Effect of planting distance and organic fertilization on growth and yield of Broccoli (Brassica oleracea var. Italica)

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ABSTRACT

The experiment was conducted in the fields of the Department of Horticulture and Landscape Gardening, College of Agriculture, Al-Qasim Green University during the agricultural season (2017-2018) in order to study the effect of planting distance and organic fertilization on growth and yield of Broccoli (Brassica oleracea var. Italica), where the experiment included eight treatments for each replicate, which is the interaction between planting distances (35x50 cm and 50 x50 cm) and organic fertilization (15 tons.ha^{-1} rice waste and 3 tons.ha^{-1} poultry manure). The control treatment was (chemical fertilization NPK 300 kg.ha^{-1}). The split-plot design system was used according to the Randomized Complete Block Design (RCBD), with three replicates, where the planting distances were placed in the main plot and the fertilization in the subplot. The averages were compared using the least significant difference (L.S.D) at the probability level 0.05. The most important results can be summarized as follows: The planting distance significantly affected the plant height and percentage of chlorophyll, where the planting distance (50 x 50 cm) gave the highest plant height for the plant and the planting distance (35 x 50 cm) gave the highest percentage of chlorophyll. It is noted that the results of organic fertilization with rice waste and poultry manure did not differ significantly from the results of chemical fertilization in the plant height and percentage of chlorophyll. The planting distance in all the traits of the studied quantitative yield and the organic fertilization did not differ from the chemical fertilization in the traits of the quantitative yield except for the trait of diameter and perimeter of the curd, where the superiority was significant for chemical fertilization compared to rice waste, which recorded the lowest diameter and perimeter. In the results of bi-interaction, it is noted that some bi-interaction has significantly affected the traits of the quantitative yield. No significant differences were observed in planting distances and fertilization factors on the traits of quantitative and qualitative yield. It is noted from the results of the bi-interaction that there is a variation in the significant and non-significant effect on the qualitative and quantitative traits.

Keywords: broccoli, planting distance, organic fertilization.

تأثير مسافة الزراعة و التسميد العضوي في نمو وحاصل البروكلي (Brassica olerace var . Italica)

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المخلص:-

نفذت التجربة في حقول قسم البستنة وهندسة الحدائق كلية الزراعة /جامعة القاسم الخضراء خلال الموسم الزراعي 2017-2018 لدراسة مسافة الزراعة والتسميد العضوي في نمو وحاصل البروكلي ,إذ تضمنت التجربة ثمانية معاملة لكل مكرر هي عبارة عن التداخل بين مسافتي زراعة 50x35 سم و50x50 سم والتسميد العضوي وفي معاملة المقارنة (التسميد الكيميائي 300NPK كغم .هكتار$^{-1}$) ومخلفات الرز15 طناً .هكتار$^{-1}$ ومخلفات الدواجن 3 طن .هكتار$^{-1}$ استخدم نظام القطع المنشقة Split plot design في تصميم القطاعات العشوائية الكاملة RCBD وبثلاثة مكررات ,إذ وضعت مسافات الزراعة في القطع الرئيسة Main plot والتسميد في القطع تحت الثانوية Sub plot وقورنت المتوسطات باستخدام أقل فرق معنوي L.S.D على مستوى احتمال 0.05يمكن تلخيص أهم النتائج بما يلي إنَّ مسافة الزراعة اثرت معنويا في صفة ارتفاع النبات ونسبة الكلوروفيل ,إذ أعطت مسافة 50X50 سم أعلى ارتفاع للنبات ومسافة 50X35 سم أعطت أعلى نسبة كلوروفيل. ويلاحظ أنَّ نتائج التسميد العضوي بمخلفات الرز والدواجن لم تختلف

معنوياً عن نتائج التسميد الكيمائي ارتفاع النبات ونسبة كلوروفيل. ان مسافة الزراعة في جميع صفات الحاصل الكمي المدروسة ولم يختلف التسميد العضوي عن الكيميائي في صفات الحاصل الكمي باستثناء صفة قطر ومحيط القرص الزهري حيث كان التفوق معنوياً للتسميد الكيميائي قياساً بمخلفات الرز التي سجلت أقل قطر ومحيط .في نتائج التداخل الثنائي يلاحظ أنَّ بعض التداخلات الثنائية قد أثرت معنوياً في صفات الحاصل الكمي. لم يلاحظ وجود فروقات معنوية لمسافات الزراعة ومعاملات التسميد على صفات الحاصل الكمية والنوعية ، ويلاحظ من نتائج التداخل الثنائي أن هنالك تباين في التأثير المعنوي وغير المعنوي على صفات الحاصل النوعية والكمية.

