

**EFFECT OF PLANT DENSITY AND CLIMATIC CONDITIONS ON  
SOME CHINESE CABBAGE CULTIVARS  
BY**

**Esmail, A. A. M.**

Central Laboratory for Agricultural Climate (CLAC), Agricultural Research  
Center, Ministry of Agriculture, Dokki, Egypt.

**ABSTRACT**

Two experiments were conducted to find out the effect of 2 cultivars, 3 densities and 7 planting dates on the growth and yield of Chinese cabbage in the field of EL-Bossaily Protected Cultivation Unit, EL-Bahaira Governorate, Egypt in 2001-2002 and 2002-2003 seasons. The cultivars Chinese Express and Tropical Delight were each raised from 7 sowing dates (5, 20 July; 5, 20 August; 5, 20 September and 5 October) and planted in the field on 10, 25 August; 10, 25 September; 10, 25 October and 15 November, respectively. Three different planting densities were compared for each cultivar, which were 20000 (70×30 cm<sup>2</sup>), 15000 (70×40 cm<sup>2</sup>) and 12000 (70×50 cm<sup>2</sup>) plants/Feddan. Plant population had a significant effect on marketable yield. Head weight decreased as plant population increased. The most suitable density for this crop was 20000 plants/Feddan. This density led to increase the marketable yield and decrease the percentage of unmarketable heads. The influence of the planting date on yield was mainly related to the duration of the growing period. However, under the condition of our experiments September 10<sup>th</sup>, 25<sup>th</sup> and October 10<sup>th</sup> and 25<sup>th</sup> were the most appropriate dates for planting Chinese cabbage. Planting in these dates increased the length, width, weight and yield and gave rise to minimum values of total defects. There was a significant interaction between variety, plant density and planting date. The most satisfactory result was observed on China Express at spacing of 70×30 cm<sup>2</sup> and planting date of September 25<sup>th</sup> which gave the highest marketable yield, while the lowest value was obtained on Tropical Delight spaced at 70×50 cm<sup>2</sup> and planted in November 15<sup>th</sup>.

**INTRODUCTION**

Heading Chinese cabbage (*Brassica campestris* L. var. *pekinensis*) is a popular leafy vegetable and widely distributed crop in Asia (Spiltstosser, 1984). This plant is probably a native of China where it has been in cultivation since the 5<sup>th</sup> century (Thompson and Kelly, 1957). Chinese cabbage is grown for its compact head. Yield is directly associated with circumstances of its growth (Anony, 1992). To attain optimum production, the management of this vegetable such as its density and planting date are very important. The optimum density adapted for early maturing varieties was about 40×40 cm<sup>2</sup> (Opena *et al.*, 1988).

Total yield increases with plant density, but heads become smaller (Waters *et al.*, 1992). A row spacing of around 35cm produced heads of about 1 kg, and 40cm about 1.0 to 1.8 kg (Tomkins and Daly, 1998). Regular spacing is important as irregular will result in greater variation in head size and overall lower yield (Ynazawa and Fujji, 1976). Early maturing cultivars require less space than late ones (Waters *et al.*, 1992).

Optimal temperature varies with growth stage, being 18-20°C during early growth, 15-16°C during heading and 10-13°C during final head formation (Waters *et al.*, 1992). Chinese cabbage is a cool season crop. The optimum mean temperature range for excellent growth and good heading is 15-20°C (Asian Vegetable Research and Development Center (AVRDC), 1981 and Keto, 1981). If the temperature exceeds 25°C plants cannot form compact head and both yield and quality become poor and diseases are often severe (Opena *et al.*, 1988). However, different varieties are available for different regions, from temperate to tropical (Tomkins and Daly, 1998). It requires at least 15-16°C to produce a well formed and quality head (Guttormsen and Moe, 1985). Lower temperatures induce bolting while high temperatures resulted narrow leaves. Heads formed at temperatures above 24°C are often soft and bitter (Waters *et al.*, 1992). Bolting is avoided by keeping growth out of low temperature or maintaining above 18°C at which seedlings are raised (Wiebe, 1990). It is important to grow at either high temperatures or short days from emergence until there are enough leaves for head formation and thus, subsequent low temperatures or long days after transplanting are not likely to induce bolting (Manrique, 1993).

This experiment was established to have full understand about two important cultivars of Chinese cabbage and the most suitable plant density and planting date for producing high yield with good quality.

