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GROWTH AND DEVELOPMENT OF *Brassica oleracea* var. *italica* PLENK IN RESPONSE TO PLANTING DATE

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ABSTRACT

This investigation was conducted at the Experimental Station of the Faculty of Agriculture, Cairo University during the two successive winter seasons of 2002/2003 and 2003/2004 to study the effect of planting date (15 Aug., 15 Sep., and 15 Oct.) on the morphological characters and growth formulas, along with some of the associated characters in broccoli hybrid Green Comet. Early Planting on 15 August resulted in a significant increase in plant and leaf dry matter, plant height, economic yield, top and side head yield, leaf area index and crop growth rate in both seasons and head diameter and compactness in 2003/2004. Meanwhile, it resulted in a significant reduction in the total number of leaves and leaf primordia, head dry matter percent, and head chlorophyll and carotenoides content in both season and head vitamin C content in 2003. The third planting date on 15 Oct. was significantly the highest in total number of leaves and leaf primordia and leaf chlorophyll content and the lowest in biological yield, economic yield, top and side head yield, and leaf area index. It was also the latest date in head differentiation and took the longest period from transplanting to harvest.

Key words: Broccoli, *Brassica oleracea* var *italica*, planting date, number of leaves, leaf primordia, plant height, dry matter, leaf chlorophyll content, head differentiation, yield, head characters, accumulated heat units, carotenoids, vitamin C, carbohydrates, growth formulas.

INTRODUCTION

Broccoli (*Brassica oleracea* L. var. *italica* Plenk) is an important nutrional cole vegetable. It is high in vitamin A, ascorbic acid and is a good source of calcium, niacin and riboflavin (Decoteau, 2000). It is anticarcinogens and its beneficial effect on health is probably dut to the immense variety of biologically active secondary metabolites which it contains (Fahey and Stephenson, 1999; Johnson, 2000)

Broccoli is a new crop for Egypt. Only few studies have highlighted the complex and interrelated effects of cultural practices and environmental conditions on broccoli production (Aboul-Nasr and Ragab, 2000; Hifny *et al.* 2002)

Egypt exported 22 tons of broccoli in 2004, and 130 tons in 2005*. The increasing popularity of this crop is due to the recent increase in its consumption by some people and by resorts. It was, therefore, deemed important to initiate improvement work of its production under local conditions.

Broccoli is a cool-season crucifer. It has about the same climatic requirements as cauliflower. It is well adapted to all areas when grown during the coolest months of the year, although it is not as sensitive to hot weather. It is harvested over a longer period of time than cauliflower since lateral broccoli shoots develop marketable heads after the center head is harvested. The upper stem and clusters of unopened flower buds (heads) are the edible parts of the plant. Hot weather during harvest period results in heads developing so rapidly that it is difficult to harvest at the proper time.

Salter *et al.* (1984) indicated that broccoli plant growth and development were affected by seasonal environmental conditions. When crops were grown from sowings in early April and May, maturing was, respectively, in June and July. Yield, head weight, diameter, shape, colour and harvest index were similar for the two sowings dates. However, crops sown later in early July, which matured in September, gave lower yields, smaller heads, inferior head colour, and had lower harvest index. They also found that accumulated degree-days above a base temperature of 20 C° during the first half of the period from planting to maturity gave the closest correlation with good crop performance.

Chung (1985) studied the effect of sowing time from December to January and March (Mean daily temperatures were 15.1, 16.7 and 12.1C°, respectively). He showed that, delay in sowing time after December reduced marketable spear yield (MSY) and total dry matter (TDM). At each sowing time, there was a positive linear relationship between TDM and MSY. Delay in sowing time from December to January had little effect on the length of growing period (87 days). However, a delay in sowing to March increased the growing period by about three weeks.

Krumbein and Schonhof (1999) reported that vitamin C and β-carotene content in broccoli are mainly influenced by preharvest parameters, depending on the climatic conditions during the production and developmental stages. At harvest, the content of vitamin C and β-carotene showed variation from 90 to 134 mg/100 g fresh weight and from 0.3 to 1.9 mg/100 g fresh weight, respectively. High daily mean temperatures and high photosynthetic photon flux density levels inhibited the biosynthesis of β-carotene and vitamin C, respectively.