الكلمات المفتاحية: بروكلي, مسافة الزراعة, التسميد العضوي.

1. INTRODUCTION

Broccoli (Brassica olerace var. Italica) is considered one of the vegetable crops belonging to the Brassicaceae family. Wild species found in the Mediterranean region, it is an annual herbal plant similar to the morphology of Cauliflower plant, and it was cultivated from ancient times to obtain the middle and lateral curds (Boras et al., 2004; Decoteau, 2000). The crop is harvested before opening the curds. The broccoli plant is characterized by a high nutritional value, where each 100 g of the curds contains 5.9 g of sugars 0.3 fat, 3.6g protein, 32 calories, 89.1g of water. Broccoli has good nutritional value where it is considered one of the foods with low free fat, sodium, and calories, and it is a good source for many vitamins such as vitamin A, C, D, riboflavin, niacin, carotenoids and folic acid (Michaud et al., 2002). Broccoli also has a high therapeutic nutritional value, not all of which are available in another plant. It is a powerful regulator and antibiotic for many common diseases. It reduces high blood pressure and helps to regulate blood sugar and lowers the level of cholesterol in it. It also helps build bones and increasing physical strength. It also helps protect against heart, urinary, and reproductive diseases and reducing the infection with cancer. Broccoli is a rich source of Glucosinoldes, which has been proven to be anti-cancer, it was found that eating more than one meal during the week reduces the risk of cancer with the percentage of 45% as well as it helps prevent infecting with retinal diseases (Kirsh et al., 2007). The plant density per unit area means the distance between cultivated plants and broccoli is usually planted at a distance of 50 cm between one plant and another. Broccoli is a vegetable crop that responds to plant density, where the planting distance directly affects the quantity of the crop and the size, diameter and weight of the main curds and it affects the number of sub-curds formed by the plants and the formation date of the curds and completing their growth, where the density affects the prolong the flowering period. The planting distances between plants and between the cultivation lines have a great influence on the vegetative growth for plants and the quantitative and qualitative yield for the produced curds (Hassan, 2002). Fertilizers play a major role in increasing crop production, whether chemical or organic fertilizers, when cultivating vegetable crops and because of the negative effects for chemical fertilizers on humans and the environment. As a result of these bad effects resulting from the use of chemical fertilizers, the interests in many countries of the world tended to encourage the use of organic fertilizers of various types (animal and plant), being an integrated management and production system that encourages animal and environmental diversity, it raises the soil content of organic matter and improves its chemical and physical properties (Abu Rayyan, 2010). Madhumathi et al., (2017) indicated when studying three planting distances (30 x 50, 45 x 45 and 45 x 60 cm) and four seedling dates (11/20, 10/12, 31/12 and 20/1) for broccoli plant, the planting distances (45 x 60 cm) and the seedling date (12/12) gave significant differences in plant height, number of leaves per plant, stem diameter, curd weight, curd length, the width of the curd and the yield per unit area. Roni et al., (2014) mentioned when studying five levels of nitrogen (0, 80, 120, 160, 200 $kg.ha^{-1}$) and three planting distances (30 x 60, 45 x 60, 60 x 60 cm) for broccoli plants. they were observed that the planting distances (60 x 60) with zero nitrogen

gave the highest values in the percentage of ascorbic acid and carotenoids and the percentage of calcium, while the percentage of iron was higher in the planting distance (60 x 60 cm) with fertilization of (200 $kg.ha^{-1}$ nitrogen) and the percentage of potassium was higher in the planting distance (45 x 60 cm) with fertilization of (120 $kg.ha^{-1}$ nitrogen). Turbin et al., (2012) found that the best height for cauliflower was at a planting distance of (70 x 50 cm) amounted to (60.9 cm). Manea and Abbas, (2018) showed that adding rice wastes and palm frond residues under three levels of spraying with seaweed extracts for the broccoli cultivar (MAX). It gave the highest plant height, the number of leaves, leaf area, and head diameter amounted to (68.32 cm, 25.40 $leaves.plant^{-1}$, 14,352 $cm^2.Plant^{-1}$, 22.23 cm), respectively, when using (20 $tons.ha^{-1}$) of rice waste, While the highest head weight and the number of sub-heads amounted to (687.2 $g.plant^{-1}$ and 4.75 $sub\text{-}head.plant^{-1}$) when using 20 tons of palm frond fertilizer. Jigme et al., (2015) observed when using organic fertilizer (poultry manure extract) were given in three concentrations of (control, 100 ml/week, 200 ml/week) and chemical fertilizer (42.73 g NPK, 31.76 P_2O_5, and 26.96 K_2O g/m) In addition to the control (without fertilizer), the traits of vegetative growth (stem diameter, number of leaves, leaf width, length of plant and plant weight) and The traits of yield (head weight and head yield) were significantly excelled at chemical fertilization but did not differ significantly with the addition of 200 ml per week of poultry manure extract. According to the above, this study aims to determine the appropriate planting distance and the effect of adding organic matter on the growth and yield of broccoli.

