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Effect of Planting Date, Boron Forms on Growth, Head Yield and Quality of Broccoli Plants

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ABSTRACT

The present study was carried out at the experimental farm of Faculty of Agriculture Benha University, Egypt during the two growing seasons of 2017/2018 and 2018/2019to comparison the three different forms of boron fertilization i.e. chelated boron, Nano-boron and boric acid on broccoli F1-hybrid "Larson RZ" growth and yield under different planting dates i.e. 1st, 15th and 30th October, respectively. The obtained results confirmed that all broccoli growth traits, head yield and quality significantly affected by planting date, boron forms and their interactions in both seasons. The data confirmed that all growth traits, head yield and chemical properties gradually increased with delaying planting date. leaves number, foliage fresh and dry weight/plant, number of primary and secondary head, head weight, total head yield/plant, head content of ascorbic acid and total carbohydrate were recorded in broccoli plant that planted in the end of October in both seasons. All boron forms resulted in significant increase all growth traits, head yield and head chemical properties compared with the control. The highest measured data were recorded in broccoli plant that treated with chelated boron followed by Nano-boron in both seasons. Broccoli plants that treated with chelated boron in the late planting date (end of October) recorded the highest vegetative growth, head yield and head quality. It can be recommended to plant broccoli plants at the end of October with foliar spray with chelated boron to get the highest head yield with best quality.

KEYWORDS: Broccoli, Planting Date, Boron, Head Yield

1. INTRODUCTION

Broccoli (*Brassica oleracea*), is one of the vegetables with high nutritional value and has a wide spread in the world. Their heads had high amount of K, S, P, Mg (Gao *et al.*, 2018), vitamin A, vitamin C, vitamin B2, calcium and proteins (Aires, 2015). Also, it has been appointed as an anti-cancer source by American Cancer Society (Yoldas *et al*., 2008). Nutritional value, quality and yield of any crop are affected by many factors such as and soil fertility (Cartea *et al*., 2008). Plant fertilization is one of the most important factor affecting plant quality (Savci, 2012). The Agricultural practices such as planting date, irrigation and fertilization can highly impact the levels of bioactive components in brassica (Aires *et al*., 2015).

Vegetable crops vary in their needs of light and heat throughout the growing season, especially in germination and seedling growth stages, so choosing the appropriate planting date

is one of the most important factors affecting growth and production.

Broccoli plants can be grown during a long time range compared to other vegetable crops. Broccoli is best grown in Egypt from the middle of July to the end of October, and the most appropriate date for producing the best specifications and the highest crop is from mid-September to mid-October. There is a significantly relationship between planting dates (and thus temperatures) and heads formation and quality. Many experiments were conducted in this field, and some varieties of broccoli were tested in terms of the effect of temperatures on the formation of flower heads. Concerning to these studies some varieties did not produce heads in the short days of the day as well as in the long days when temperature was 20 ° C, while at a temperature of 17 ° C, some varieties formed heads in short and long days, and from this it is clear that the low temperature with the length of the photoperiod pushes the plants to form flower heads (EMALR 2020) Egyptian Ministry of Agriculture and Land Reclamation 2021). In the previous studies El-Magd (2013) found that medium planting date (1st Oct.) recorded the tallest plants, the highest fresh weight and dry weight percentage of leaves and heads followed by the early plantation. Late planting date recorded the lowest values of leaf content of N, P and K was recorded in the late planting date. While, Thakare *et al*., (2015) reported that plant height, number of leaves per plant, stem diameter, leaf length, leaf area, days required for curd initiation, curd maturity, compactness and days required for 50 per cent to last harvest were found significantly superior in 15th September planting date. Foliage content of pigments chlorophyll and carotene and leaf content of N, P, K, Mg, Fe and Zn were lower in 15th September planting date than 15th and 30th October. Rahman *et al*., (2016) obtained the highest plant height, numbers of leaves per plant, leaf length and leaf breadth at harvest were recorded from Planting on 15 November and the lowest leaf content of chlorophyll a and b, nitrogen, phosphorus, potassium and Fe were recorded from 1 December.

The broccoli plant is characterized by a high response to the fertilization if the yield and its quality are increased by increasing the fertilizer dose. To obtain the highest yield and quality of broccoli, plants must be supplied with balanced doses of nutrients, as excessive nitrogen fertilization leads to an increase in vegetative growth and a decrease in fruit growth. Minor elements such as iron, zinc, manganese and boron must be added because of their effective role in increasing production and improving the quality of the crop.