## MATERIALS AND METHODS

Two cultivars China Express F1 and Tropical Delight F1 (*Brassica campestris* L. var. *pekinensis*) were used in this investigation. Two trials were conducted at EL-Bossally Protected Cultivation Unite, EL-Behara Governorate during the two successive seasons of 2001-2002 and 2002-2003. The experimental layout was a split plot design with cultivars as the main plots, plant density as the subplot and planting dates as sub-subplot with three replicates. The size of each plot was 10.5m<sup>2</sup> and consisted of three rows. Each row was 5m long and 70cm wide. Drip irrigation was applied and other agriculture practices took place whenever it was necessary according to the recommendations of Sajjapongse and Roan (1983).

Seeds of the two cultivars in both seasons of 2001-2002 and 2002-2003 were sown in seedbed on 5<sup>th</sup>, 20<sup>th</sup> of July, 5<sup>th</sup>, 20<sup>th</sup> of August, 5<sup>th</sup>, 20<sup>th</sup> of September and 5<sup>th</sup> of October. Plants were transplanted in the field on 10<sup>th</sup>, 25<sup>th</sup> of August; 10<sup>th</sup>, 25<sup>th</sup> of September; 10<sup>th</sup>, 25<sup>th</sup> of October and 15<sup>th</sup> of November. Spacing between rows were 70cm and between plants were 30cm (20000 plant/Feddan), 40cm (15000 plant/Feddan) and 50cm (12000

rows. At harvesting time, Ten heads were randomly chosen from each plot for determination of head length (cm), width (cm) and weight (g), beside bolting (%), marketable rate (%), marketable yield (kg/plot). The chemical contents of ascorbic acid, total chlorophyll, total carotenoids and total sugars, were also determined. Ascorbic acid was determined by using 2.6 dichlorophenolindophenol method (A.O.A.C., 1980). The results were calculated as mg/100g fresh weight. Total chlorophyll and total carotenoids were determined as mg/100g fresh according to Robbelen method (1957). Total sugars were determined adopting the colorimetric method for the determination of sugar and related substances according to Dubois *et al.*, (1956) and the results were calculated as g/100g dry weight.

#### **Statistical analysis:**

The physical and chemical results of this study were statistically analyzed using the analysis of variance method described by Snedecor (1956).

## **RESULTS**

### **A- Physical characteristics:**

Yield and its components as affected by the different plant spacings and planting dates are presented in Tables (1-6).

#### **1-Head length and width:**

It is evident from the results that the change in head length and width due to the various planting dates in the two cultivars showed increases up to the planting date in September 25<sup>th</sup>, then tended to decrease at the last two examining dates in October 25<sup>th</sup> and November 15<sup>th</sup>. The results in the two seasons cleared that the longest and widest heads resulted from those plants planted in September 25<sup>th</sup> whereas the lowest were obtained from the late date in November 15<sup>th</sup>.

Various spacings showed significant effect on head length and width of the two cultivars China Express and Tropical Delight. Head length and width generally increased as the distance between plants increased, but they differed within cultivars. However, the length and width of China Express were greater than those of Tropical Delight. The maximum head length of 37.5 and 35.5 cm and head width of 22.17 and 21.50cm in the two seasons respectively of China Express were recorded from the spacing of 70×50 cm<sup>2</sup>, while the maximum head length of 36.0 and 32.5 cm and head width of 19.5 and 20.0 cm in the two seasons respectively of Tropical Delight were recorded from the spacing of 70×50 cm<sup>2</sup>.

#### **2- Head weight:**

It is obvious from Table (3) that this character significantly responded to the widening of plant spacing in both seasons. In other words, the heaviest heads were obtained from the widest spacing (70×50 cm<sup>2</sup>).

**Table (1): Effect of cultivars, density and planting dates on head length (cm) of Chinese cabbage during 2001-2002 and 2002-2003 seasons.**

