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EFFECT OF PLANTING DATE AND SPACING ON YIELD AND QUALITY OF CABBAGE (*Brassica oleracea* var. *capitata* L.)

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ABSTRACT

Two field trials were carried out during two consecutive winter seasons of 2009/10 and 2010/2011 at Baramon Experimental Farm, Dakahlia Governorate to investigate the effect of three planting dates (1st Nov., 15th Nov. and 1st Dec.) and three plant spacing (50, 60 and 70 cm) on cabbage cv. Brunswick. The trials were laid out in a split-plot design with three replicates.

Results indicated that the earliest planting date (1st of November) significantly promoted vegetative growth characters, i.e. plant weight, number and weight of outer leaves. Moreover, the earliest planting date increased average head weight, total and marketable yield. Head quality attributes, i.e. head equatorial and polar diameters, head volume, head density and dry matter content were increased when planting at the earliest planting date, compared to the later planting dates.

The wider plant spacing (70 cm within row) exhibited the largest values of plant weight, number and weight of outer leaves. The wider plant spacing produced heads with larger dimensions, volume and density. Otherwise, the closer plant spacing (50 cm within row) produced larger total and marketable yield in relation to that yield produced by wider spacing.

The interaction effects among the experimental factors were significant at both seasons of this investigation for plant weight, total yield and dry matter content, whereas no significant interaction was found for other studied characters.

INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata* L.) is an important leafy vegetable grown in Egypt. It is rich in minerals and vitamins A, B1, B2 and C (Singh *et al*, 2010) besides it is a rich source of essential and sulpher containing amino acids and some anti-oxidant compounds since it is rich in certain substances with high antioxidant capacity such as vitamin C (ascorbic acid), carotenoids and polyphenols (Leja *et al.,* 2007).

According to world wide estimations, there are more than two million hectares under production with an average yield of 27.8 tonnes per hectare. Egypt is one of the top production countries and is considered the tenth when using the total yield and production value of cabbage (FAOSTAT, 2012)

Planting date and plant spacing are of the important factors for production practices of cabbage. The use of suitable planting date and proper plant spacing affects on the yield contributing characters and consequently on the overall yield. Moreover, the head quality attributes are mainly affected.

The effect of planting date on cabbage vegetative characters, yield and head attributes has been reported in earlier investigations (Singh *et al*., 2010; Thirupal *et al*, 2014 and Jayamanne *et al*., 2015). Planting date plays a direct

role in the maturity and harvesting time of cabbage plants. It is associated with temperature, day length and light intensity. The suitable planting date determines the favorable environmental climatic conditions for cabbage growing. Planting date affects total and marketable yield of cabbage as well (Wszelaki and Kleinhenz, 2003 and Maria and Sawicki, 2012). They reported that maximum yield was obtained at earlier planting date while delaying planting date brought about a significant decrease in total and marketable yield. Moreover, planting date affects head and core traits (Greenland *et al*, 2000; Orzolek *et al* 2000; Kleinhenz and Wszelaki, 2003 and Khan *et al*. 2015). They reported that the late planting date resulted in denser cabbage heads and head volume, but the early planting date produced heavier heads with larger diameters and wider core width than late planting. In the same manner, Khan *et al*. 2015 reported that head diameter and head weight were reduced at delayed planting date.

The economical production of cabbage depends on maintenance of optimum plant density in the field (Nahar *et al*. 1996 and Wien and Wurr, 1997). Plant spacing associated with plant density and determines the number of plants per unit area. Successful production of cabbage depends on the number of plants per unit area. Generally, increasing plant density decreased plant growth parameters, i.e., plant fresh weight, weight of unwrapped leaves, plant stem dimension and dry matter content (Firoz *et al*., 2000; El-Shabrawy *et al*., 2005 and Asadul Haque *et al*., 2015).

