

EFFECT OF PLANTING DATE AND PHOSPHATE FERTILIZATION ON GROWTH AND YIELD OF BROCCOLI PLANTED IN SOUTHERN IRAQ

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ABSTRACT

The experiment was conducted during the winter season 2017-2018 on broccoli variety Paraiso under desert conditions in southern Iraq, as it nine factorial treatments in which three planting dates interacted (1/9, 15/9 and 1/10) and three levels of phosphate fertilization (0, 400 and 800 kg ha⁻¹) added once after two weeks of transplanting, to find out the best date and level of fertilization that will affect growth, increase production and improve its quality, the results showed that plants grown on the first date, as well as plants fertilized at the level of 800 kg ha⁻¹ were significantly higher in vegetative growth indicators represented by plant height, number of leaves, leaf area and fresh and dry weights of the total vegetative growth, and yield indicators that included weight (666.15, 552.75 g) and curd diameter, number and weight of lateral curds, yield of a plant (0.789, 0.656 kg) and total productivity (17.36, 14.44 ton ha⁻¹) and the qualitative and chemical characteristics that included crud total chlorophyll concentration (4.17, 3.96 mg 100 g⁻¹ fresh weight), percentage of total soluble solids (9.60, 8.75%), vitamin C (87.23, 79.77 mg 100 g⁻¹ fresh weight), total soluble carbohydrates (28.95, 25.32 mg g⁻¹ dry weight) and the percentage of total nitrogen, phosphorous, potassium and sulfur. Only the first date plants exceeded in stem diameter, while first and second dates and plants fertilized at the level of 800 kg ha⁻¹ significantly exceeded in the percentage of dry matter. The bilateral interaction between the experiment factors achieved a significant effect on some of the characteristics under study.

Keywords: Broccoli, Planting date, Phosphate fertilization, Vegetative growth.

تأثير موعد الزراعة والتسميد الفوسفاتي في نمو وحاصل البروكولي المزروع في جنوب العراق

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المستخلص

اجريت التجربة اثناء الموسم الشتوي 2017 – 2018 على نبات البروكولي صنف paraiso تحت الظروف الصحراوية جنوبي العراق، إذ تضمنت تسعة معاملات عاملية تداخل فيها ثلاثة مواعيد للزراعة (9/1 و 9/15 و 2017/10/1) وثلاثة مستويات من التسميد الفوسفاتي (0 أو 400 أو 800 كغم هكتار⁻¹) تضاف على دفعة واحدة بعد اسبوعين من الشتل، لمعرفة افضل موعد ومستوى سمادي تأثيرا في النمو وزيادة الإنتاج وتحسين نوعيته، أوضحت النتائج تفوق النباتات المزروعة بالموعد الاول وكذلك النباتات المسمدة بالمستوى 800 كغم هكتار⁻¹ معنويا في مؤشرات النمو الخضري متمثلة في ارتفاع النبات وعدد الأوراق والمساحة الورقية والوزنين الطري والجاف للمجموع الخضري، وفي مؤشرات الحاصل التي شملت وزن (666.15, 552.75 غم) وقطر القرص الزهري الرئيس وعدد ووزن الاقراص الجانبية وحاصل النبات الواحد الكلي (0.789, 0.656 كغم) والانتاجية الكلية للاقراص الزهرية (17.36, 14.44 طن هكتار⁻¹)، وفي الصفات النوعية والكيميائية التي تضمنت تركيز الاقراص الزهرية الرئيسة من الكلوروفيل الكلي (4.17, 3.96 ملغم 100غم⁻¹ وزن طري) والنسبة المئوية للمواد الصلبة الذائبة الكلية (9.60, 8.75 %) وفيتامين C (87.23, 79.77 ملغم 100غم⁻¹ وزن طري) والكربوهيدرات الذائبة الكلية (28.95, 25.32 ملغم 100غم⁻¹ وزن طري) والنسبة المئوية للنتروجين الكلي والفسفور والبوتاسيوم والكبريت. تفوقت نباتات الموعد الاول فقط في قطر الساق في حين تفوقت نباتات المواعدين الاول والثاني والنباتات المسمدة بالمستوى 800 كغم هكتار⁻¹ معنويا في النسبة المئوية للمادة الجافة. تفوقت نباتات المستوى 800 كغم هكتار⁻¹ فقط في قطر الاقراص الجانبية. حقق التداخل الثنائي بين عوامل التجربة تأثيرا معنويا في بعض الصفات قيد الدراسة.