Cultivars (A)	Density Plants/ Fe (B)	2001-2002 Season							
		Planting dates (C)							
		10 Aug.	25 Aug.	10 Sep.	25 Sep.	10 Oct.	25 Oct.	15 Nov.	Mean
China Express F <sub>1</sub>	20000	24.00	25.00	26.00	27.50	26.00	23.17	20.00	24.52
	15000	24.50	30.00	32.33	34.50	32.00	30.00	27.00	30.76
	12000	33.00	34.00	36.50	37.50	35.00	32.00	29.00	33.86
	Mean	28.83	29.67	31.61	33.17	31.00	28.39	25.33	29.71
Tropical Delight F <sub>1</sub>	20000	21.50	22.00	24.00	25.50	24.00	21.00	19.50	22.50
	15000	26.50	27.00	29.50	31.00	29.33	26.00	23.83	27.60
	12000	31.00	32.00	33.50	36.00	34.00	30.17	27.00	31.95
	Mean	26.33	27.00	29.00	30.83	29.11	25.72	23.44	27.35
<b>2002-2003 Season</b>									
China Express F <sub>1</sub>	20000	20.33	22.00	24.00	25.00	23.83	20.50	16.50	21.74
	15000	27.00	25.67	31.17	33.50	31.00	27.00	24.00	28.48
	12000	30.50	31.50	33.83	35.50	33.00	30.50	26.50	31.62
	Mean	25.94	26.39	29.67	31.33	29.28	26.00	22.33	27.28
Tropical Delight F <sub>1</sub>	20000	20.00	20.50	22.00	24.00	22.50	19.00	16.50	20.64
	15000	24.50	25.00	28.00	29.50	28.50	25.00	18.50	25.57
	12000	29.17	30.00	31.00	32.50	31.50	29.00	25.00	29.74
	Mean	24.56	25.17	27.00	28.67	27.50	24.33	20.00	25.32

L.S.D at 5%		2001/2002	2002/2003		2001/2002	2002/2003
	A	N.S	2.661	A x B	0.8010	1.305
	B	0.5667	0.9227	A x C	1.224	1.993
	C	0.8625	1.409	B x C	1.499	2.441
				A x B x C	2.119	3.452

The results summarize the effect of various planting dates and plant spacing on head weight in the two seasons of 2001-2002 and 2002-2003. It is clear that, there was an increase in head weight with the delay of sowing dates to September 25<sup>th</sup> after which a decrease tendency took place. It evident that sowing dates affected significantly the head weight. However, in both seasons the highest figures resulted from planting in September 25<sup>th</sup>, whereas the lowest ones obtained from planting in November 15<sup>th</sup>. China Express plants produced heavier weight compared with the Tropical Delight plants.

### 3- Marketable rate (%):

Spacing had no significant effect on the marketable rate (%). However, the significant highest marketable rate (%) resulted from planting dates of September 25<sup>th</sup> and October 10<sup>th</sup>. The lowest marketable rate (%) was obtained from planting at August 10<sup>th</sup>.

**Table (2): Effect of cultivars, density and planting dates on head width (cm) of Chinese cabbage during 2001-2002 and 2002-2003 seasons.**

Cultivars (A)	Density (B) Plants/Fe	2001-2002 Season							
		Planting dates (C)							
		10 Aug.	25 Aug.	10 Sep.	25 Sep.	10 Oct.	25 Oct.	15 Nov.	Mean
China Express F <sub>1</sub>	20000	12.50	12.83	14.33	15.00	14.50	11.17	10.00	12.90
	15000	15.00	15.50	16.50	17.50	16.50	13.50	12.00	15.21
	12000	19.00	19.50	21.50	22.17	21.00	18.50	16.00	19.67
	Mean	15.50	15.94	17.44	18.22	17.33	14.39	12.67	15.93
Tropical Delight F <sub>1</sub>	20000	11.00	11.50	12.50	13.50	13.00	10.50	9.00	11.57
	15000	13.00	13.50	14.50	16.50	14.50	12.00	10.50	13.50
	12000	16.50	17.00	18.50	19.50	19.00	17.00	15.00	17.50
	Mean	13.50	14.00	15.17	16.50	15.50	13.17	11.50	14.19
<b>2002-2003 Season</b>									
China Express F <sub>1</sub>	20000	14.50	15.00	15.50	16.50	15.50	13.00	10.00	14.29
	15000	17.00	17.50	18.00	19.50	18.33	15.50	13.00	16.98
	12000	21.00	21.00	21.50	21.50	20.00	18.50	16.50	20.00
	Mean	17.50	17.83	18.33	19.17	17.94	15.67	13.17	17.09
Tropical Delight F <sub>1</sub>	20000	13.00	13.50	15.00	15.50	15.00	12.00	10.50	13.50
	15000	15.00	15.50	16.50	17.00	16.50	14.00	12.00	15.21
	12000	17.50	18.00	19.50	20.00	19.00	17.00	15.00	18.00
	Mean	15.17	15.67	17.00	17.50	16.83	14.33	12.50	15.57