Although detailed growth studies and yield analysis are common for agronomic crops, their application to horticulture crops is limited.

Therefore, the objectives of this investigation were to study the effect of planting date on the morphological characters and growth formulas along with some of the associated characters in broccoli.

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MATERIALS AND METHODS

This investigation was conducted at the experimental station of the Faculty of Agriculture, Cairo University, Giza, during the two successive winter seasons of 2002/2003 and 2003/2004 to study the effect of planting date on broccoli morphological characters and growth formulas along with some of the associated characters. The soil of the experimental area was clay.

Seeds of broccoli hybrid Green Comet (Takii Co., Japan) were sown in the two season on mid August, mid September and mid October in Speedling trays. Four week-old transplants were field planted in a complete randomized block design with four replicates. Each experimental plot was 28 m^2 and consisted of 10 rows, each 4.0 m long and 0.7 m wide. Transplants were planted on one side of rows 50 cm apart. Yield was recorded on plants grown in the two central rows of each plot, vegetative samples were taken randomly from plants of the outer rows.

Various cultural practices were conducted as commonly followed in commercial cauliflower fields. Plants were fertilized with 40 kg N, 30 kg P_2O_5 and 50 kg K_2O/fed. Application was in two equal parts at 3 and 6 weeks after transplanting. Temperature recorded during the growing seasons is presented in Table 1.

Table (1): Average monthly temperature (°C) during growing seasons.

Month	2002-2003 Season			2003-2004 Season		
	Max	Min	Mean	Max	Min	Mean
Aug.	35.4	25.7	30.5	35.4	22.6	29.0
Sep.	34.3	21.2	27.7	32.8	20.2	26.5
Oct.	29.3	17.7	23.5	29.6	17.6	23.6
Nov.	28.3	14.9	21.6	25.2	13.7	19.5
Dec.	20.8	7.7	14.2	22.1	9.7	15.9
Jan.	21.0	6.2	13.6	19.0	6.4	12.7
Feb.	22.0	7.6	14.8	21.9	7.8	14.8
Mar.	21.1	12.5	16.8	24.7	11.7	18.2

Data were recorded on the following characters:

Vegetative characters:

Three plants were taken randomly from each experimental plot as a representative sample one month after transplanting and every 15 days thereafter for measuring the following characters:

- Plant height from cotyledonary scar to shoot tip (cm).
- Total number of leaves and leaf primordia.
- Number of leaves more than 1-cm-long (including scars).
- Chlorophyll content (SPAD reading) in the most recent fully expanded leaf.
- Total plant dry weight (the roots were cut off at the cotyledonary scar) and leaf dry weight were measured 15 days after transplanting and every 15 days thereafter.

- Days from transplanting to apex differentiation and until it reached 1 cm in diameter was measured, in each sampling date, on one plant taken at random from each experimental plot 2 weeks after transplanting and every week thereafter. In each plant sample, apices were observed under a dissecting microscope for any sign of curd initiation.
- Days from transplanting to harvest. A head was considered mature at the time just before it started to lose compactness or just before buds started to break up.

Yield:

Yield of top head and yield of side heads were recorded in the two central rows only of each plot.

Head characters:

At harvest, eight heads were taken from each experimental plot for measuring the following characters:

- Head diameter in two directions (cm).
- Color (1, pale green to 5, dark green).
- Compactness (1, loose to 5, compact).
- Floret length (cm).
- Head dry matter percent.

Head chemical composition:

All chemical determinations were conducted on 12 heads, three heads were taken at random from each replicate. Determinations included the following characters:

- Total carbohydrates as determined according to the method described in AOAC (1980).
- Ascorbic acid content as determined by titration method using 2,6 dichlorophenol-indophenol dye according to AOAC (1980).
- Total chlorophyll and total cratonoids as determined by using N.N. dimethyl formamide according to Nornai (1982).

Growth parameters:

The following growth parameters were calculated at harvest:

- Biological yield (W) = total plant dry matter at harvest.
- Economic yield (EY) = yield of economic part of the plant.
- Harvest index (HI) = (EY/W) × 100.