الكلمات المفتاحية: البروكولي، موعد الزراعة، التسميد الفوسفاتي، النمو الخضري.

INTRODUCTION

Broccoli (*Brassica oleracea* var. Italica) is a plant of the family Brassicaceae. The planting date is considered the most important factor among the factors affecting the growth and yield characteristics of different crops, as it determines the chance of success or failure of the crop. Broccoli is classified from plants that need a moderate atmosphere that tends to warmth during the vegetative growth stage at the beginning of its life, and to a moderate to cold atmosphere during the formation of heads (Matloob *et al.*1989). Yaseen and Ahmed (2017), studied the effect of planting date on growth and yield of broccoli hybrid variety Agassi F1, on two dates which were 20/10 and 10/11/2016, and it was found that the second date gave the highest main crud weight which reached 347.62 g, and the highest total yield 2438.17 g, compared to the first date, which recorded the lowest main crud weight reached 253.16 g, the lowest total yield 2260.89 g and the highest lateral curd weight reached 199.01 g, compared to the second date, which gave the lowest yield of it reached 140.01 g. Kanase *et al.* (2018), noticed during their study to find out the effect of different planting dates on the growth and yield of broccoli variety Green Magic, which was planted on eight dates: 11/10, 18/10, 25/10, 1/11, 8/11, 15/11, 22/11 and 29/11/2016, that the date 1/11 gave the highest values of growth and production indicators, as the plant height reached 59.82 cm, number of

leaves was 23.00, leaf area was 724.00 cm², weight and diameter of the main curd were 638.84 g and 20.88 cm, the or a yield of a plant was 30.07 kg., total yield 4,455 ton ha⁻¹, chlorophyll concentration 0.31 mg 100g⁻¹ fresh weight and Vitamin C concentration 125.50 mg 100 g⁻¹ fresh weight in the curds. In a study conducted by Yassin (2018) to find out the effect of three planting dates on the growth and yield of broccoli, which were 1/8, 15/8, and 1/9/2017, it was found that the plants planted on the third date significantly exceeded the percentage of nitrogen, phosphorus, potassium, and sulfur in the curd, reaching 1.92, 0.54, 2.22 and 1.53% compared to the lowest values recorded on first date plants, which were 1.70, 0.49, 2.07 and 1.23% for each, respectively. Latif *et al.* (2019) concluded in their study to find out the effect of planting dates on two varieties of broccoli, Rocco F1 and Galabrese, under semi-arid conditions in Pakistan, as the plants were planted on 15/9, 1/10, 15/10, 1/11, and 15/11/2013 that the most suitable date for planting was the first week of October (1/10), as the plants planted on that date exceeded all other dates in weight and diameter of the main curd (299.99 g and 14.50 cm), number and weight of lateral curd (7.3 curds and 221.1 g), chlorophyll concentration in leaves (71.91 mg 100 g⁻¹ fresh weight) and total yield (20.84 ton ha⁻¹) compared to the lowest values that appeared on the 15/11 date plants, as they reached 156.43 g, 12.03 cm and 3.4 curds, 27.46 g, 69.82 mg 100 g⁻¹ fresh weight and 7.36 ton ha⁻¹ for the mentioned characteristics respectively. In an experiment that included the planting of four broccoli varieties (Palam Samridhi, Palam Vichitra, Pusa Broccoli KTS-1, and Palma Haritika) on three dates: 1/12, 15/12, and 30/12/2015 Patel *et al.* (2019) found that the best date for planting was on 15/12, as the plants significantly exceeded on that date in plant height 64.23 cm and number of leaves 19.79 leaves compared to the lowest values found on the 1/12 date plants, reaching 58.33 cm and 19.72 leaves for the mentioned characteristics respectively.