L.S.D at 5%		2001/2002	2002/2003		2001/2002	2002/2003
	A	N.S	N.S	A x B	1.096	1.301
B	0.7784	0.9203	A x C	1.674	1.988	
C	1.183	1.406	B x C	2.050	2.435	
			A x B x C	2.899	3.443	

**4- Bolting (%):**

Plant density had no effect on the bolting (%) in both cultivars of China Express and Tropical Delight during the two seasons. The influence of the planting date on bolting (%) was mainly related to the duration of the growing period. The highest bolting percentage was obtained from the planting date of November 15<sup>th</sup>

**5- Marketable yield:**

Marketable yield was greater in China Express compared to China Delight. Spacing effect widely induced different marketable yields. The plants with the closest spacing 70x30 cm<sup>2</sup>, gave significantly the highest plot marketable yield which was statistically different from other plant densities. The lowest marketable yield/plot was obtained from plants spaced at 70x50 cm<sup>2</sup>. The results showed an indication that the yield increased with the decrease of spacing. The maximum marketable yield was obtained from the closest spacing due to the increase in the number of plants per unit area. A planting date in September 25<sup>th</sup> resulted in higher marketable yield as compared with the other different dates.

Table (3): Effect of cultivars, density and planting dates on head weight (g) of Chinese cabbage during 2001-2002 and 2002-2003 seasons.

Cultivars (A)	Density (B) Plants/ Fe	2001-2002 Season							
		Planting dates (C)							
		10 Aug.	25 Aug.	10 Sep.	25 Sep.	10 Oct.	25 Oct.	15 Nov.	Mean
China Express F <sub>1</sub>	20000	2665	2700	2750	2807	2753	2710	2403	2684
	15000	2850	2877	2907	3117	2927	2750	2600	2861
	12000	3070	3120	3217	3400	3360	3043	2870	3154
	Mean	2862	2899	2958	3108	3013	2834	2624	2900
Tropical Delight F <sub>1</sub>	20000	2420	2500	2653	2683	2667	2400	1917	2463
	15000	2610	2630	2753	2793	2740	2510	2120	2594
	12000	2747	2777	2890	2970	2874	2640	2338	2730
	Mean	2592	2636	2766	2816	2751	2517	2092	2595
2002-2003 Season									
China Express F <sub>1</sub>	20000	2420	2505	2573	2605	2550	2500	2210	2480
	15000	2660	2650	2710	2905	2710	2560	2420	2659
	12000	2830	2960	3060	3290	3117	2840	2660	2965
	Mean	2637	2705	2781	2933	2792	2633	2430	2702
Tropical Delight F <sub>1</sub>	20000	2210	2320	2410	2480	2387	2200	1740	2250
	15000	2400	2410	2560	2580	2530	2333	1930	2392
	12000	2560	2580	2670	2880	2640	2430	2005	2538
	Mean	2390	2437	2547	2647	2519	2321	1892	2393

L.S.D at 5%		2001/2002	2002/2003		2001/2002	2002/2003
	A	N.S	N.S	A x B	105.90	123.50
	B	74.88	87.31	A x C	161.80	188.60
	C	114.4	133.40	B x C	198.10	231.00
				A x B x C	280.20	326.70

**Table (4): Effect of cultivars, density and planting dates on marketable rate (%) of Chinese cabbage during 2001-2002 and 2002-2003 seasons.**

Cultivars (A)	Density (B) Plants/ Fe	2001-2002 Season							
		Planting dates (C)							
		10 Aug.	25 Aug.	10 Sep.	25 Sep.	10 Oct.	25 Oct.	15 Nov.	Mean
China Express F <sub>1</sub>	20000	55.00	76.00	97.00	98.00	98.00	95.00	73.00	84.57
	15000	55.00	75.00	97.00	98.00	97.83	96.00	72.17	84.43
	12000	52.17	75.00	97.00	97.67	98.00	96.00	71.00	83.83
	Mean	54.06	75.33	97.00	97.89	97.94	95.67	72.06	84.28
Tropical Delight F <sub>1</sub>	20000	50.00	84.00	97.00	98.00	98.00	96.00	73.33	85.19
	15000	51.00	81.17	97.00	98.00	98.00	95.00	72.00	84.60
	12000	50.67	82.00	97.00	98.00	98.00	96.00	70.67	84.62
	Mean	50.56	82.39	97.00	98.00	98.00	95.67	72.00	84.80
<b>2002-2003 Season</b>									
China Express F <sub>1</sub>	20000	54.00	79.00	95.00	98.00	98.17	94.00	72.00	84.31
	15000	54.00	78.00	95.00	98.00	98.00	93.00	70.00	83.71
	12000	52.00	76.00	96.00	98.00	98.00	92.00	70.00	83.14
	Mean	53.33	77.67	95.33	98.00	98.06	93.00	70.67	83.72
Tropical Delight F <sub>1</sub>	20000	51.33	82.00	97.00	95.00	98.00	95.00	70.00	84.05
	15000	51.00	82.00	97.00	98.00	98.00	94.00	70.67	84.38
	12000	50.00	72.43	97.00	98.00	98.00	94.00	71.00	82.92
	Mean	50.78	78.81	97.00	97.00	98.00	94.33	70.56	83.78