Boron (B) is an essential nutrient for plant growth (Batabyal *et al*., 2015). the application of boron can provide further improvements in the vegetative and reproductive growth of the plants (Singh *et al*., 2015), in contrast the deficiency of boron may lead to significant physiological and morphological disorders such as reductions in plant height, total leaf area and maximum leaf width (Choi *et al*., 2016) in addition to, the head shape becomes irrigular, smaller in size and bitter in taste (Thapa *et al*., 2016). On the other hand, it is considered as a relatively phloem immobile nutrient (Mora *et al*., 2016) and its deficiency symptoms appear mainly on the younger growing parts of plants (Miwa and Fujiwara, 2010). Thus, foliar or soil applications with boron can effectively correct B-deficiency (Ratan and Kavita, 2017) and exhibit more marketable products of broccoli yield (Thapa *et al*., 2016), especially when applied in the form of boron nanoparticles (Davarpanah *et al*., 2016).

Excessive use of traditional chemical fertilizers leads to many problems where these materials lead to impalanced the Eco-system, as they are one of the main causes of water, air and soil pollution, and cause the death of birds, fishes and natural enemies of pests. In addition, these substances affect human and animal health, such as the spread of cancer and kidney and liver diseases. The search for safe alternatives to traditional chemicals used in the agricultural field is one of the most important trends worldwide.

Nano-materials are emerging as one of the best modern trends as one of the alternatives to traditional chemicals, as they are used in very small quantities, which reduces the risks of wasteful application on the environment and humans.

Nanotechnology has proven its position in agricultural sciences and related industries as a multidisciplinary technology and pioneer in solving problems in pesticides, fertilization and

pesticides residues removal (Mousavi and Rezaei, 2011). So, nanotechnology is a tool that helps in solving challenges facing farmers in managing crops by obtaining high producing crops and minimizing the use of synthetic chemicals fertilizers and pesticides (Prasad *et al*., 2014). Nano-materials had high ability to penetration into plant tissues where it defined as materials their minutes are between 1 to 100 nanometers (Ghorbani *et al*., 2011). The mode of action of the nanoparticles on plant growth may be attributed mainly to their small diameters that do not exceed the pore size of plant cell walls (Navarro *et al*., 2008). These nano-fertilizers are also coated with thin nano-materials that increase their surface tension and hence facilitate various metabolic processes within the plants (Weil and Brady, 2016). This might, in turn, improve the utilization efficiency of nutrients (around 70 %) by plants as compared with the traditional fertilizers (El-Ramady *et al*., 2018). Bozorgi (2012) clarified that spraying nano-iron on the vegetative parts of eggplant significantly increased plant height, number of branches and number of fruits compared to the control treatment. Pariona *et al*, (2016) showed that spraying nano-iron on maize leaves resulted in significant increase plant height, leaf length, chlorophyll content, root dry weight, shoot weight, and weight of 1000 grains compared to control, in line with the concentration increment. Boghori (2016) confirmed that foliar spray of nano-iron on sesame plants increased significantly plant height, seed protein percentage, and weight of 1000 seeds compared to control.

Therefore the present study is a try to determine:

- The effect of planting date on growth, yield and yield quality of broccoli plants.
- The effect of different boron sources on growth, yield and yield quality of broccoli plants.

2. MATERIALS AND METHODS

The present study was carried out at the experimental farm of Faculty of Agriculture Benha University, Egypt during the two growing seasons of 2017/2018 and 2018/2019 to comparison the three different forms of boron fertilization i.e. chelated boron, Nano-boron and boric acid on broccoli F1-hybrid "Larson RZ" growth and yield under different planting dates i.e. 1st, 15th and 30th October, respectively. The experimental soil is clay with PH 7.36. Also, some of agro climatological data for the three locations during 2018 and 2019 growing seasons are presented in Table 1.

Table 1. Some of agro-climatological data for the experiment locations during 2017/2018 and 2018/2019 growing seasons.

Month	HC Air temperature [°C]			Relative humidity [%]
	Min	Max	Avg	
		2017/2018		
Oct.	17.45	35.90	26.68	77.28
Nov.	16.81	33.69	25.25	76.43
Dec.	11.89	26.10	18.99	82.08
Jan.	12.00	21.57	16.79	89.00
Feb.	13.35	25.11	19.23	88.40
Mar.	14.70	27.48	21.09	89.18
		2018/2019		
Oct.	17.67	35.41	26.54	75.19
Nov.	15.86	32.64	24.25	77.13
Dec.	11.22	25.29	18.26	82.82
Jan.	11.33	20.91	16.12	89.82
Feb.	12.59	24.32	18.46	89.20
Mar.	13.87	26.63	20.25	89.99

During the two growing seasons of 2017/2018 and 2018/2019 the broccoli F1-hybrid "Larson RZ" USA was planted in the 1st, 15thand 30th of October in a field experiment designed in split plot design with three replicates. In both seasons the three planting

dates were allocated in the main plots while the three forms of boron fertilization as well as the control were randomly distributed in the sub-plots. This experiment included 12 treatments which were the combination between 3 planting date and 3 boron forms as well as control. The plot size was four ridges. Each ridge was four meters long and 1 m apart. broccoli seedlings were transplanted on the two side of the ridge at 30 cm hill spacing with one plant per hill. Flood irrigation was used and all cultural practices (recommended irrigation and mineral fertilization, weed control and hand honing) were followed as recommended.