2. MATERIALS AND METHODS

The experiment was conducted in the fields of the Department of Horticulture and Landscape Gardening, College of Agriculture, Al-Qasim Green University during the agricultural season (2017-2018) in order to study the effect of planting distance and organic fertilization on growth and yield of Broccoli (Brassica oleracea var. Italica). Samples were taken from the field soil and from different regions before starting the experiment with a depth of 30 cm of the surface layer (root zone). It was then aerobically dried, ground and passed through a 2 mm sieve diameter, and analyzed to see some chemical and physical traits for the field soil. Table (1) shows some of the physical and chemical traits for the soil experiment before cultivating.

Table 1: Some physical and chemical traits for a field soil before cultivating.

Traits	Units	Value
Degree of soil reaction (pH)	---	7.01
Electrical conductivity (EC)	$dS.m^{-1}$	3.6
Organic matter	$g.kg^{-1}$	1.6
Nitrogen availability	$mg.kg^{-1}$	31
Phosphorous availability		5
Potassium availability		100
Sand	$g.kg^{-1}$	335
Silt		334
Clay		331
Soil texture		**Silty loam**

The chemical and physical traits for the soil were analyzed in the College of Agriculture Laboratory, Al Qasim Green University.

The field soil designated for the experiment was prepared, after removing the growing weeds and plants, the of plowing, smoothing and leveling processes were conducted in a good and homogeneous manner, the land was then divided into three replicates to include each

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replicate of 18 experimental units, where the one unit was represented with dimensions of (3x1m length x width). The distance between the terrace and another was 0.75 m, leaving a distance of 0.75 m between the units as an insulator to prevent mixing between treatments with leaving a barrier distance at the beginning and end of each sector and mixing fertilizer with soil. The drip irrigation system was installed, and all the experimental units were then covered with black plastic cover. The seeds of the broccoli (parasio cultivar) were sown in cork dishes. After the seedlings reached the stage of four _ five real leaves, it was transported in the afternoon to the field on 10/10/2017. The seedlings were planted inside the terraces according to the planting distances, and the cultivated plants were taken care of from the first day until the completion of the ripening process. The experiment included studying the following factors:

The first factor: The seedlings were planted in the permanent field at planting distances as follows:

The first planting distance is (35 x 50 cm).

The second planting distance is 50 x 50 cm (35 and 50 cm between plants and 50 cm between planting lines).

The second factor: organic fertilizers: the following levels included rice waste fertilizer (15 tons.ha^{-1}) and dried poultry manure fertilizer (3 tons.ha^{-1}). The control treatment is the chemical fertilization (300 kg.ha^{-1} NPK).

Table 2: Physical and chemical traits for organic fertilizers.

Traits	Units	Rice waste	Poultry manure
Ec	dS.m^{-1}	-	0.93
pH	-	%7	6.50
C	%	%41	44.6
Total N	%	%4	2.48
C/N	%	-	18.0
P2O5	%	%4	0.540
K2O	%	%4	0.260
Ca	%	-	1.30
Mg	%	%0.5	0.38
Na	%	-	0.430
Fe	%	%0.8	0.259
Zn	%	-	0.031
Mn	%	-	0.011
Cu	%	-	0.003
Humidity	%	%12	35-30

The split-plot design system was used according to the Randomized Complete Block Design (RCBD), with three replicates, where the planting distances were placed in the main plot and the fertilization in the subplot.

The studied traits: Several measurements were made on vegetative growth and included the plant height (cm) and the percentage of chlorophyll in the leaves (Spad)

The yield traits: It was measured and included the diameter of the main curd (cm), the perimeter of the curd (cm), the percentage of nitrogen (N%), the percentage of potassium (K%) and the percentage of protein, and estimating the nitrate content in the curd (mg.g^{-1}).