Fertilization is one of the most important crop service operations and one of the important agricultural production methods in increasing the qualitative and quantitative traits of production because of its great impact on regulating the plant's nutritional conditions, especially the abundance of the macrolelements, including phosphorus, which is one of the essential and basic nutrients needed by the plant in its different growth stages as it works to reduce the harmful effect of increasing nitrogen in the soil because its abundance reduces the absorption of inorganic nitrogen and thus early in ripening and eliminates the harmful effect of increasing the nitrogen component that directs the plant towards the vegetative growth, and also encourages roots growth, especially the adventitious and fibrous roots (Hassan, 2016) , but the small quantities of it in the soil may not meet the needs of different plants, and this may require fertilization with the triple superphosphate fertilizer, which is one of the most important fertilizers used in this field. The quantity

required to obtain maximum yield varies greatly, according to the variation of the soil characteristics, climatic conditions, and the cultivated plant needs, Islam *et al.* (2010) confirmed in an experiment on broccoli plant when the triple superphosphate fertilizer was added in three levels (0, 100 and 200 kg P₂O₅ ha⁻¹), there was a significant increase in yield indicators of the plants fertilized at level 200 kg P₂O₅ ha⁻¹ compared to the comparison treatment plants, as the values of the main curd diameter for both levels were 15.12, 13.30 cm, and its weight 163.40, 127.71 g, number and weight of the lateral curds were 4.31, 3.74 curds and 54.64, 32.08 g and total yield 8.05, 5.89 ton ha⁻¹. Katiyar *et al.* (2012) found that the best yield for broccoli plant when adding four levels of mono superphosphate fertilizer (0, 30, 60, and 90 kg P₂O₅ ha⁻¹) was at the 90 kg P₂O₅ ha⁻¹ fertilization level as it reached 1.60 ton ha⁻¹ compared to the lowest yield at the 30 kg P₂O₅ ha⁻¹ fertilization level (1.46 ton ha⁻¹). Hassan *et al.* (2013) concluded that adding five levels of phosphorus (22.8% P₂O₅) to broccoli variety Condi (0, 50, 75, 100, and 125 kg dunum⁻¹) indicated a significant increase at the 100 kg dunum⁻¹ fertilization level as the plant height reached 49.15, 50.15 cm, number of leaves 18.58, 18.41 leaves, leaf area 480.82 447.72 cm², main curd weight 739.6, 674.7 g, and its diameter 32.15, 30.62 cm, the percentage of total soluble solids 8.01, 8.27%, vitamin C concentration 116.6, 115.9 mg 100 g⁻¹ fresh weight, in the main curd and total plant yield 4.16, 7.28 ton ha⁻¹, compared to the lowest values for the comparison treatment plants as they were 43.87, 43.23 cm, 15.41, 15.66 leaves, 365.67, 380.17 cm², 577.9, 511.9 g 29.6, 26.38 cm, 5.68, 6.1%, 89.1, 86.6 mg 100 g⁻¹ fresh weight and 3.08, 3.13 ton ha⁻¹ for the mentioned characteristics for both seasons respectively. Neethu *et al.* (2015) indicated that adding phosphate fertilizer to broccoli at four levels, which were 0, 40, 60, and 80 kg P₂O₅ ha⁻¹ led to a significant increase in the plants fertilized at the 80 kg P₂O₅ ha⁻¹ level compared to comparison treatment plants that showed the lowest values, as the values for both levels in plant height were 24, 23.14 cm, number of leaves 16.92, 16.34 leaves, leaf area 4821, 4489 cm², total yield 39.54, 36.38 ton ha⁻¹ and the percentage of nitrogen 4.42, 4.04%, phosphorus 0.99, 0.94%, potassium 4.69, 4.51%, sulfur 0.14, 0.12 respectively in the main curd. Kamlesh (2017) indicated the effect of adding four levels of mono superphosphate fertilizer (16% P₂O₅) on the growth and yield of broccoli plant (0, 25, 50, and 75 kg P₂O₅ ha⁻¹), that the fertilizer level 50 kg P₂O₅ ha⁻¹ exceeded compared to the comparison treatment plants which gave the lowest values as it reached for both levels in plant height 30.02, 28.62 cm, number of leaves 17.81, 16.85 leaves, leaf area 808.23, 722.25 cm², stem diameter 2.48, 2.35 cm, diameter 14.23, 13.02 cm and weight 197.60, 172.91 g of the main curd, yield of a plant 5.87, 5.15 kg and total plant yield 724.4, 635.3 ton ha⁻¹.