The three forms of boron chelated boron), Nano-boron and boric acid) (H_3BO_3) were sprayed individually at the rate of 100 ppm three times during broccoli vegetative growth started after 3 weeks of transplanting with 2 week intervals between each.

2.1. Data Recorded.

Five guarded plants randomly taken from each sub-pot were used at the beginning of harvest in the two growing seasons to determine the following vegetative growth traits:

2.1.1. Vegetative growth traits:

Leaves number/plant, foliage fresh weight (g)and foliage dry weight (g).

2.1.2. Head yield and head physical properties:

At harvest stage ten guarded plants randomly taken from each sub-pot were used to determine:

Number of heads/plant, main head weight (g), secondary heads

2.1.3. Head chemical properties:

Head content of total soluble solids (%), head content of ascorbic acid (mg/100 g) and head content of total carbohydrate (g/100g).

2.1.4. Determination of total soluble solids (TSS):

Head content of total soluble solids content (TSS) was measured in using a hand refractometer, 0-32 scale (ATAGO N-1_E, Japan) and expressed in °Brix after making the temperature correction at 20°C.

2.1.5. Determination of ascorbic acid:

Samples of head were used, oxalic acid solution was added to each sample and titrated with 2,6-dichlorophenol-indophenol dye solution and expressed as a milligram of ascorbic acid and was calculated as mg/100 ml of the juice.

2.1.6. Determination of carbohydrates percentage in leaves and heads:

Total carbohydrate determined in leaves and heads using 0.5 g accurately weight and extracted with 1 M HCL and the volume of extract raised up to 50 ml after neutralization, precipitation and filtration. Total carbohydrate content determined calorimetrically at 540 nm according to Miller. (1959) with DNS method and the concentration estimated from the calibration standard curve

2.2. Statistical Analysis:

Results were expressed as mean. The data were analyzed by using **Two-way** ANOVA followed by LSD test through SPSS v.16. The treatments means were compared using least significant difference (LSD) tested at significant levels of 5% as described by **Gomez and Gomez (1984)**.

3. RESULTS AND DISCUSSIONS

3.1. Effect of planting dates, boron forms and their interactions on broccoli plants growth traits during 2017/2018 and 2018/2019 seasons.

3.1.1.Number of leaves/plant:

Data in Table 2 confirmed that leaves number of broccoli plants gradually increased with delaying planting date where the lowest leaves number/plant (14.33 and 15.73) were found in the early planting date in first October while the largest number of leaves/plant (17.90 and 19.73) were found in the late planting date in the end of October in both seasons, respectively. Leaves number of broccoli plant gradually increased with delayed planting date.

Regarding to the effect of boron forms in leaves number/plant, the results in Table 2 showed that all boron forms led to significant increase of number of leaves/plant compared with the control in both seasons. Broccoli plants that sprayed with chelated boron had the highest number of leaves/plant (17.87 and 19.73) followed by Nano-boron (16.47 and 18.23) in the first and second seasons, respectively. On the other hand, the lowest leaves number/broccoli plants were observed in the control treatment (14.67 and 16.17) in both seasons, respectively.

For the interaction effect onnumber of leaves/plant, the obtained results in Table 2 cleared that broccoli plants differ in their response to boron forms according to the different planting date. Broccoli plants that treated with chelated boron in the late planting

Table 2. Effect of planting dates, boron forms and their interactions on number of leaves/plant and foliage fresh and dry weight and leaves area/plant of broccoli plants during 2017/2018 and 2018/2019 seasons.