L.S.D at 5%		2001/2002	2002/2003		2001/2002	2002/2003
	A	N.S	N.S	A x B	1.038	1.424
	B	N.S	1.007	A x C	1.585	2.176
	C	1.121	1.538	B x C	1.941	2.665
				A x B x C	2.746	3.768

Table (5): Effect of cultivars, density and planting dates on bolting (%) of Chinese cabbage during 2001-2002 and 2002-2003 seasons.

Cultivars (A)	Density (B) Plants/ Fe	2001-2002 Season							
		Planting dates (C)							
		10 Aug.	25 Aug.	10 Sep.	25 Sep.	10 Oct.	25 Oct.	15 Nov.	Mean
China Express F <sub>1</sub>	20000	0.00	0.00	0.00	0.00	0.00	0.00	22.67	0.00
	15000	0.00	0.00	0.00	0.00	0.00	0.00	23.30	0.00
	12000	0.00	0.00	0.00	0.00	0.00	0.00	22.40	0.00
	Mean	0.00	0.00	0.00	0.00	0.00	0.00	22.76	0.00
Tropical Delight F <sub>1</sub>	20000	0.00	0.00	0.00	0.00	0.00	0.00	27.07	0.00
	15000	0.00	0.00	0.00	0.00	0.00	0.00	25.33	0.00
	12000	0.00	0.00	0.00	0.00	0.00	0.00	27.00	0.00
	Mean	0.00	0.00	0.00	0.00	0.00	0.00	26.47	0.00
2002-2003 Season									
China Express F <sub>1</sub>	20000	0.00	0.00	0.00	0.00	0.00	0.00	23.00	3.29
	15000	0.00	0.00	0.00	0.00	0.00	0.00	23.33	3.33
	12000	0.00	0.00	0.00	0.00	0.00	0.00	22.33	3.19
	Mean	0.00	0.00	0.00	0.00	0.00	0.00	22.89	3.27
Tropical Delight F <sub>1</sub>	20000	0.00	0.00	0.00	0.00	0.00	0.00	22.33	3.19
	15000	0.00	0.00	0.00	0.00	0.00	0.00	21.40	3.06
	12000	0.00	0.00	0.00	0.00	0.00	0.00	21.67	3.10
	Mean	0.00	0.00	0.00	0.00	0.00	0.00	21.80	3.11

L.S.D at 5%		2001/2002	2002/2003		2001/2002	2002/2003
	A	N.S	N.S	A x B	0.4859	0.6637
	B	N.S	N.S	A x C	0.7422	1.014
	C	0.5248	0.7169	B x C	0.9091	1.242
				A x B x C	1.286	1.756



**Table (6): Effect of cultivars, density and planting dates on marketable yield (Kg/plot) of Chinese cabbage during 2001-2002 and 2002-2003 seasons.**