In light of the above and given the lack of studies on broccoli plant in Iraq, the experiment was conducted to find out the most appropriate date among the

three dates for planting the plant, as well as the effect of adding different levels of phosphate fertilization (triple superphosphate 47% P_2O_5) on the growth and yield of broccoli variety paraiso under the desert conditions in southern Iraq.

MATERIALS AND METHODS

The experiment was conducted during the winter season 2017-2018 in the project of developing tomato cultivation with modern technologies of Basra Agriculture Directorate in Khor Al-Zubair, in a mixed sandy soil with a pH of 7.31 and electrical conductivity of 7.11 Des.m^{-1} , the maximum and minimum temperatures and relative humidity were recorded for the research area during planting season, using the data of Al-Barjisiah agricultural research station near the site Table, 1. The experiment included nine factorial treatments in which three planting dates interacted (1/9, 15/9, and 1/10/2017) and three levels of phosphate fertilization (0, 400, and 800 kg ha^{-1}) added once after two weeks of transplanting. Randomized Complete Block Design was used for a split-plot design, as the planting dates were considered the main plots and the fertilization levels with triple superphosphate were considered the sub-plots and by three replications so that the number of units would be 27 experimental units. The mean results were analyzed statistically using Genstat, V. 10.3 (2011), and the Least Significant Difference Test (L.S.D.) was used to compare the averages at a probability level of 0.05 (Al-Rawi and Khalaf Allah, 1980). The soil of the field was plowed twice, perpendicularly, smoothed, and flattened, then divided into three sectors. Each sector contained nine lines with a length of 30 m, width 40 cm, height of 15 cm, and a distance of 80 cm between one line and another so that the number of experimental units became nine experimental units within each sector. Seedlings were planted at a distance of 50 cm between one and another so that the number of plants in the line would be 60 plants, and the density of 22000 plants per hectare. The agricultural operations were conducted according to the recommendations followed in broccoli cultivation (Matloob *et al.* 1989). The seedlings were transferred to the field after the calibration irrigation with the addition of some peatmoss around the roots during the transplantation to maintain soil moisture. Broccoli hybrid seeds Paraiso which were produced by Syngenta (Australia), and imported by Debbane Modern Agriculture Company Ltd., were sown at the mentioned dates.

Table 1. Maximum and minimum temperatures (°C) and relative humidity during the agricultural season 2017-2018

| Season (2017 – 2018) | | | | | | | |
|----------------------|------------------|---------|-----------------------|------------|------------------|---------|-----------------------|
| Date | Temperature (°c) | | Relative humidity (%) | date | Temperature (°c) | | Relative humidity (%) |
| | Maximum | Minimum | | | Maximum | Minimum | |
| 10/09/2017 | 46.20 | 28.14 | 35.54 | 10/01/2018 | 21.05 | 7.51 | 69.78 |
| 20/09/2017 | 45.18 | 26.26 | 29.95 | 20/01/2018 | 21.30 | 6.08 | 73.46 |
| 30/09/2017 | 42.72 | 24.59 | 35.05 | 31/01/2018 | 19.62 | 6.06 | 74.06 |
| 10/10/2017 | 38.32 | 21.55 | 40.14 | 10/02/2018 | 24.02 | 5.28 | 57.84 |
| 20/10/2017 | 36.43 | 20.11 | 33.96 | 20/02/2018 | 25.56 | 13.24 | 73.33 |
| 31/10/2017 | 36.08 | 18.84 | 59.89 | 02/03/2018 | 23.39 | 13.41 | 89.34 |
| 10/11/2017 | 32.90 | 18.38 | 77.98 | 12/03/2018 | 29.00 | 14.08 | 80.45 |
| 20/11/2017 | 26.94 | 11.98 | 59.46 | 22/03/2018 | 28.58 | 14.08 | 63.39 |
| 30/11/2017 | 21.63 | 10.51 | 78.00 | 02/04/2018 | 34.65 | 17.02 | 54.83 |
| 10/12/2017 | 20.66 | 7.23 | 66.21 | | | | |
| 20/12/2017 | 21.43 | 6.46 | 70.70 | | | | |
| 31/12/2017 | 24.82 | 9.56 | 74.88 | | | | |