Factors		Number of leaves/plant		Foliage fresh weight (g)		Foliage dry weight (g)	
		1st	2nd	1st	2nd	1st	2nd
Planting dates							
First October		14.33 c	15.73 b	468.10 c	482.23 c	96.48 c	98.68 c
Mid October		16.33 b	18.00 a	487.03 b	500.90 b	99.78 b	102.80 b
End October		17.90 a	19.73 a	503.00 a	518.70 a	101.15 a	108.15 a
Treatments							
Control		14.67 d	16.17 c	456.40 d	471.07 d	96.80 b	99.20 d
Boric acid		15.73 c	17.13 c	483.00 c	495.87 c	97.87 b	101.67 c
Chelated boron		17.87 a	19.73 a	508.43 a	526.33 a	101.60 a	107.67 a
Nano boron		16.47 b	18.23 b	496.33 b	509.17 b	100.27 a	104.30 b
P. Date	**Treat.**						
First October	**Control**	12.50	13.70	431.60	452.90	93.50	94.70
	Boric acid	13.90	14.60	465.40	481.70	95.70	98.10
	Chelated boron	16.20	18.50	491.30	503.70	99.50	102.60
	Nano boron	14.70	16.10	484.10	490.60	97.20	99.30
Mid October	**Control**	15.10	16.70	461.20	475.20	96.20	98.70
	Boric acid	15.80	17.50	486.10	492.70	98.60	100.60
	Chelated boron	17.90	19.60	507.60	526.10	103.60	107.80
	Nano boron	16.50	18.20	493.20	509.60	100.70	104.10
End October	**Control**	16.40	18.10	476.40	485.10	100.70	104.20
	Boric acid	17.50	19.30	497.50	513.20	99.30	106.30
	Chelated boron	19.50	21.10	526.40	549.20	101.70	112.60
	Nano boron	18.20	20.40	511.70	527.30	102.90	109.50
LSD 5%		0.90	1.60	6.96	7.76	2.18	2.48

date (end of October) recorded the highest leaves number/plant (19.50 and 21.10) followed by Nano-boron at the end of October (18.20 and 20.40) then plants that treated with chelated boron in the mid planting date with averages of 17.90 and 19.60 in both seasons, respectively. In the contrary broccoli plants under the control treatment in the early planting date had the lowest number of leaves/plant (12.50 and 13.70) in the first and second seasons, respectively. In general broccoli plants in the late planting date exceeded the early and the mid planting date in leaves number/plant. Also, broccoli plants that treated with chelated boron superior all the other forms of boron in leaves number/plant in the three planting dates.

3.1.2. Foliage fresh weight (g):

The obtained data in Table 2 revealed that foliage fresh weight/plant were significantly increased with the delaying planting date where the lowest foliage fresh weight/plant (468.10 and 482.23g) were recorded in the early planting date in first October while the highest foliage fresh weight/plant (503.00 and 518.70g) were found in the late planting date in the end of October in both seasons, respectively.

For the effect of boron forms in foliage fresh weight/plant the presented data in Table 2 showed that all boron forms resulted in significant increase of foliage fresh weight compared with the control in both seasons. Broccoli plants that sprayed with chelated boron had the highest foliage fresh weight/plant (509.43 and 526.33g) followed by Nano-boron (496.33 and 509.17 g) in the first season and second season, respectively. In the contrast of this, the lowest foliage fresh weight/plant were recorded in the control treatment (456.40 and 471.07g) in both seasons, respectively. Boron

sprayed at any form led to significant increase of foliage fresh and dry weight.

Regard to the effect of interaction on foliage fresh weight/plant, the results in Table 2 showed that broccoli plants differ in their response to boron forms according to the different planting date. Broccoli plants that treated with chelated boron in the late planting date (end of October) recorded the highest foliage fresh weight/plant (526.40 and 549.20g) followed by Nano-boron in the end of October (511.70 and 527.30g) then plants that treated with chelated boron in the mid planting date with averages of 507.60 and 526.10g in both seasons, respectively. In contrast broccoli plants under the control treatment in the early planting date showed the lowest foliage fresh weight/plant (431.60 and 425.90g) in both seasons,respectively. In general broccoli plants in the late planting date exceeded the early and the mid planting date in foliage fresh weight/plant. Also, broccoli plants that treated with chelated boron superior all the other forms of boron in foliage fresh weight/plant in the three planting dates.

3.1.3.Foliage dry weight (g):

The obtained data in Table 2 revealed that foliage dry weight/plant were significantly increased with the delaying planting date where the lowest foliage dry weight/plant (96.48 and 98.68 g) were recorded in the early planting date in first October while the highest foliage dry weight/plant (101.15 and 108.15 g) were found in the late planting date in the end of October in both seasons, respectively.

For the effect of boron forms in foliage dry weight/plant the presented data in Table 1 showed that all boron forms resulted in significant increase of foliage dry weight/plant compared with the control in both seasons. Broccoli plants that sprayed with chelated boron had the highest foliage dry weight/plant (101.60 and 107.67 g) followed by Nano-boron (100.27 and 104.30 g) in the first season and second season, respectively. In the contrast of this, the lowest foliage dry weight/plant were recorded in the control treatment (96.80 and 99.20 g) in both seasons, respectively. Boron sprayed at any form led to significant increase of foliage fresh and dry weight.