On the other hand, total and marketable yield have increased with increasing plant density at closer plant spacing (Khadir *et al*., 1989; Mahmoud *et al*., 2004; El-Shabrawy *et al*., 2005; Znidarcic *et al*.,2007 and Moniruzzaman, 2011). While total yield increases with low plant spacing, the average head weight decreases (Stofella and Fleming, 1990; El-Shabrawy *et al*., 2005; Semuli, 2005 and Khan *et al*, 2015).

The Objective of this investigation was to study the effect of different planting dates and the plant spacing on vegetative growth, yield and its components and quality attributes of cabbage cv. Brunswick planted in Delta region, Dakahlia Governorate at winter season.

MATERIALS AND METHODS

Two field trials were carried out at two growing winter seasons of 2009/10 and 2010/11 at Baramon Experimental Farm, Dakahlia Governorate to study the effect of planting dates and plant spacing on cabbage vegetative growth, yield and its components and head quality attributes. The soil is a clay loam textured with an average pH =7.9

The monthly average maximum and minimum temperatures during the growth seasons of cabbage plants are shown in Table (1)*:

Table 1. The minimum and maximum temperatures during 2009/10 and 2010/11 seasons.

Months	Air Temperature (Celsius)			
	2009/10		2010/11	
	Minimum	Maximum	Minimum	Maximum
November	13.4	27.4	13.4	25.9
December	11.8	24.4	11.8	22.5
January	10.3	22.8	10.3	20.5
February	9.5	20.9	9.5	19.8
Mars	11.1	23.8	11.1	21.5
April	12.4	27.2	12.4	28.4
May	20.6	31.4	20.6	30.5

***Agricultural Meteorological Station, Aga, Dakahlia.**

Seeds of cabbage cv. Brunswick were sown in the nursery at three planting date, i.e. 1st of November, 15th of November and 1st of December in both growing seasons of 2009/10 and 2010/11, while transplanting took place at the field when seedlings were 45 days old. Seedlings were spaced, in each planting date, at 50, 60 and 70 cm. apart within rows and 75 cm. between rows.

The experiments were laid out in a split plot design with three replicates. The main plots contained the three planting dates, whereas the sub-plots devoted to the different plant spacing. The sub-plot area was 19 m^2. Each sub-plot consisted of 5 rows, 5 m. long and 0.75 m. width.

The common agricultural practices for cabbage production were followed according to the recommendation of Ministry of Agriculture.

At harvesting time, plant sample was taken randomly from each experimental sub-plot and the following data were recorded:

Vegetative growth characters:

Plant fresh weight (kg.) number and weight (kg) of outer leaves (unwrapped leaves) and plant stem diameter (cm).

Yield and its components characters:

Head weight (kg): Plants were trimmed and unwrapped leaves were removed then the average head weight was recorded, total yield (ton/fed.) and marketable yield (ton/fed.)

Head quality attributes:

Head polar and equatorial diameters (cm), head volume (cm^3) which was computed according to Radovich and Kleinhenz, 2004., head density (kg/cm^3) as well as dry matter percentage (%).

To estimate dry matter percentage, fresh leaves from each treatment weighted, cut into slices then dried in an oven at 70° C until constant weight and the dried slices of leaves were weighted then the dry matter percentage was calculated as follow:

Dry matter content (%) = weight of dried leaves/weight of fresh leaves x 100

All obtained data were subjected to statistical analysis of variance (ANOVA), using split-plot design and the treatments means were compared using LSD at 5% level of probability according to Gomez and Gomez, 1984.