The service operations were performed in a similar manner to all seedlings and were transferred to the field at the age of 45 days from planting for each date after the hardening process. the seedling contained an average of 4-6 leaves, and an average height of 10-12 cm. Field data were taken from five plants randomly selected from each experimental unit at the end of the harvest season for each date, the average was calculated for each plant and included plant height (cm), stem diameter (cm), number of leaves, leaf area (Dcm²) according to Watson and Watson (1953), fresh (kg) and dry (g) weights of the total vegetative, weight (g) and diameter (cm) of main curd, number ,weight (g) and diameter (cm) of lateral cruds, total yield of plant(kg) and total productivity of the floral cruds(ton ha⁻¹), cruds qualitative and chemical characteristics which included total chlorophyll concentration (mg 100g⁻¹ fresh weight) according to Abbas and Abbas, (1992), percentage of total soluble solids and vitamin C (mg 100g⁻¹ fresh weight) as shown by A.O.A.C. (1970) , percentage of dry matter and total soluble carbohydrates (mg g⁻¹ dry weight) in the manner described by Dubois *et al.* (1956) , percentage of

nitrogen and potassium depending on the method of Page *et al.* (1982), phosphorous according to Murphy and Riley (1962), and sulfur according to the method described by Patel *et al.* (1997).

RESULTS AND DISCUSSION

Table 2 shows the effect of planting date and phosphate fertilization and their interactions on the vegetative growth characteristics of the hybrid broccoli Parasio, as the first date plants (1/9) significantly exceeded in plants height, stem diameter, number of leaves, leaf area, and fresh and dry weights of the total.

Table 2. effect of planting dates and phosphate fertilization and their interactions on the vegetative Growth characteristics of the broccoli hybrid Parasio

| Planting date | Phosphate fertilization (kg ha ⁻¹) | Plant height (cm) | Stem diameter (cm) | Number of leaves | Leaf area (Dcm ²) | Total vegetative fresh weight (kg) | Total vegetative dry weight (g) |
|--------------------------|--|-------------------|--------------------|------------------|-------------------------------|------------------------------------|---------------------------------|
| First date 1/9/2017 | 0 | 58.78 | 4.87 | 21.44 | 50.58 | 0.98 | 151.43 |
| | 400 | 59.38 | 4.93 | 21.63 | 51.40 | 1.08 | 164.29 |
| | 800 | 59.74 | 4.88 | 23.30 | 51.95 | 1.13 | 168.23 |
| Second date 15/9/2017 | 0 | 55.25 | 4.32 | 18.07 | 41.32 | 0.55 | 95.40 |
| | 400 | 56.74 | 4.56 | 19.67 | 46.73 | 0.59 | 101.74 |
| | 800 | 56.96 | 4.64 | 19.78 | 47.02 | 0.60 | 103.58 |
| Third date 1/10/2017 | 0 | 55.46 | 4.42 | 18.48 | 42.93 | 0.48 | 83.91 |
| | 400 | 55.74 | 4.50 | 19.67 | 43.80 | 0.51 | 87.90 |
| | 800 | 56.52 | 4.67 | 19.78 | 46.52 | 0.60 | 100.74 |
| R.L.S.D. 5% | | NS | NS | NS | 0.52 | 0.02 | 2.93 |
| Date average | First date | 59.30 | 4.89 | 22.12 | 51.31 | 1.06 | 161.32 |
| | Second date | 56.32 | 4.51 | 19.17 | 45.02 | 0.58 | 100.24 |
| | Third date | 55.91 | 4.53 | 19.31 | 44.41 | 0.53 | 90.85 |
| R.L.S.D. 5% | | 0.20 | 0.03 | 0.45 | 0.36 | 0.02 | 2.90 |
| Phosphate average level | 0 | 56.50 | 4.54 | 19.33 | 44.94 | 0.67 | 110.25 |
| | 400 | 57.29 | 4.66 | 20.32 | 47.31 | 0.72 | 117.98 |
| | 800 | 57.74 | 4.73 | 20.95 | 48.49 | 0.77 | 124.18 |
| R.L.S.D. 5% | | 0.26 | NS | 0.46 | 0.32 | 0.01 | 1.13 |