Regard to the effect of interaction on foliage dry weight/plant, the results in Table 2 showed that broccoli plants differ in their response to boron forms according to the different planting date. Broccoli plants that treated with chelated boron in the late planting date (end of October) recorded the highest foliage dry weight/plant (101.70 and 112.60 g) followed by Nano-boron in the end of October (102.90 and 109.50 g) then plants that treated with chelated boron in the mid planting date with averages of 103.60 and 107.80 g in both seasons, respectively. In contrast broccoli plants under the control treatment in the early planting date showed the lowest foliage dry weight/plant (93.50 and 94.70 g) in both seasons, respectively. In general broccoli plants in the late planting date exceeded the early and the mid planting date in foliage dry weight/plant. Also, broccoli plants that treated with chelated boron superior all the other forms of boron in foliage dry weight/plant in the three planting dates

3.2. Effect of planting dates, boron forms and their interactions on broccoli head yield and head physical properties during 2019 and 2020 seasons.

3.2.1.Main head weight (g):

Data in Table 3 confirmed that main head weight gradually increased with delaying planting date where the shortest plants (280.80 and 309.40 g) were observed in the early planting date in first October while the highest main head weight (312.30 and 321.29 g) were found in the late planting date in the end of October in both seasons, respectively. Delayed planting date of broccoli resulted in increase the main head weight.

With regard to the effect of boron forms in main head weight the results in Table 3 showed that all boron forms resulted in significant increase of main head weight compared with the control in both seasons. Broccoli plants that sprayed with chelated boron had the highest main head weight (304.50 and 318.22 g) followed by Nano-boron (302.06 and 328.10 g) in the first and second seasons, respectively. On the other side, the lowest main head weight was observed in the control treatment (286.73 and 305.48 g) in both seasons, respectively but this value did not differ significant with boric acid in

the second season. The results confirmed a large increase in main and secondary heads under all boron forms compared with the control. For the interaction effect of main head weight, the obtained results in Table 3 showed that broccoli plants differ in their response to boron forms according to the different planting date.

Table 3. Effect of planting dates, boron forms and their interactions on main head weight, secondary heads weight and total heads weight/plant of broccoli during 2017/2018 and 2018/2019 seasons.

Factors		Main head weight (g)		Secondary Heads weight (g)		Total head weight (g)	
		1st	2nd	1st	2nd	1st	2nd
Planting dates							
First October		280.80 c	309.40 b	102.80 c	112.80 c	383.60 c	401.90 c
Mid October		298.04 b	310.56 b	120.30 b	130.38 b	418.34 b	443.23 b
End October		312.30 a	321.29 a	133.10 a	139.98 a	441.68 a	465.65 a
Treatments							
Control		286.73 c	305.48 c	106.87 d	115.27 d	393.60 d	406.32 d
Boric acid		294.90 b	303.20 c	112.80 c	124.43 c	408.01 c	430.53 c
Chelated boron		304.50 a	318.22 b	133.27 a	141.37 a	432.50 a	462.87 a
Nano boron		302.06 a	328.10 a	122.00 b	129.80 b	424.06 b	447.99 b
Date	**Treat**						
First October	**Control**	269.60	318.87	91.60	99.50	361.20	372.50
	Boric acid	274.90	288.50	97.70	110.20	372.60	398.70
	Chelated boron	289.70	297.30	118.40	124.30	408.10	421.60
	Nano boron	289.00	332.93	103.50	117.20	392.50	414.80
Mid October	**Control**	290.70	291.60	107.50	118.20	398.20	409.77
	Boric acid	299.10	303.87	112.60	125.90	411.70	436.40
	Chelated boron	303.00	325.50	134.20	146.20	437.20	471.80
	Nano boron	299.37	321.27	126.90	131.20	426.27	454.97
End October	**Control**	299.90	305.97	121.50	128.10	421.40	436.70
	Boric acid	310.70	317.23	128.10	137.20	439.73	456.50
	Chelated boron	320.80	331.87	147.20	153.60	452.20	495.20
	Nano boron	317.80	330.10	135.60	141.00	453.40	474.20
LSD 5%		7.18	8.32	2.71	3.34	13.97	13.31

Broccoli plants that treated with chelated boron in the late planting date (end of October) recorded the highest main head weight (320.80 and 331.87 g) followed by Nano-boron in late planting date (317.80 and 330.10 g) then plants that treated with chelated boron in the mid planting date with averages of 303.00 and 325.50 g in both seasons, respectively. In contrast broccoli plants under the control treatment in the early planting date showed the lowest main head weight (269.60 and 318.87g) in the first and second seasons, respectively. In general broccoli plants in the late planting date exceeded the early and the mid planting date in main head weight. Also, broccoli plants that treated with chelated boron superior all the other forms of boron in main head weight in the three planting dates.

3.2.2. Secondary heads weight (g):

The obtained results in Table 3 cleared that secondary heads weight of broccoli plants gradually increased with the delaying planting date where the lowest secondary heads weight (102.80 and 112.80g) were found in the early planting date in first October while the largest secondary heads weight (133.10 and 139.98g) were found in the late planting date in the end of October in both seasons, respectively.