The following parameters were measured one month after transplanting and every 15 days thereafter (Stoskopf, 1981).

- Specific leaf weight (SLW) = dry matter per unit of leaf area.
- Leaf area ratio (LAR) = L/W,
  Where: L = total leaf area.
- Leaf area index (LAI) = L/P,
  Where: P = land area given for each plant.

- Relative growth rate (RGR) = (accumulated dry matter in plant per base weight unit at time unit) $\Delta W/W \times$ time,
  Where: ΔW is the change in plant dry matter.
- Crop growth rate (CER) = (accumulated dry matter in plant at time unit per land area given for each plant) $\Delta W/P \times$ time.
- Net assimilation rate (NAR) = (accumulated dry matter in plant per unit of leaf area time unit) = $\Delta W/L \times$ time.

Environmental measurements:

Daily maximum and minimum temperature were recorded (central laboratory of Agricultural Climate, Ministry of Agriculture). Heat units (day-degrees) accumulated above a minimum growth (or base) temperature were calculated based on a base temperature of 0 °C for broccoli as follows (Tan *et al.*, 2000):

Accumulated degree – days = Σ [(maximum + minimum daily temperature) / 2] – base temperature

The accumulated daily heat units were recorded from transplanting to harvest.

The L.S.D method (Snedecor and Cochran, 1967) was used for testing the significance of means.

RESULTS AND DISCUSSION

Effect of planting date on foliage characters:

Data obtained on the effect of planting date on number of leaves more than 1-cm-long, total number of leaves and leaf primordia, and plant height during the 2002/2003 and 2003/2004 winter plantings are presented in Table 2.

In both years of the study, the number of leaves more than 1-cm-long was significantly highest at the second planting date. In addition, the first planting date had the lowest total number of leaves and leaf primordi with no significant differences found among the treatments at 30 and 45 days after transplanting in 2002 and 2003, respectively. However, the third date had the highest number of leaves. A reverse trend was observed with plant height. First planting date on 15 August had the highest plant height compared with the other two tested planting dates (Average monthly temperature was 29, 26, and 23 °C in Aug., Sep., and Oct., respectively).

Our results agree with those obtained by Fortunato and Damato (2000), who studied the response of broccoli raab to three sowing dates, namely Aug. 27, Oct. 2, and Nov. 6 (average daily temperature was 26, 23, and 18 °C, in Aug., Sep., and Oct., respectively). The length of vegetative stage period was 30, 45 and 55 d for the first, second and third sowing dates, respectively.

Data obtained on the effect of planting date on total plant dry matter and leaf dry content matter are presented in Table 3. Such data show that total plant dry matter and leaf dry matter content were significantly highest in the first planting date (15 August). On the contrary, the third planting date (15 October) gave the lowest value in

this respect in both season. Our results agree with those obtained by Chung (1985), who concluded that delaying sowing time from December to January and March (mean daily temperature were 15.1, 16.7 and 12.1 °C, respectively) it was warmer with greater sunlight hours during December and January sowings than during March sowing, which significantly reduced the total dry matter. Moreover, our results agree with those obtained by Everaarts *et al.* (1998), who studied three planting dates of Brussels sprouts between the end of April and early July. The highest final dry matter production was always realized with the first planting date. Average monthly temperature during their experimental period was 14.4 °C in May, 14.5 °C in June, 15.8 °C in July, 16.1 °C in August, 13.9 °C in September, 10.8 °C in October, 5.7 °C in November, 6.6 °C in December and 4.4 °C in January.

Data on the effect of planting date on chlorophyll content of leaves (SPAD reading) are presented in Table 4. Chlorophyll content had the highest value in the third planting date in both years. Meanwhile, second date was the lowest in the 2002 season. No significant differences were found between the first and second date in 2003 season. Low temperature related to a higher accumulation of chlorophyll pigments in leaves (McKay, 1949). Azia and Stewart (2001) concluded that leaf chlorophyll was influenced by nutrient elements, and environmental factors such as air temperature, light, and carbon dioxide.

Table (2): Effect of planting date on foliage characteristics, of broccoli plants hybrid Green Comet.