Vegetative growth. The plants fertilized with phosphorus significantly exceeded the comparison treatment plants in the mentioned characteristics, stem diameter, as the plants fertilized at the level of 800 kg ha⁻¹ exceeded that. The bilateral interaction between planting date and phosphate fertilization showed the superiority of the first date plants fertilized at the level of 800 kg ha⁻¹ in leaf area (51.95 Dcm²) and fresh (1.13 kg) and dry (168.23 g) weight of the total vegetative growth.

Table 2 results showed the superiority of the first date plants (1/9) in the vegetative growth indicators compared to the second (15/9) and third (1/10) dates plants, and this might be due to the suitability of climatic conditions, especially the temperature during plant's early growth stages which give plants with a good total vegetative Table, 1 and this is consistent with Hassan (2004) that broccoli needs a moderate atmosphere that tends to warmth during the vegetative growth stage at the beginning of its life, and the positive effect of phosphate fertilization on vegetative growth indicators in the aforementioned characteristics compared to the comparison treatment plants might also be due to the increased absorption of nutrients, including phosphorus, which plays an important role in the process of photosynthesis, plant cell division and regulation of vital activities, and this is reflected positively on plant growth and development (El-Gizawy and Mehasen, 2009), and this comes in line with Al-Batawi (2015) on Broad bean.

Table 3 results showed the superiority of the first date plants in yield characteristics represented by main curd weight and diameter, number, weight, and diameter of the lateral curds, total yield of the plant, and total productivity of the floral curds. The plants fertilized with phosphorus significantly exceeded compared to the comparison treatment plants in the aforementioned characteristics, and the plants fertilized at the level of 800 kg ha^{-1} were significantly superior to those fertilized at the level of 400 kg ha^{-1} then the comparison treatment plants which gave the lowest yield. The bilateral interaction between planting date and phosphate fertilization did not have a significant effect on most of the yield characteristics, the first date interaction with phosphate fertilization at the level of 800 kg ha^{-1} in main curd diameter (20.79 cm) curd weight (129.77 g) and diameter (8.63 cm) of the lateral curds.

Table 3. Effect of planting dates and phosphate fertilization and their interactions on the yield Characteristics of the broccoli hybrid Parasio