According to the effect of boron forms in secondary heads weight the data in Table 3

indicated that all boron forms resulted in significant increase of secondary heads weight compared with the control in both seasons. Broccoli plants that sprayed with chelated boron recorded the highest secondary heads weight (133.27 and 141.37g) followed by Nano-boron (122.00 and 129.80 g) in the first and second seasons, respectively. On the other hand, the lowest secondary heads weightwas found in the control treatment (106.87 and 115.27g) in both seasons, respectively. The results confirmed a large increase in main and secondary heads under all boron forms compared with the control.

Respect to the interaction effect on secondary heads weight, the results in Table 3 cleared that broccoli plants differ in their response to boron forms according to the different planting date. Broccoli plants that treated with chelated boron in the late planting date (end of October) recorded the highest secondary heads weight (147.20 and 153.60g) followed by chelated boron in mid-October (134.20 and 146.20g) then plants that treated with Nano-boron in the late planting date with averages of 135.60 and 141.00g in both seasons, respectively. On the other side, broccoli plants under the control treatment in the early planting date showed the lowest secondary heads weight (91.60 and 99.50 g) in the first and second seasons, respectively. In general broccoli plants in the late planting date exceeded the early and the mid planting date in secondary heads weight. Also, broccoli plants that treated with chelated boron superior all the other forms of boron in secondary heads weight in the three planting dates.

3.2.3. Total head weight (g):

The obtained data in Table 3 revealed that total head weight significantly increased with the delaying planting date where the lowest total head weight (383.60 and 401.90g) were recorded in the early planting date in first October while the highest total head weight (441.68 and 465.65g) were found in the late planting date in the end of October in both seasons, respectively. Delayed planting date to the end of October resulted in significantly increase the total heads yield/plant. These increase may due to the lower air temperature in this period then the beginning of this month and this may be suitable to seedling growth.

For the effect of boron forms in total head weight the presented data in Table 3 showed that all boron forms resulted in significant increase of total head weight compared with the control in both seasons. Broccoli plants that sprayed with chelated boron had the highest total head weight (432.50 and 462.87g) in the first and second season, respectively. In the contrast of this, the lowest total head weightwas recorded in the control treatment (393.60 and 406.32g) in both seasons, respectively. In the previous studies broccoli or cauliflower yield influenced significantly due to various treatments of boron (Ningawale *et al.*, 2016).

Regard to the effect of interaction on total head weight, the results in Table 3 showed that broccoli plants differ in their response to boron forms according to the different planting date. Broccoli plants that treated with chelated boron in the late planting date (end of October) recorded the highest total head weight (452.20 and 495.20g) followed by Nano-boron in the end of October (453.40 and 474.20g) then plants that treated with chelated boron in the mid planting date with averages of 437.20 and 471.80g in both seasons, respectively. In contrast broccoli plants under the control treatment in the early planting date showed the lowest total head weight(361.20 and 372.50 g) in both seasons, respectively. In general broccoli plants in the late planting date exceeded the early and the mid planting date in total head weight. Also, broccoli plants that treated with chelated boron superior all the other forms of boron in total head weight in the three planting dates.

3.3. Effect of planting dates, boron forms and their interactions on broccoli head chemical properties during 2017/2018 and 2018/2019 seasons.

3.3.1. Total soluble solids content (TSS%):

The obtained results in Table 4 cleared that head content of TSS gradually increased with delaying planting date where the lowest head content of TSS (6.97 and 7.20%) were observed in the early planting date in first October while the highest head content of TSS (7.66 and 7.89%) were found in the late planting date in the end of October in both seasons,

respectively. In the present study total soluble solids content of broccoli heads significantly affected by planting dates. With regard to the effect of boron forms on head content of TSS the results in Table 4 showed that all boron forms resulted in significant increase of head content of TSS compared with the control in both seasons.

Table 4. Effect of planting dates, boron forms and their interactions on broccoli heads content of total soluble solids, ascorbic acid and total carbohydrates at harvest during2017/2018 and 2018/2019 seasons.