Planting date	Age after transplanting 2002/ 2003 season			Age after transplanting 2003/2004 season		
	30 days	45 days	60 days	30 days	45 days	60 days
	Number of leaves > 1cm long					
15 August	11.13 a	16.00 b	17.38 c	12.41 b	17.88 b	22.08 b
15 September	11.90 a	17.63 a	23.75 a	14.08 a	19.75 a	26.13 a
15 October	8.67 b	14.50 c	20.67 b	13.66 a	15.63 c	23.50 b
Mean	10.56	16.04	20.60	13.39	17.75	23.50
$LSD_{0.05}$	1.11	1.00	1.00	0.52	0.89	1.14
	Total number of leaves and leaf primordi					
15 August	13.94	21.33 c	21.75 c	17.49c	24.25	22.08 c
15 September	15.60	23.13 b	23.50 b	21.42 b	2588	26.38 b
15 October	13.58	26.33 a	26.33 a	24.00 a	25.92	27.42 a
Mean	14.37	23.60	23.86	20.97	25.35	25.29
$LSD_{0.05}$	NS	0.92	0.78	1.52	NS	0.56
	Plant height (cm)					
15 August	7.04 a	12.29 a	24.06 a	7.46 ab	12.17 a	21.79 a
15 September	7.08 a	10.81 b	17.15 b	8.20 a	12.66 a	21.44 a
15 October	4.38 b	7.54 c	12.04 c	6.50 b	8.36 b	13.44 b
Mean	6.16	10.21	17.75	7.38	11.06	18.89
$LSD_{0.05}$	0.69	1.36	0.53	1.17	1.64	2.70

Table (3): Effect of planting date on dry matter content of broccoli plants hybrid Green Comet.

Planting date	Age after transplanting (day)			
	15	30	45	60
	Total Plant Dry Matter (g) 2002/2003 season			
15 August	1.21 a	10.26 a	46.70 a	112.13 a
15 September	0.92 b	7.16 b	37.41 b	71.33 b
15 October	0.94 b	1.34 c	9.69 c	29.72 c
Mean	1.02	6.25	31.27	71.06
$LSD_{0.05}$	0.08	0.72	2.00	4.46
	2003/2004 season			
15 August	1.01 b	9.58 a	46.85 a	74.84 a
15 September	1.56 a	8.09 a	33.12 b	63.81 b
15 October	0.58 c	5.93 b	12.20 c	37.02 c
Mean	1.05	7.87	30.72	58.55
$LSD_{0.05}$	0.29	1.98	1.88	9.31
	Leaf Dry Matter (g) 2002/2003 season			
15 August	1.09 a	9.04 a	40.29 a	56.28 a
15 September	0.82 b	5.08 b	23.96 b	43.71 b
15 October	0.83 b	0.99 c	6.59 c	18.08 c
Mean	0.91	5.03	23.61	39.36
$LSD_{0.05}$	0.08	0.99	1.13	0.71
	2003/2004 season			
15 August	0.89 b	5.89 a	24.73 a	31.81 a
15 September	1.35 a	4.98 ab	18.46 b	25.73 b
15 October	0.49 c	3.37 b	6.69 c	17.47 c
Mean	0.91	4.75	16.63	25.00
$LSD_{0.05}$	0.25	1.62	2.18	2.26

Table (4): Effect of planting date on leaves chlorophyll content (SPAD) of broccoli plants hybrid Green Comet.

Planting date	Age after transplanting (day)		
	30	45	60
	2002/2003 season		
15 August	45.99 b	54.46 b	60.27 b
15 September	41.34 c	50.53 c	45.60 c
15 October	54.65 a	64.73 a	68.97 a
Mean	47.32	56.57	58.28
$LSD_{0.05}$	3.06	3.37	4.29
	2003/2004 season		
15 August	47.14 b	49.00 b	54.02 b
15 September	52.41 ab	46.98 b	55.70 b
15 October	52.89 a	59.87 a	61.95 a
Mean	50.81	51.95	57.22
$LSD_{0.05}$	5.39	5.89	3.73