RESULTS AND DISCUSSION

1. Effect of planting date:

Vegetative growth:

Data presented in Table (2) show the effect of planting date in both seasons on plant weight, number and weight of outer leaves and plant stem diameter. Planting date significantly affected on vegetative traits in both seasons of the study, with the exception of diameter of plant stem in the second season. The earliest planting date (1st of November) recorded the highest values of plant weight, number and weight of outer leaves in both seasons and the highest value of stem diameter in the first season only, whereas delaying planting exhibited a significant decrease in all studied traits, excluding stem diameter in the second season. It could be suggested that planting at 1st of November represented the suitable climatic conditions for cabbage vegetative growth. These findings are in agreement with those obtained by Singh *et al*., 2010 ; Thirupal *et al*., 2014 and Khan *et al* 2015 who reported that vegetative growth measurements were significantly affected by planting date and the earlier planting promoted vegetative development.

Table 2. Effect of planting date and plant spacing on vegetative growth traits of cabbage plants during 2009/10 and 2010/11 seasons.

Treatment	Plant weight (kg)		No. outer leaves		Weight of outer leaves (kg)		Stem diameter (cm)	
	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11
Date								
1st Nov.	4.71	4.25	14.01	11.41	1.40	1.28	3.66	3.64
15thNov.	4.20	4.03	13.89	11.00	1.37	1.13	3.55	3.43
1st Dec.	3.89	3.78	12.89	10.55	1.02	1.07	3.42	3.42
LSD at 5%	0.18	0.10	0.70	0.58	0.17	0.10	0.14	ns
Spacing								
50	3.86	3.66	13.15	10.37	1.12	1.09	3.42	3.43
60	4.32	3.98	13.33	11.04	1.21	1.05	3.55	3.40
70	4.64	4.42	14.33	11.55	1.44	1.39	3.66	3.61
LSD at 5%	0.13	0.13	0.69	0.61	0.11	0.15	0.09	0.13

Yield and its components:

There were significant effects of planting date on yield and its components in both seasons as shown in Table (3). The earliest planting date at 1st of November exhibited the highest values of average head weight, total and marketable yield in both seasons. The highest values for total yield were recorded when planting at the 1st of November (41.07 and 36.92 ton/fed. at the first and second seasons, respectively). In he same manner, planting at 1st of November produced the largest marketable yield (28.85 and 26.95 ton/fed. at the first and second seasons, respectively), suggesting that the earlier planting date is more suitable for cabbage production and maximize yield compared with the late planting dates. Many investigations proved that the earlier planting dates produced larger total or marketable yield in

comparison to late planting dates. Cebula *et al*., 1996; Orzolek *et al*., 2000; Singh *et al*. 2010; and Maria and Sawicki, 2012.

Table 3. Effect of planting date and plant spacing on yield and its components of cabbage plants during 2009/10 and 2010/11 seasons.

Treatment	Head weight (kg)		Total yield (ton/fed)		Marketable yield (ton/fed)	
	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11
Date						
1st Nov.	3.32	3.01	41.07	36.92	28.85	26.95
15th Nov.	2.84	2.88	37.01	35.38	25.13	26.05
1st Dec.	2.88	2.72	34.59	32.29	25.49	24.44
LSD at 5%	0.18	0.13	1.60	1.08	1.58	1.46
Spacing						
50	2.73	2.61	41.12	38.76	29.10	27.81
60	3.10	2.94	38.37	35.40	27.62	26.02
70	3.20	3.06	33.18	31.42	27.75	23.60
LSD at 5%	0.12	0.03	1.10	1.22	1.20	1.59

Head quality attributes:

Data presented in Table (4) reveal that the effect of planting date on head quality attributes, e.g. equatorial and polar diameters, head volume, head density and dry matter content in both seasons of the investigation. The earliest planting date resulted in the highest values of head polar and equatorial diameter, head volume, head density and dry matter percentage. Thus, planting at 1st of November produced heads with favourable quality traits for the consumer demands other than the late planting dates. These findings are in agreement of those obtained by previous investigations (Greenland *et al*., 2000; Orzolek *et al*., 2000; Sarker *et al*., 2002 and Khan *et al*., 2015). However, these results partially disagree with those obtained by Kleinhenz and Wszelaki, 2003 who reported that late planting date resulted in denser cabbage heads and volumes, while early planting date produced heavier heads with bigger diameters and wider core width.