Factors		TSS %		V.C (mg/100g)		Total Carbohydrates	
		1st season	2nd season	1st season	2nd season	1st season	2nd season
Planting dates							
First October		6.97 c	7.20 c	62.18 b	68.53 b	15.76 c	17.56 b
Mid October		7.28 b	7.59 b	68.03 a	75.12 a	16.56 b	18.00 ab
End October		7.66 a	7.89 a	73.10 a	78.33 a	18.88 a	19.98 a
Treatments							
Control		7.04 d	7.23 c	64.00 b	69.10 d	15.69 d	18.02 ab
Boric acid		7.20 c	7.45 b	66.57 ab	71.80 c	16.45 c	17.53 b
Chelated boron		7.59 a	7.96 a	70.80 a	79.00 a	18.99 a	19.95 a
Nano boron		7.36 b	7.61 b	69.70 a	76.06 b	17.15 b	18.54 ab
P. Date	**Treat.**						
First October	**Control**	6.64	6.93	59.40	62.30	14.70	19.64
	Boric acid	6.95	7.06	62.30	67.50	14.92	15.25
	Chelated boron	7.21	7.59	61.20	74.10	17.61	18.41
	Nano boron	7.06	7.22	65.80	70.20	15.81	16.93
Mid October	**Control**	7.01	7.12	63.90	70.10	15.08	16.31
	Boric acid	7.12	7.45	66.20	72.50	15.91	17.71
	Chelated boron	7.62	8.12	72.60	79.50	18.71	19.86
	Nano boron	7.35	7.68	69.40	78.37	16.54	18.12
End October	**Control**	7.47	7.63	68.70	74.90	17.29	18.11
	Boric acid	7.54	7.84	71.20	75.40	18.51	19.63
	Chelated boron	7.93	8.16	78.60	83.40	20.65	21.59
	Nano boron	7.68	7.92	73.90	79.60	19.09	20.57
LSD 5%		0.18	0.28	6.57	2.80	0.37	3.47

Broccoli plants that sprayed with chelated boron had the highest head content of TSS (7.58 and 7.96%) followed by Nano-boron (7.36 and 7.61%) in the first and second seasons, respectively. On the other side, the lowest head content of TSS were observed in the control treatment (7.04 and 7.23%) in both seasons, respectively. Boron had better effect yield and yield quality parameters of cauliflower as TSS, ascorbic acid, total sugar, total protein and total carbohydrates (Kumar ,2005).

For the effect of the interaction on head content of TSS, the obtained results in Table 4 showed that broccoli plants differ in their response to boron forms according to the different planting date. Broccoli plants that treated with chelated boron in the late planting date (end of October) recorded the highest head content of TSS (7.93 and 8.16%) followed by Nano-boron in the end of October (7.68 and 7.92%) then plants that treated with chelated boron in the mid planting date with averages of 7.62 and 8.12% in both seasons, respectively. In contrast broccoli plants under the control treatment in the early planting date showed the lowest head content of TSS (6.64 and 6.93%) in the first and second seasons, respectively. In general broccoli plants in the late planting date exceeded the early and the mid planting date in head content of TSS. Also, broccoli plants that treated with chelated boron superior all the other forms of boron in head content of TSS in the three planting dates.

3.3.2. Head content of ascorbic acid (mg/100g):

The obtained results in Table 4 cleared that head content of ascorbic acid increased with the delaying planting date where the lowest head content of ascorbic acid (62.18 and 68.53 mg/100g) were found in the early planting date in first October while the largest head content of ascorbic acid (73.10 and 78.33 mg/100g) were found in the late planting date in the end of October in both seasons, respectively. The exceeded of the late planting date did not differ significant with the mid planting date. In this study ascorbic acid content of broccoli heads significantly affected by planting dates.

According to the effect of boron forms in head content of ascorbic acid, the data in Table 4 indicated that all boron forms resulted in significant increase in head content of ascorbic acid compared in both seasons. Broccoli plants that sprayed with chelated boron recorded the highest head content of ascorbic acid (70.80 and 79.00 mg/100g) followed by Nano-boron (69.70 and 76.06 mg/g) in the first and second seasons, respectively without any significant differ among all boron forms in the first season. On the other hand, the lowest head content of ascorbic acidwas found in the control treatment (64.00 and 69.10 mg/100g) in both seasons, respectively.Boron had better effect yield and yield quality parameters of cauliflower as TSS, ascorbic acid, total sugar, total protein and total carbohydrates Kumar (2005).

Respect to the interaction effect on head content of ascorbic acid, the results in Table 4 cleared that broccoli plants differ in their response to boron forms according to the different planting date. Broccoli plants that treated with chelated boron in the late planting date (end of October) recorded the highest head content of ascorbic acid (78.60 and 83.40 mg/100g) in both seasons, respectively followed by chelated boron in mid-October and Nano-boron in the late planting date in both seasons. On the other side, broccoli plants under the control treatment in the early planting date showed the lowest in both seasons, respectively (59.40 and 62.30mg/100 g) in the first and second seasons, respectively. In general broccoli plants in the late planting date exceeded the early and the mid planting date in head content of ascorbic acid. Also, broccoli plants that treated with chelated boron superior all the other forms of boron in head content of ascorbic acid in the three planting dates.