3. RESULTS AND DISCUSSION

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Table (3) indicates that there were significant differences between planting distances in plant height, where the planting distance (50 x 50 cm) has excelled by giving it the highest average plant height amounted to (55.33 cm) compared to a planting distance (35 x 50) which gave (49.85 cm). The results of the same table show that fertilization treatments did not significantly affect the plant length. The results of the bi-interactions indicate the presence of significant differences between the bi-interaction of the planting distance and fertilization, where the bi-interaction treatment between the planting distance (50x50 cm) and fertilization with rice waste achieved the highest plant length amounted to (56.0 cm), which did not differ significantly from chemical fertilization and fertilization with poultry manure compared to the planting distance (35x50 cm), and chemical fertilization, which gave the lowest length amounted to (48.56 cm).

Table 3: Effect of planting distances, fertilization treatments and their interaction on plant length (cm).

Distances (cm)	Chemical fertilization (NPK)	Rice waste	Poultry manure	Average of Distance
35x50	48.56	49.56	51.44	49.85
50 x50	55.56	56.00	54.44	55.33
Average of fertilization	52.06	52.78	52.94	For distance = 4.49
LSD	For fertilization = NS	For interaction = 4.99		

Table (4) indicates that there were significant differences between the planting distances in the percentage of chlorophyll, where the planting distance (50x50 cm) has excelled by giving it the highest percentage of chlorophyll amounted to (81.5 spads) compared to the planting distance (35x50 cm) which gave (74.2 spads). The results of the same table show that fertilization treatments did not significantly affect the percentage of chlorophyll. The results of the bi-interactions indicate the presence of significant differences between the bi-interaction of the planting distance and fertilization, where the bi-interaction treatment between the planting distance (50x50 cm) and fertilization with poultry manure achieved the highest percentage of chlorophyll amounted to (83.7 spads) compared to fertilization with poultry manure at a planting distance of 35x50 cm, which amounted to (72.3 spads).

Table 4: Effect of planting distances, fertilization treatments and their interaction on the percentage of chlorophyll (spad).

Distances (cm)	Chemical fertilization (NPK)	Rice waste	Poultry manure	Average of Distance
35x50	74.6	75.7	72.3	74.2
50 x50	81.0	79.9	83.7	81.5
Average of fertilization	77.8	77.8	78.0	For distance = 6.29
LSD	For fertilization = NS	For interaction = 8.07		

Table (5) indicates that the planting distance did not significantly affect the diameter of the main curd, while the results of the same table showed significant differences for the diameter of the curd, where chemical fertilization has excelled by giving it the highest average of curd diameter amounted to (16.22 cm) compared to rice waste which gave the lowest curd diameter amounted to (15.14 cm). The results of the bi-interactions indicate the presence of significant differences between the bi-interaction of the planting distance and fertilization, where the bi-interaction treatment between the planting distance (50x35 cm) and chemical fertilization

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achieved the highest curd diameter amounted to (16.60 cm) compared to fertilization with rice wastes at a planting distance of 35x50 cm, which amounted to (14.37 cm).

Table 5: Effect of planting distances, fertilization treatments and their interaction on the curd diameter (cm).

Distances (cm)	Chemical fertilization (NPK)	Rice waste	Poultry manure	Average of Distance
35x50	16.60	14.37	15.47	15.48
50 x50	15.84	15.92	16.49	16.09
Average of fertilization	16.22	15.14	15.98	For distance = NS
LSD	For fertilization = 0.81	For interaction = 1.53		

Table (6) indicates that there were no significant differences in planting distances and fertilization treatments in the percentage of nitrogen. The results of the bi-interactions between planting distances and fertilization showed that they did not significantly affect the percentage of nitrogen in the main curd.

Table 6: Effect of planting distances, fertilization treatments and their interaction on the percentage of nitrogen in the main curd.

Distances (cm)	Chemical fertilization (NPK)	Rice waste	Poultry manure	Average of Distance
35x50	4.00	4.78	5.17	4.65
50 x50	3.72	4.76	4.35	4.28
Average of fertilization	3.86	4.77	4.76	For distance = NS
LSD	For fertilization = NS	For interaction = NS		

Table (7) indicates that the planting distance and fertilization treatments, as well as bi-interactions, did not significantly affect the percentage of potassium in the main curd.