Data obtained on the effect of planting date on head differentiation are presented in Table 5. Obtained data revealed that the second plating date resulted in significantly the earliest head differentiation, i.e., after four weeks from transplanting in 2002/2003 season, while first planting date was the earliest in

2003/2004 season. Moreover, First planting date had the largest head after seven weeks in both seasons. On the other hand, the third planting date was the latest date in differentiation in both seasons. These results are in accordance with those reported by Fortunato and Damato (2000), who studied three sowing dates (Aug. 27, Oct. 2, and Nov. 6) of broccoli raab (average daily temperature was 26, 23, and 18 °C in Aug., Sep., and Oct., respectively). For the first and second sowing dates, apex differentiation occurred at the same time. Apex transition occurred 34-37 days after sowing (DAS), and differentiation 46-47 DAS. For the third sowing date, apex transition occurred 55 DAS and ended 30 days afterwards.

Table (5): Effect of planting date on head differentiation, i.e., head diameter in mm of broccoli plants hybrid Green Comet.

Planting date	Age after transplanting (day)			
	28	35	42	49
	2002/2003 season			
15 August	0.00 b	2.38 a	8.33 a	32.50 a
15 September	0.33 a	2.35 a	6.28 b	13.07 b
15 October	0.00 b	0.88 b	2.17 c	5.25 c
Mean	0.11	1.87	5.59	16.94
$LSD_{0.05}$	0.12	0.46	0.96	2.46
	2003/2004 season			
15 August	0.88 a	2.36 a	8.45 a	25.25 a
15 September	0.50 b	2.25 a	8.99 a	14.67 b
15 October	0.50 b	1.00 b	3.00 b	7.25 c
Mean	0.63	1.87	6.81	15.72
$LSD_{0.05}$	0.25	0.48	0.92	5.91

Table 6 shows the accumulated heat units (AHU) from transplanting to maturity and season length. In this respect, plants took the longest time (80 days) from transplanting to maturity and the lowest AHU in the third date in both years. Meanwhile planting on first date had the shortest time to maturity (60 days) and the highest AHU. These results agree with those obtained by Chung (1985), who concluded that delays in sowing time from December to January had little effect on the length of growing period (87 days). However, a delay in sowing to March increased the growing period by about three weeks (mean daily temperature was 15.1, 16.7 and 12.1 °C, in Dec., Jan. and March, respectively).

Table (6): Accumulating heat units (AHU) from transplanting to maturity and season length

Planting date	2002/2003 season		2003/2004 season	
	season length (days)	AHU	season length (days)	AHU
15 August	60	1400	60	1383
15 September	65	1321	69	1361
15 October	80	1165	80	1228

Base temperature 0 °C

Effect of planting date on head characteristics:

Data obtained on the effect of planting date on head diameter, floret length, color and compactness are presented in Table 7. There were significant differences among the planting dates for both head diameter and head compactness during both growing seasons. The first and second dates were superior in head diameter and head compactness compared to third one. There were no significant differences between planting dates in both floret length and head color in the first season. Meanwhile, third date in the second season had the shortest floret length. These results partially agree with those of Salter *et al.* (1984), who concluded that broccoli plant grown from sowings in early April and May, produced heads similar in both head diameter and color. However, crops sown later in early July, gave smaller and inferior colored heads. An average daily temperature of 20°C during the first half of the period from planting to maturity gave the closest correlation with good crop performance. Moreover, these results are in agreement with those of Butt *et al.* (1988), who studied cauliflower planting date (28 July, 25 Aug, 22 Sep and 22 Oct) under Assiut conditions. Results revealed that the largest curd diameter was obtained from the earliest planting date, and the smallest curd diameter was obtained from the latest planting date.

Our results do not confirm those reported by Aboul-Nasr and Ragab (2000), who studied two sowing dates (Oct., 1st and Oct., 15th) of broccoli under Assiut conditions, where head diameter was affected by planting date, with the second date being superior compared to the first. Difference in sowing date did not affect floret length or head compactness.

Table (7): Effect of planting date on head characteristics of broccoli plants hybrid Green Comet.

