mosul. Iraq: Page 488.

3- Al-Sahaf, Fadel Hussein. 1989. Applied Plant Nutrition, Ministry of Higher Education and Scientific Research. Bayt Al-Hikma, University of Baghdad. Iraq.

4- Al-Eyada, Samira A. K. Matroad. 1995. Effect of Some Plant Growth Regulators and cultivating distances on Growth, Yield and Storagability for snake cucumber (Cucumis melo var. flexuosus Naud.) cultivated in southern Iraq. Master Thesis, College of Agriculture, University of Basra.

5- Al-Naimi, Saadallah Najm Abdullah. 1999. Fertilizers and soil fertility, Ministry of Higher Education and Scientific Research. University of Mosul. Iraq.

6- Abbas, Muayad Fadel, and Abbas, Mohsen Jalab Abbas. 1992. Care and storage of practical fruit and vegetables. Dar al-Hikma Press, University of Basra. Iraq: 143 pages.

7-Decoteau, D.R. 2000. Vegetable Crops. Prentice Rever, Upper Rever Company. New Jersey, U.S.A.: 464p.

8-Dev, H. 2012. Standardization of planting time and spacing in broccoli cv. Green Head for lower hills of northern India. Int. J. Farm Sci., 2(1), 36-42.

9-El-Helaly, M.A. 2012. Effect of nitrogen fertilization rates and potassium sources on broccoli yield, quality, and storability. Res. J. Agric. Biol. Sci., 8(4), 385-394.

10-Hossain, M.F.; Ara, N.; Udine, M.R.; Dey, S. and Islam, M.R. 2011. Effect of time of sowing and plant spacing on broccoli production. Trop. Agric. Res. Ext., 14(4) 90-92.

11- International Potash Institute (IPI). 2001. Assessing Potassium Availability in Indian Soils. Basel, Switzerland. p. 125-157.

12- Kaur, G. 2016. Growth, yield and quality of broccoli (*Brassica oleracea var. italic*a) as influenced by nitrogen and plant population under different dates of sowing (Doctoral dissertation, Punjab Agricultural University, Ludhiana).

13- Kirsh, V. A., Peters, U., Mayne, S. T., Subar, A. F., Chatterjee, N., Johnson, C. C., & Hayes, R. B. 2007. A prospective study of fruit and vegetable intake and risk of prostate

ISSN 2072-3875

cancer. Journal of the National Cancer Institute, 99(15), 1200-1209.

14- Mengel, K. and Kirkby, E.A. 1989. Principle of Plant Nutrition. International Potash Institute Bern, Switzerland.151-157.

15- Mirdad, Z.M. 2014. Effect of K^+ and salicylic acid on broccoli (*Brassica oleraceae* var. *italica*) plants grown under saline water irrigation. Journal of Agricultural Science, 6(10), 57.

16- Page, A.L.; Miller, R.H. and Keeney, D.R. 1982. Methods of Soil Analysis.Part (2) 2nd ed. American Society of Agronomy. U.S.A.

17- Rana, M.K. 2008. Olericulture in India. Kalyan Publishers, New Delhi. 301p.

18- Ranawat, R. 2008. Effect of N, P and K on Growth, Yield and Quality of Broccoli (*Brassica oleracea. var. Italica*) cv. Hybrid-1(Doctoral dissertation, Department of Horticulture, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology: Udaipur.

19- Saikia, P.D.B and Sanchita, B. 2010. Effect of time of planting and planting densities on growth, yield and economic production of broccoli(*Brassica oleracea* var. *italica*) cv. Pusa Broccoli KTS-1. Journal of Hill Agriculture, 1(2): 135-139.

20- Singh, B., Phookan, D. B., Gautam, B. P., & Bora, D. K. 2002. Effect of nitrogen, phosphorus, and potassium in the production of broccoli (*Brassica oleracea* var. italica) cv. KTS-1. *Vegetable Science*, 29(2), 154-156.

21- Taiz, L., andE.Zeiger .1988. Plant physiology .p:103-124 .2nd ed. Sinouer Associates.Inc Publishers Sunderland, Massachusetts. U.S.A.

22- Thirupal, D., Madhumathi, C., & Syam Sundar Reddy, P. 2014. Effect of planting dates and plant spacing's on growth, yield, and quality of broccoli under Rayalaseema zone of Andhra Pradesh, India. Plant Archives, 14(2), 1095-1098.

23- Wyatt, J.E.; Mullins, J.A.; Mullins, C.A. 1989. Potassium fertilization of broccoli transplants. Ferti. Res., 21(1): 13-18.

24- Zaki, M.F.; Saleh, S.A.; Tantawy, A.S. and El-Dewiny, C.Y. 2015. Effect of different rates of potassium fertilizer on the growth, productivity and quality of some broccoli cultivars under new reclaimed soil conditions. Int. J. Chemtech Res., 8(12): 28-39.

25- Zhao, H.; Lin, J.; Barton, G.H.; Hernandez, L.M.; Dinney, C.P. and Wu, X. 2007. Dietary isothiocyanates, GSTMI, GSTTI, NAT2 polymorphisms, and bladder cancer risk, International Journal of Cancer, 120(10): 2208-2213.

ISSN 2072-3875

ISSN 2072-3875