| Planting date | Phosphate fertilization (kg ha ⁻¹) | Main curd weight (g) | Main curd diameter (cm) | Number of lateral cruds | Lateral curds weight (g) | Lateral curds diameter (cm) | Total plant yield (kg) | Cruds total productivity (ton ha ⁻¹) |
|--------------------------|--|----------------------|-------------------------|-------------------------|--------------------------|-----------------------------|------------------------|--|
| First date 1/9/2017 | 0 | 620.46 | 19.75 | 7.28 | 115.18 | 7.29 | 0.736 | 16.19 |
| | 400 | 670.37 | 20.30 | 7.85 | 123.15 | 7.70 | 0.793 | 17.46 |
| | 800 | 707.61 | 20.79 | 8.80 | 129.77 | 8.63 | 0.837 | 18.42 |
| Second date 15/9/2017 | 0 | 342.20 | 15.54 | 5.26 | 60.11 | 5.58 | 0.402 | 8.85 |
| | 400 | 464.95 | 17.61 | 6.24 | 89.19 | 6.39 | 0.554 | 12.19 |
| | 800 | 484.79 | 17.84 | 6.37 | 92.14 | 6.48 | 0.577 | 12.69 |
| Third date 1/10/2017 | 0 | 381.00 | 16.16 | 5.41 | 69.41 | 5.77 | 0.450 | 9.91 |
| | 400 | 402.42 | 16.66 | 5.89 | 72.63 | 5.98 | 0.475 | 10.45 |
| | 800 | 465.87 | 17.96 | 6.26 | 88.69 | 6.48 | 0.554 | 12.20 |
| R.L.S.D. 5% | | NS | 0.38 | NS | 2.20 | 0.18 | NS | NS |
| Date average | First date | 666.15 | 20.28 | 7.98 | 122.70 | 7.87 | 0.789 | 17.36 |
| | Second date | 430.65 | 17.00 | 5.96 | 80.48 | 6.15 | 0.511 | 11.24 |
| | Third date | 416.43 | 16.93 | 5.85 | 76.91 | 6.08 | 0.493 | 10.85 |
| R.L.S.D. 5% | | 21.95 | 0.20 | 0.32 | 1.81 | 0.16 | 0.024 | 0.52 |
| Phosphate average level | 0 | 447.88 | 17.15 | 5.98 | 81.57 | 6.21 | 0.530 | 11.65 |
| | 400 | 512.58 | 18.19 | 6.66 | 94.99 | 6.69 | 0.608 | 13.37 |
| | 800 | 552.75 | 18.87 | 7.14 | 103.53 | 7.20 | 0.656 | 14.44 |
| R.L.S.D. 5% | | 25.67 | 0.25 | 0.20 | 1.23 | 0.09 | 0.026 | 0.58 |

The superiority of the first date plants (1/9) in yield and its components represented by main and lateral curds weight, diameter, plant yield, and total productivity might be attributed to the availability of favorable environmental conditions for vegetative growth and its reflection on the increase of the processed nutrients accumulated inside the plant, which led to an increase in the plant total yield and thus an increase in the total productivity, this comes in line with Jarjnazi (2020) who emphasized that the favorable climatic conditions led to the superiority of plants in all studied characteristics and that the superiority in vegetative growth (number and length of leaves) worked to increase the efficiency of the photosynthesis process and thus increasing the processed nutrients and storing the excess at the storage sites then increasing the yield of the carrot plant (*Daucus carota* L.).

The addition of phosphate fertilizer positively affected the yield characteristics and the effect increased with the increase in the level of the added fertilizer, and this might be due to the role of phosphorus in the analysis of carbohydrates and other substances resulted from the photosynthesis process to

release the energy necessary for the plant vital processes and improve plant growth and thus its reflection on the yield quantity and quality (Elahi *et al.* 2015).

Table 4 results showed the effect of planting date and phosphate fertilization and their interactions on the qualitative and chemical characteristics of the broccoli hybrid Parasio, as the first date plants (1/9) exceeded in total chlorophyll, total soluble solids, vitamin C, dry matter, total soluble carbohydrates, nitrogen, phosphorous, potassium, and sulfur the followed by the second and third dates plants respectively, also the plants fertilized with phosphorous significantly exceeded the comparison treatment plants, and the interaction between the two factors showed the superiority of the first date plants (1/9) fertilized at the level of 800 kg ha⁻¹ in total soluble carbohydrates (30.59 mg⁻¹ dry weight), percentage of total soluble solids, nitrogen, potassium, and sulfur as each reached 10, 2.703, 3.063 and 0.418% respectively.