Planting date	Head diameter (cm)	Floret Length (cm)	Head color[z]	Head compactness[y]
	2002/2003 season			
15 August	19.42 a	5.86	3.21	2.95 a
15 September	19.49 a	5.53	3.36	3.01 a
15 October	13.72 b	5.44	3.08	1.87 b
Mean	17.54	5.61	3.21	2.61
$LSD_{0.05}$	1.58	NS	NS	0.27
	2003/2004 season			
15 August	22.35 a	6.02 a	2.95	2.99 a
15 September	15.67 b	5.22 b	3.08	2.93 a
15 October	11.82 c	3.74 c	3.00	2.19 b
Mean	16.41	4.99	3.01	2.70
$LSD_{0.05}$	1.52	0.74	NS	0.43

[z] color (score; 1= pale green; 5= dark green)

[y] compactness (score; 1= loose; 5= compact)

Effect of planting date on head chemical composition:

Data obtained on the effect of planting date on head dry matter percentage, side head dry matter percentage, total chlorophyll, total carotenoids,

vitamin C and total carbohydrates during the 2002/2003 and 2003/2004 winter planting are presented in Table 8. Significant differences were detected among planting dates in head dry matter, total chlorophyll and total carotenoids. The second and third planting dates gave the highest values in these characters, whereas first sowing date gave the least values in both years of the study. There were no significant differences among planting dates in the side head dry matter percentage and total carbohydrates in the first year. Meanwhile, first date was significantly the lowest in side head dry matter percentage, and vitamin C in the second year.

Our results partially agree with those obtained by Krumbein and Schonhof (1999), who reported that vitamin C and β-carotene contents in broccoli is mainly influenced by preharvest parameters. High daily mean temperatures inhibit the biosynthesis of β-carotene and vitamin C, respectively. Meanwhile, the present results disagree with those of Diputado and Nichols (1989), who reported that head dry matter percent varied with sowing dates, being lower during winter than during summer.

Table (8): Effect of planting date on head, chemical composition of broccoli plants hybrid Green Comet.

Planting date	Head dry matter (%)	side head dry matter (%)	Total chlorophyll (mg/g fresh weight)	Total carote-noids (mg/g fresh weight)	Vitamin C (mg/100g fresh weight)	Total Carbohy-drates (mg/100g fresh weight)
	2002/2003 Season					
15 August	9.54 b	11.89	0.35 c	0.14 b	200.88 a	294.33
15 Sept.	11.08 a	12.39	0.78 b	0.32 a	80.36 c	229.66
15 October	11.05 a	12.60	0.95 a	0.35 a	168.48 b	307.25
Mean	10.56	12.29	0.69	0.27	149.90	227.08
$LSD_{0.05}$	1.29	NS	0.12	0.06	16.78	NS
	2003/2004 Season					
15 August	9.96 b	11.69 b	0.58 b	0.21 b	119.03 c	351.66 b
15 Sept.	11.32 a	12.98 a	0.88 a	0.34 a	135.54 b	484.00 a
15 October	11.80 a	13.01 a	0.98 a	0.36 a	151.20 a	338.33 b
Mean	11.03	12.56	0.80	0.30	135.26	391.33
$LSD_{0.05}$	0.85	0.94	0.13	0.06	9.88	76.83

Effect of planting date on yield and growth formulas:

Data obtained on the effect of planting date on biological yield, economic yield, harvest index, total head yield and side head yield during the 2002/2003 and 2003/2004 winter planting are presented in Table 9. In both years of the study, the biological yield, economic yield, total head yield and side head yield were significantly the lowest at the third planting date. Meanwhile, the first planting date gave the highest values for economic yield, total head yield and side head yield in both seasons. There were no significant among the between planting dates in the harvest index in the first year. Meanwhile, harvest index was significantly the lowest at the third planting date in the second year.