Table 4. . Effect of planting date and plant spacing on head quality attributes of cabbage plants during 2009/10 and 2010/11 seasons.

Treatment	Equatorial diameter (cm)		Polar diameter (cm)		Head volume (cm^3)		Head density (Kg/cm^3)		Dry matter (%)	
	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11
Date										
1st Nov.	26.26	22.89	15.48	14.48	3252.77	2547.24	1.06	1.21	6.88	6.65
15th Nov.	22.48	21.41	14.13	14.67	2372.59	2118.84	1.23	1.41	6.49	6.06
1st Dec.	22.85	21.15	13.63	13.04	2234.22	1893.05	1.13	1.47	5.64	5.80
LSD at 5%	0.92	0.68	0.99	0.97	478.52	321.03	0.21	0.23	0.23	0.35
Spacing										
50	22.67	20.99	13.28	12.92	2096.65	1838.07	1.31	1.43	5.95	5.79
60	22.82	21.19	14.39	13.52	2488.21	2047.41	1.27	1.48	6.47	6.24
70	25.11	23.26	15.59	14.74	3274.72	2673.65	1.02	1.17	6.59	6.47
LSD at 5%	0.63	0.71	0.76	0.66	273.39	240.59	0.14	0.21	0.19	0.19

2. Effect of plant spacing:

Vegetative growth:

The effects of plant spacing on vegetative growth are shown in Table (2). There were significant effects for plant spacing on vegetative growth characters in both seasons. The wider plant spacing showed the highest values of fresh plant weight (4.64 and 4.42 Kg at the first and second seasons, respectively), number (14.33 and 11.55 at the first and second seasons, respectively) and weight (1.44 and 1.39 at the first and second seasons, respectively) of outer leaves as well as plant stem diameter (3.66 and 3.61 cm at the first and second seasons, respectively). It could be concluded that the wider plant space between plants promote vegetative growth. Similar results were obtained by Firoz *et al*., 2000; Mahmoud *et al*., 2004; El-Shabrawy *et al*., 2005 and Asadul Haque *et al*., 2015.

Yield and its components:

Data presented in Table 3 indicate the presence of significant effect of plant spacing on yield and its components characters. Generally the wider space produced heavier average head weight. On the other hand, the wider space decreased the total (33.18 and 31.42 ton/fed in both seasons) and the marketable yield (27.75 and 23.60 ton/fed in both seasons). Consequently, the closer plant spacing produced larger total and marketable yield. These results may be ascribed to the high plant density per unit area when using low plant spacing, so that the number of plants per unit area was increased at closer spaces than those of wider space. Previous investigations illustrated that low plant spacing had increased the overall yield compared with large plant spacing. (Khadir *et al*., 1989; Stofella and Fleming, 1990 Firoz *et al*.; 2000; Mahmoud *et al*., 2004; El- Shabrawy *et al*., 2005; Moniruzzaman, 2011; Znidarcic *et al*., 2007; Asadul Haque *et al*., 2015 and Jayamanne et al., 2015)

Head quality attributes

Data in Table 4 demonstrated the presence of significant effect of plant spacing on head quality attributes. In this respect, the wider plant spacing gave the highest values for equatorial and polar diameters, head volume, and head density, whereas the closer plant spacing showed the highest dry matter content in both seasons. The fore mentioned results revealed that the wide plant spacing produce heads with larger dimensions and density. This may attributed to the low number of plants per unit area. These results are in accordance with those reported by Nahar *et al*. 1996; Wien and Wurr, 1997, Asadul Haque *et al*., 2015 and Khan *et al*., 2015. They pointed that the plant grow under wider spacing received more nutrients, light and moisture around compared to plants of closer space.