Table 7: Effect of planting distances, fertilization treatments and their interaction on the percentage of potassium in the main curd.

Distances (cm)	Chemical fertilization (NPK)	Rice waste	Poultry manure	Average of Distance
35x50	5.98	5.73	6.59	6.10
50 x50	7.01	7.10	6.59	6.90
Average of fertilization	6.49	6.42	6.59	For distance = NS
LSD	For fertilization = NS	For interaction = NS		

Table (8) indicates that the planting distances did not significantly affect the perimeter of the curd, while significant differences were observed in the perimeter of the disc at fertilization treatments, where chemical fertilization has excelled by giving it the highest average amounted to (51.09 cm) compared to fertilizing with rice wastes which amounted to (47.62 cm) and the results of bi-interaction between the planting distance and fertilization indicate the absence of significant differences in the perimeter of the curd.

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Table 8: Effect of planting distances, fertilization treatments and their interaction on the perimeter of the curd.

Distances (cm)	Chemical fertilization (NPK)	Rice waste	Poultry manure	Average of Distance
35x50	52.09	45.66	47.73	48.49
50 x50	50.10	49.58	52.14	50.61
Average of fertilization	51.09	47.62	49.94	For distance = NS
LSD	For fertilization = 2.87	For interaction = NS		

Table (9) indicates that the planting distance and spraying with boron and fertilization treatments did not significantly affect the percentage of protein. The results of the bi-interactions indicate that the bi-interaction between distance and boron and between distance and fertilization, which did not significantly affect the percentage of protein, while it was observed that the interaction between boron and fertilization had a significant effect on the percentage of protein, where the bi-interaction treatment between spraying with boron (200 mg.L^{-1}) and poultry manure gave the highest percentage amounted to (36.1%) compared to the spraying treatment with water only (0 mg boron) and chemical fertilization amounted to (23.1%).

Table 9: Effect of planting distances, fertilization treatments and their interaction on the percentage of protein in the main curd.

Distances (cm)	Chemical fertilization (NPK)	Rice waste	Poultry manure	Average of Distance
35x50	25.0	29.3	32.3	28.9
50 x50	23.4	29.7	27.2	26.8
Average of fertilization	24.2	29.5	29.8	For distance = NS
LSD	For fertilization = NS	For interaction = NS		

Table (10) indicates that the planting distance and fertilization treatments did not affect the content of nitrate in the main curd. It is noted from the results of the bi-interaction between the planting distance and fertilization a significant effect on the content of nitrate in the main curd, where the planting distance (35x50 cm) and fertilization with rice wastes gave the lowest content of nitrate amounted to (37 mg.kg^{-1}), while the planting distance (50x50 cm) and fertilization with rice waste gave the highest content amounted to (74.4 mg.kg^{-1}).

Table 10: Effect of planting distances, fertilization treatments and their interaction on the content of nitrate in the main curd.

Distances (cm)	Chemical fertilization (NPK)	Rice waste	Poultry manure	Average of Distance
35x50	65.1	37.9	51.2	51.4
50 x50	59.1	74.4	60.5	64.6
Average of fertilization	62.1	56.2	55.8	For distance = NS
LSD	For fertilization = 33.71	For interaction = NS		

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It is noted from the results of the traits of vegetative growth under study that the planting distance affected the plant height and the percentage of chlorophyll as shown in tables (4, 3). It was found that the planting distance (50x50 cm) was significantly excelled as shown in Table (4) by giving it the highest plant height amounted to (55.33 cm) compared to the plant distance (35x 50 cm) which gave (49.85 cm), The reason is due to the increase in the nutritional area for the cultivated plants over a wide distance, which led to obtaining a high percentage of nutrients, water, and light, which improved vegetative growth and its reflection on the increase in the percentage of chlorophyll as shown in Table (4). These results agree with (Moniruzzam, 2006). The results of Tables (5 and 8) showed that the addition of organic fertilizer had a significant effect on the traits of the yield, The reason is that organic fertilizers improve the physical, chemical, and fertile soil properties, increasing the absorption of some necessary nutrients for the plant and encouraging physiological activities within it; which reflected positively on them, but the superiority was to chemical fertilization (NPK), This is due to the rapid decomposition of chemical fertilizers and its ability to supply the plant with high concentrations of chemical elements. This encouraged bio-activities in the plant and increasing photosynthesis, which positively affected the diameter and perimeter of the head.

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