Table (9): Effect of planting date on biological yield, economic yield, harvest index, top head yield, and side head yield of broccoli plants hybrid Green Comet

Planting date	Biological yield (g/plant)	Economic yield (g/plant)	Harvest index (g/plant)	Top head yield (kg/fed)	side head Yield (kg/fed)
	2002/2003 season				
15 August	178.44 a	57.88 a	32.44	3533.57 a	3936.07 a
15 September	123.37 b	39.04 b	31.67	3409.33 a	2149.52 b
15 October	88.45 c	25.51 c	28.89	2640.82 b	489.76 c
Mean	130.09	40.81	31.01	3194.57	2191.78
$LSD_{0.05}$	8.98	3.21	NS	270.10	290.40
	2003/2004 season				
15 August	128.00 b	48.77 a	38.08 a	4030.38 a	945.18 a
15 September	158.02 a	54.38 a	34.40 a	2255.24 b	738.75 b
15 October	106.84 c	28.61 b	26.76 b	1473.37 c	526.79 c
Mean	130.95	43.92	33.08	2586.33	736.91
$LSD_{0.05}$	5.89	6.86	3.89	197.20	94.95

Our results disagree with those obtained by Sterrett *et al.* (1990), who studied three planting dates, viz., 10 Aug, 19 Aug and 10 Sep (average daily temperature during August and early September could exceed 24 °C). Lower yields were noted for the second planting date.

Data obtained on the effect of planting date on leaf area index, leaf area ratio and specific leaf weight are presented in Table 10. In both years of the study, the leaf area index was significantly highest at the first planting date. However third planting date showed the lowest values. The leaf area ratio was significantly highest at the second planting date in the first year. Meanwhile, there was no significant differences between the three planting dates in the second year.

In both years of the study, there was no significant difference among the three planting dates in specific leaf weight. Our results agree with those obtained by Abuzeid and Wilcockson (1989), who tried three sowing dates (16 May, 6 June and 27 June) for Brussels sprouts (trend of air temperature during May, June, and July was, respectively, 10, 16, and 18 °C for maximum and 8, 10, and 16°C for minimum temperature). The last sowing in both years maintained a significantly higher leaf area index than the earliest sowing.

Data obtained on the effect of planting date on relative growth rate, crop growth rate and net assimilation rate are presented in Table 11. There were significant differences among the planting dates in relative growth rate; the third plating date had the lowest rate at 30 days after transplanting and increased thereafter to reach the highest rate at 45 and 60 days after transplanting in first year. However, the first date had the highest rate at 30 and 45 days and decreased thereafter to be the lowest rate at 60 days in the second year.

There were significant differences among the planting dates on crop growth rate, the first planting date had the highest rate. Meanwhile, the third date had the lowest rate in the first year. The first date had the highest rate at 30 and 45 days after transplanting. No significant differences were found among planting dates after 60 days in the second year.

Table (10): Effect of planting date on leaf area index, leaf area ratio, and specific leaf weight of cv. Green Comet.

Planting date	Age after transplanting 2002/2003 season			Age after transplanting 2003/2004 season		
	30 days	45 days	60 days	30 days	45 days	60 days
	Leaf Area Index					
15 August	0.36 a	1.50 a	2.13 a	0.33 a	1.25 a	1.62 a
15 September	0.32 b	1.41 b	2.15 a	0.24 b	0.95 b	1.41 b
15 October	0.05 c	0.28 c	0.65 b	0.18 b	0.32 c	0.72 c
Mean	0.24	1.07	1.64	0.25	0.84	1.25
$LSD_{0.05}$	0.02	0.08	0.08	0.07	0.14	0.05
	Leaf Area Ratio					
15 August	122.39 b	112.65 b	66.57 c	123.42	93.08	76.50
15 September	156.68 a	132.22 a	105.28 a	107.07	100.76	77.38
15 October	129.97 b	102.12 b	76.15 b	105.86	93.03	68.75
Mean	136.35	115.66	82.67	112.12	95.62	74.21
$LSD_{0.05}$	13.81	10.98	6.94	NS	NS	NS
	Specific Leaf Weight (10^{-2} cm)					
15 August	0.7	0.8	0.8	0.5	0.6	0.6
15 September	0.5	0.5	0.6	0.6	0.6	0.5
15 October	0.6	0.7	0.8	0.5	0.6	0.7
Mean	0.6	0.6	0.7	0.5	0.6	0.6
$LSD_{0.05}$	NS	NS	NS	NS	NS	NS

Table (11): Effect of planting date on relative growth rate, crop growth rate, and net assimilation rate of cv. Green Comet.