3. Effect of interaction between plant date and plant spacing:

Vegetative growth

The effect of the interaction of planting date and plant spacing on vegetative growth is shown in Table 5. The interaction of planting date and plant spacing had a significant effect on plant fresh weight in both seasons. It is apparent that the highest values of plant weight were obtained from planting at first of November with 70 cm spaced between plants (4.98 and 4.83 kg in the first and second seasons, respectively), whereas the interaction had no significant effects on the number and weight of outer

leaves and plant stem diameter. This could be explained by the individual effect of planting date or spacing on the fore mentioned vegetative growth characters.

Table 5. Effect of interaction of planting date and plant spacing on vegetative growth traits of cabbage plants during 2009/10 and 2010/11 seasons.

Treatment		Plant weight (kg)		No. outer leaves		Weight of outer leaves (kg)		Stem diameter (cm)	
Date	Spacing	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11
1st Nov.	50	4.02	3.73	13.22	10.78	1.27	1.23	3.57	3.57
	60	4.76	4.20	13.78	11.44	1.33	1.19	3.60	3.54
	70	4.98	4.83	15.11	12.00	1.60	1.43	3.08	3.77
15th Nov.	50	3.86	3.70	13.34	10.67	1.18	1.04	3.47	3.37
	60	4.27	4.03	13.56	10.89	1.27	0.99	3.60	3.40
	70	4.50	4.35	14.78	11.44	1.57	1.41	3.60	3.50
1st Dec.	50	3.70	3.54	12.89	9.67	0.93	0.98	3.27	3.37
	60	3.92	3.73	12.67	10.78	0.95	0.97	3.40	3.32
	70	4.07	4.08	13.11	11.22	1.17	1.26	3.60	3.53
LSD at 5%		0.22	0.23	ns	ns	ns	ns	ns	ns

Yield and it components:

Data of the interaction effect of planting date and spacing are presented in Table (6). There are significant effects of the interaction of planting date and spacing on total yield in both seasons. It is obvious that the highest values of total yield were obtained in the first and second planting dates when using 50 cm spacing, whereas the lower spacing decreased total yield. Similar results were obtained by El-Shabrawy *et al*., 2005 and Maria and Sawicki, 2012. Meanwhile, the interaction of planting date and spacing significantly affected the head weight in the first season but that was not confirmed in the second season. As for marketable yield, there were no significant effects of interaction of planting date and spacing. This is probably due to independence of the single effects of planting date and spacing on the marketable yield.

Table 6. Effect of interaction of planting date and plant spacing on yield and its components of cabbage plants during 2009/10 and 2010/11 seasons.

Treatment		Head weight (kg)		Total yield (ton/fed.)		Marketable yield (ton/fed.)	
Date	Spacing	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11
1st Nov.	50	2.75	2.62	42.85	39.12	39.32	27.89
	60	3.75	3.01	40.27	37.30	30.46	26.76
	70	3.88	3.40	38.18	34.34	26.30	26.19
15thNov.	50	2.60	2.61	41.15	39.41	28.50	28.32
	60	2.82	3.04	37.92	35.82	26.05	27.00
	70	2.97	2.96	31.99	30.90	20.86	22.85
1st Dec.	50	2.80	2.55	39.44	37.74	29.49	27.22
	60	2.87	2.77	35.25	33.09	26.37	24.33
	70	2.97	2.82	29.37	29.03	20.62	21.77
LSD at 5%		0.98	ns	1.91	1.68	ns	ns

Head quality attributes:

Data in Table 7 show that the interaction effect of planting date and spacing had no significant effects on most head quality attributes in both seasons. The differences of equatorial and polar diameters, head volume, and head density could be ascribed to the independent effect of planting date or plant spacing. On the other hand, data reflected a significant interaction effect of planting date and spacing on dry matter content in both seasons and that the highest values for dry matter content were obtained when planting at 1st of November at 70 cm between plants (7.42 and 7.18 % at the first and second seasons, respectively).