Table 4. effect of planting dates and phosphate fertilization and their interactions on the qualitative and chemical characteristics of the broccoli hybrid

| Planting date | Phosphate fertilization (kg ha ⁻¹) | Total chlorophyll concentration (mg 100g ⁻¹) | Total soluble solids (%) | vitamin C (mg 100g ⁻¹) | Dry matter (%) | Total carbohydrates (mg g ⁻¹) | N (%) | P (%) | K (%) | S (%) |
|--------------------------|--|--|--------------------------|------------------------------------|----------------|---|-------|-------|-------|-------|
| First date 1/9/2017 | 0 | 4.04 | 9.35 | 84.81 | 12.76 | 27.73 | 2.619 | 0.353 | 2.956 | 0.397 |
| | 400 | 4.11 | 9.45 | 85.48 | 13.52 | 28.54 | 2.631 | 0.359 | 3.009 | 0.407 |
| | 800 | 4.37 | 10.00 | 91.41 | 13.57 | 30.59 | 2.703 | 0.392 | 3.063 | 0.418 |
| Second date 15/9/2017 | 0 | 3.48 | 6.68 | 65.15 | 12.87 | 17.03 | 1.363 | 0.274 | 2.487 | 0.313 |
| | 400 | 3.70 | 7.94 | 73.37 | 13.11 | 22.23 | 2.112 | 0.302 | 2.698 | 0.356 |
| | 800 | 3.79 | 8.15 | 74.15 | 13.68 | 22.80 | 2.123 | 0.308 | 2.723 | 0.361 |
| Third date 1/10/2017 | 0 | 3.53 | 7.10 | 67.00 | 12.61 | 18.53 | 1.671 | 0.282 | 2.533 | 0.319 |
| | 400 | 3.58 | 7.34 | 69.37 | 13.03 | 19.67 | 1.947 | 0.286 | 2.590 | 0.333 |
| | 800 | 3.73 | 8.11 | 73.74 | 13.22 | 22.58 | 2.320 | 0.302 | 2.711 | 0.354 |
| R.L.S.D. 5% | | NS | 0.21 | NS | NS | 0.83 | 0.064 | NS | 0.042 | 0.007 |
| Date average | First date | 4.17 | 9.60 | 87.23 | 13.28 | 28.95 | 2.651 | 0.368 | 3.009 | 0.407 |
| | Second date | 3.66 | 7.59 | 70.89 | 13.22 | 20.69 | 1.866 | 0.295 | 2.636 | 0.343 |
| | Third date | 3.61 | 7.52 | 70.04 | 12.96 | 20.26 | 1.979 | 0.290 | 2.611 | 0.335 |
| R.L.S.D. 5% | | 0.04 | 0.14 | 1.44 | 0.21 | 0.39 | 0.033 | 0.011 | 0.032 | 0.003 |
| Phosphate average level | 0 | 3.68 | 7.71 | 72.32 | 12.75 | 21.10 | 1.884 | 0.303 | 2.659 | 0.343 |
| | 400 | 3.80 | 8.24 | 76.07 | 13.22 | 23.48 | 2.230 | 0.316 | 2.766 | 0.365 |
| | 800 | 3.96 | 8.75 | 79.77 | 13.49 | 25.32 | 2.382 | 0.334 | 2.833 | 0.378 |
| R.L.S.D. 5% | | 0.04 | 0.13 | 1.35 | 0.16 | 0.56 | 0.043 | 0.007 | 0.024 | 0.004 |

Table 4 results show the superiority of the first date plants in the qualitative and chemical characteristics of the curds and this might be attributed to the exposure of its plants to more favorable environmental conditions for growth, and this is what encouraged good vegetative growth for them represented by an increase in the number of leaves and leaf area Table, 2, which worked to increase the efficiency of the photosynthesis process and increase the metabolites and thus increasing the content of the curds in the mentioned characteristics. The results of the same table also showed the presence of significant effects of phosphate fertilization on the qualitative characteristics of curds with the added fertilizer level increased and this might be because the addition of phosphate fertilizer led to an increase in the phosphorous content of the soil, which in turn increased the amount of phosphorous absorbed by the plant (Csathó *et al.* 2005), and this comes in line with Al-Zebari (2008).

CONCLUSIONS

The Parasio broccoli can be planted on the date 1/9 with phosphate fertilization (triple superphosphate 47% P_2O_5) at a level of 800 kg hectares⁻¹ added in one batch after two weeks of transplantation in the field in the desert regions of southern Iraq.

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