Planting date	Age after transplanting 2002/2003 season			Age after transplanting 2003/2004 season		
	30 days	45 days	60 days	30 days	45 days	60 days
	Relative Growth Rate					
15 August	7.48 a	3.57 c	1.40 b	8.49 a	4.17 a	0.60 c
15 September	6.79 a	4.23 b	0.91 c	4.26 b	3.12 a	0.93 b
15 October	0.43 b	6.12 a	2.08 a	9.24 a	1.07 b	2.03 a
Mean	4.90	4.67	1.46	7.33	2.78	1.19
$LSD_{0.05}$	0.69	0.46	0.27	2.10	1.36	0.24
	Crop Growth Rate					
15 August	0.60 a	2.43 a	4.36 a	0.57 a	2.48 a	1.86
15 September	0.41 b	2.01 b	2.26 b	0.43 b	1.67 b	2.04
15 October	0.03 c	0.55 c	1.33 c	0.35 b	0.42 c	1.65
Mean	0.34	1.66	2.65	0.45	1.52	1.85
$LSD_{0.05}$	0.05	0.13	0.27	0.13	0.18	NS
	Net Assimilation Rate					
15 August	0.062 a	0.032 b	0.021 ab	0.072 a	0.046 a	0.008 b
15 September	0.043 b	0.032 b	0.009 b	0.040 b	0.031 a	0.012 b
15 October	0.003 c	0.061 a	0.027 a	0.088 a	0.011 b	0.030 a
Mean	0.036	0.042	0.019	0.066	0.029	0.017
$LSD_{0.05}$	0.017	0.017	0.017	0.017	0.017	0.017

There were significant differences among the planting dates on net assimilation rate, the third planting date had the lowest rate at 30 days after transplanting and increased thereafter to reach the highest rate at 45 and 60 days in the first year. However, the first date had the highest rate at 30 and 45 days after transplanting and decreased thereafter to reach the lowest rate at 60 day in the second year.

Our results do not confirm those reported by Caruso (2000), who investigated three planting dates (April 6, May 9 and June 5) in cabbage, and who found that crop growth rate showed an increasing trend with the second planting date (trend of air temperature during April, May and June was, respectively, 18, 24 and 26 °C for maximum and 10, 14, and 16 °C, for minimum temperature).

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نمو وتطور محصول البروكولي: الاستجابة لمواعيد الزراعة

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أجريت هذه الدراسة بمحطة التجارب الزراعية – كلية الزراعة – جامعة القاهرة في الموسم الشتوي ٢٠٠٢/٢٠٠٣ و٢٠٠٣/٢٠٠٤ لدراسة تأثير مواعيد الزراعة (١٥ أغسطس و١٥ سبتمبر و١٥ أكتوبر) على الصفات المورفولوجية ومعادلات النمو وبعض الصفات المرتبطة بها على هجين البروكولي جرين كوميت. أدت الزراعة المبكرة في ١٥ أغسطس إلى حدوث زيادة معنوية في محتوى النبات والأوراق من المادة الجافة وارتفاع النبات والمحصول الاقتصادي، ومحصول الرؤوس القمية ومحصول الرؤوس الجانبية ودليل مساحة الورقة ومعدل النمو المحصولي في كلا الموسمين، وقطر واندماج الرأس في الموسم الثاني، مع حدوث نقص في العدد الكلي للأوراق ومبادئ الأوراق ونسبة المادة الجافة في الرأس ومحتوى الرأس من الكلوروفيل والكاروتين في كلا الموسمين ونقص في محتوى الرأس من حامض الأسكوربيك في الموسم الثاني فقط. أدت الزراعة في الموعد الثالث (١٥ أكتوبر) إلى حدوث زيادة معنوية في العدد الكلي للأوراق ومبادئ الأوراق ومحتوى الأوراق من الكلوروفيل، مع حدوث انخفاض في الحصول البيولوجي والمحصول الاقتصادي ومحصول الرؤوس القمية ومحصول الرؤوس الجانبية ودليل مساحة الورقة. وكان الموعد الثالث أبطأ المواعيد في تكشف الرأس وكذلك احتاج إلى أطول فترة من الشتل إلى الحصاد.