3.3.3.Head content of total carbohydrate (g/100g):

The presented results in Table 4 cleared that head content of total carbohydrate gradually increased with the delaying planting date where the lowest head content of total carbohydrate (15.76 and 17.56 g/100g) were found in the early planting date in first October while the largest head content of total carbohydrate (18.88 and 19.98 g/100g) were found in the late planting date in the end of October in both seasons, respectively. Delayed planting date of broccoli in this study had positive effect on broccoli head content of total carbohydrate. It was also found that under the late planting date yield with the best quality (El-Magd 2013).

Regarding to the effect of boron forms in head content of total carbohydrate, the results in Table 4 indicated that all boron forms led to significant increase in head content of total carbohydrate compared in both seasons. Broccoli plants that sprayed with chelated boron recorded the highest head content of total carbohydrate (18.99 and 19.95 g/100g) followed by Nano-boron (17.15 and 18.54 g/100g) in the first and second seasons, respectively. On the other hand, the lowest head contents of total carbohydrate were recorded in the control treatment (15.69 g/100g) in the first season and in boric acid (17.53 g/100 g) in the second season.Boron had better effect yield and yield quality parameters of cauliflower as TSS, ascorbic acid, total sugar, total protein and total carbohydrates(Kumar ,2005).

For the interaction effect on head content of total carbohydrate, the results showed in Table 4 confirmed that broccoli plants differ in their response to boron forms according to the different planting date. Broccoli plants that treated with chelated boron in the late planting date (end of October) recorded the highest head content of total carbohydrate (20.65 and 21.59 g/100g) followed by Nano-boron in end of October (19.09 and 20.57 g/100g) then plants that treated with chelated boron in the mid planting date with averages of 18.71 and 19.86 g/100g in both seasons, respectively. In general broccoli plants in the late planting date exceeded the early and the mid planting date in head

content of total carbohydrate. Also, broccoli plants that treated with chelated boron superior all the other forms of boron in head content of total carbohydrate in the three planting dates.

In general broccoli plants in the late planting date exceeded the early and the mid planting date in all growth traits, head yield and head quality. Also, broccoli plants that treated with chelated boron superior all the other forms of boron in all growth traits, head yield and head quality in the three planting dates.

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الملخص العربي

تأثير ميعاد الزراعة ومصادر البورون على النمو والمحصول وجودة نباتات البروكلي

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أجريت الدراسة الحالية في المزرعة البحثية بكلية الزراعة جامعة بنها خلال موسمي النمو ٢٠١٧/ ٢٠١٨و ٢٠١٨/٢٠١٩ لمقارنة صور للتسميد بالبورون وهى البورون المخلبي والنانو بورون وحمض البوريك على نمو ومحصول وجودة هجين البروكلي " Larson RZ " F1 تحت ثلاثة مواعيد زراعة مختلفة وهى ١ و ١٥ و ٣٠ أكتوبر،على التوالي. أكدت النتائج المتحصل عليها تأثر جميع صفات نمو البروكلي، محصول الأقراص والصفات الكيميائية للأقراص معنوياً بمواعيد الزراعة وأشكال البورون وتفاعلاتها في كلا الموسمين. وأكدت البيانات أن جميع صفات النمو الخضرى و محصول الأقراص والصفات الكيميائية للأقراص زاد تتدريجياً مع تأخير موعد الزراعة. حيث تم تسجيل اعلى عدد الأوراق ووزن الأوراق الطازج و الجاف / نبات وكذلك عدد الأقراص الثانوية والرئيسية، وزن القرص، محصول الأقراص للنبات، محتوى الأقراص من فيتامين سى والكربوهيدرات الكلية في نباتات البروكلي المنزرعة في نهاية أكتوبر في كلا الموسمين. أدت جميع صور البورون إلى زيادة معنوية في جميع صفات النمو الخضرى ومحصول الأقراص والصفات الكيميائية للأقراص مقارنةً بالكنترول. تم تسجيل أعلى عدد الأوراق و وزن الأوراق الرطب والجاف / نبات وكذلك عدد الأقراص الثانوية والرئيسية، وزن القرص، محصول الأقراص للنبات، محتوى الأقراص من فيتامين سى والكربوهيدرات الكلية في نباتات البروكلي المسمد بالبورون المخلبي. يليها لبورون النانوى في كلا الموسمين. أظهرت النتائج المتحصل عليها أن نباتات البروكلي إختلفت في استجابتها لصور البورون باختلاف مواعيد الزراعة. سجلت نباتات البروكلى التي سمدت بالبورون المخلبي في ميعاد الزراعة المتأخر (نهاية أكتوبر) أعلى صفات النمو الخضرى ومحصول الاقراص وصفات جودة كيميائية في كلا الموسمين. يمكن التوصية بزراعة نباتات البروكلى فى نهاية اكتوبر مع الرش الورقى بالبورون المخلبى للحصول على اعلى محصول بافضل مواصفات جودة.