Table 7. Effect of interaction of planting date and plant spacing on head quality attributes of cabbage plants during 2009/10 and 2010/11 seasons.

		Equatorial diameter (cm)		Polar diameter (cm)		Head volume (cm^3)		Head density (Kg/cm^3)		Dry matter (%)	
Date	Spacing	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11
1st Nov.	50	23.89	21.44	13.55	13.22	2298.36	1961.34	1.20	1.34	6.39	6.17
	60	24.11	22.67	14.33	14.44	2572.58	2482.91	1.16	1.23	6.83	6.59
	70	27.78	24.56	15.56	15.78	4487.39	3197.48	0.84	1.06	7.42	7.18
15th Nov.	50	26.67	20.78	13.19	12.78	1971	1777.18	1.36	1.51	6.24	5.90
	60	21.34	20.33	14.33	13.33	2305.35	1892.08	1.29	1.61	6.79	6.18
	70	24.44	23.11	14.89	14.89	2841.01	2687.27	1.04	1.12	6.46	6.10
1st Dec.	50	22.44	20.78	13.11	12.78	2020.17	1775.70	1.38	1.45	5.21	5.33
	60	23.01	20.56	13.44	12.78	2186.71	1767.23	1.39	1.60	5.82	5.93
	70	23.11	22.11	14.33	13.56	2495.77	2136.22	1.18	1.34	5.91	6.13
LSD at 5%		ns	ns	ns	ns	ns	ns	ns	ns	0.33	0.34

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تأثير ميعاد و مسافات الزراعة علي المحصول و صفات الجودة في الكرنب

محمد يو سف عابد ، السعيد محمود السعيد و انتصار فوزي شبل
قسم بحوث الخضر – معهد بحوث البساتين – مركز البحوث الزراعية – الجيزة - مصر

اجريت تجربتان حقليتان بمحطة بحوث البساتين بالبرامون –الدقهلية في موسمي ١٠/٢٠٠٩ و ١١/٢٠١٠ بهدف دراسة تأثير كل من ميعاد الزراعة (اول نوفمبر – ١٥ نوفمبر –اول ديسمبر) و مسافات الزراعة بين النباتات (٥٠-٦٠-٧٠ سم) و التفاعل بينهم علي النمو و المحصول و مواصفات الرأس للكرنب صنف برونزويك. استخدم تصميم القطع المنشقة في ثلاث مكررات و تتلخص اهم النتائج فيما يلي:

- اوضحت النتائج ان افضل ميعاد للزراعة هو الزراعة في اول نوفمبر و ادي ذلك الي حدوث زيادة معنوية في وزن النبات و عدد و وزن الاوراق الخارجية للنبات. كما حدث زيادة في متوسط وزن الرأس و المحصول الكلي و المحصول التسويقي بالاضافة الي تحسين جودة المحصول متمثلا في زيادة ابعاد الرأس و حجم و كثافة الرأس و محتوي الاوراق من المادة الجافة.
- اثرت مسافة الزراعة معنويا علي الصفات المدروسة في كلا الموسمين حيث ان زيادة مسافة الزراعة (٧٠ سم بين النباتات) ادت الي زيادة وزن النبات و عدد و وزن الاوراق الخارجية للنبات وادي الي تحسين مواصفات الرأس بزيادة ابعاد و حجم و كثافة الرأس كما ادت الزراعة علي مسافات واسعة الي انخفاض في المحصول الكلي و المحصول التسويقي. بينما الزراعة علي مسافات ضيقة (٥٠سم بين النباتات) ادت الي زيادة في المحصول الكلي و المحصول التسويقي و يرجع ذلك الي زيادة عدد النباتات في وحدة المساحة
- كان تأثير التفاعل بين عوامل الدراسة معنويا علي وزن النبات و المحصول الكلي و نسبة المادة الجافة في كلا الموسمين بينما كانت التأثيرات غير معنوية لباقي الصفات المدروسة.