Cultivars (A)	Density (B) Plants/ Fe	2001-2002 Season							
		Planting dates (C)							
		10 Aug.	25 Aug.	10 Sep.	25 Sep.	10 Oct.	25 Oct.	15 Nov.	Mean
China Express F <sub>1</sub>	20000	70.57	98.67	127.30	131.9	129.40	123.40	84.10	109.30
	15000	56.37	77.77	101.60	110.0	103.30	95.13	67.63	87.40
	12000	47.93	70.10	93.50	99.90	98.73	87.53	61.07	79.82
	Mean	58.29	82.18	107.40	113.9	110.50	102.00	70.93	92.19
Tropical Delight F <sub>1</sub>	20000	58.17	100.9	123.60	126.3	125.5	110.70	67.40	101.80
	15000	47.97	76.57	96.20	98.60	96.77	85.93	54.87	79.56
	12000	41.87	68.23	84.03	87.27	83.63	76.63	47.17	69.83
	Mean	49.33	81.90	101.30	104.0	102.00	91.00	56.48	83.73
<b>2002-2003 Season</b>									
China Express F <sub>1</sub>	20000	62.57	95.13	116.40	122.6	119.2	113.7	76.53	100.90
	15000	51.83	71.23	92.60	107.2	95.63	85.83	60.87	80.74
	12000	44.20	67.00	88.07	96.47	88.57	78.47	55.97	74.16
	Mean	52.87	77.92	99.03	108.8	101.1	92.66	64.46	85.26
Tropical Delight F <sub>1</sub>	20000	55.27	91.43	112.50	116.8	113.9	101.3	58.33	92.80
	15000	44.00	71.23	89.33	91.07	89.33	78.87	49.10	73.28
	12000	37.27	61.83	77.63	84.63	77.57	69.57	42.73	64.46
	Mean	45.51	74.83	93.17	97.49	93.61	83.26	50.06	76.85

L.S.D at 5%		2001/2002	2002/2003		2001/2002	2002/2003
	A	N.S	N.S	A x B	3.419	4.450
	B	2.417	3.147	A x C	5.222	6.798
	C	3.693	4.807	B x C	6.396	8.326
			A x B x C	9.045	11.77	

**B- Chemical characteristics:**

Presented data in Table (7-10) show that the effect of plant density and planting dates on the content of ascorbic acid, total chlorophyll, total carotenoids and total sugars in the two seasons of 2001-2002 and 2002-2003 indicated that there was no significant difference among the various examined dates and densities in both cultivars.

**Table (7): Effect of cultivars, density and planting dates on ascorbic acid content (mg/100g f.w) of Chinese cabbage during 2001-2002 and 2002- 2003 seasons.**

Cultivars (A)	Density (B) Plants/ Fe	2001-2002 Season							
		Planting dates (C)							
		10 Aug.	25 Aug.	10 Sep.	25 Sep.	10 Oct.	25 Oct.	15 Nov.	Mean
China Express F <sub>1</sub>	20000	39.13	39.37	40.00	42.33	41.33	40.17	39.97	40.33
	15000	39.20	39.43	40.43	42.17	42.00	42.70	40.03	40.55
	12000	38.90	39.13	40.47	42.33	42.00	39.83	39.83	40.47
	Mean	39.08	39.31	40.26	42.28	41.78	39.94	39.94	40.44
Tropical Delight F <sub>1</sub>	20000	39.10	39.30	41.40	42.10	41.40	39.70	39.70	40.47
	15000	39.73	39.83	41.27	42.27	41.33	39.83	39.83	40.66
	12000	39.17	39.33	40.67	41.93	41.37	39.43	39.43	40.33
	Mean	39.33	39.49	41.11	42.10	41.37	39.66	39.66	40.49
<b>2002-2003 Season</b>									
China Express F <sub>1</sub>	20000	36.27	36.43	37.07	39.07	37.97	37.60	37.33	37.39
	15000	35.20	35.50	36.30	37.73	37.00	36.80	36.50	36.43
	12000	36.13	36.10	36.57	37.03	36.60	36.17	36.10	36.39
	Mean	35.87	36.01	36.64	37.94	37.19	36.86	36.64	36.74
Tropical Delight F <sub>1</sub>	20000	42.13	35.60	36.30	36.87	36.63	36.00	36.67	37.03
	15000	35.37	35.87	36.13	36.80	36.57	36.20	35.87	36.11
	12000	36.17	36.50	37.00	37.47	37.13	36.87	36.53	36.81
	Mean	37.89	35.99	36.48	37.04	36.48	36.36	36.02	36.65

L.S.D at 5%		2001/2002	2002/2003		2001/2002	2002/2003
	A	N.S	N.S	A x B	N. S	1.194
	B	N.S	0.8442	A x C	0.5534	1.824
	C	0.3913	1.290	B x C	0.6778	2.234
			A x B x C	0.9585	3.159	

**Table (8): Effect of cultivars, density and planting dates on total chlorophyll content (mg/100g f.w) of Chinese cabbage during 2001-2002 and 2002-2003 seasons.**

Cultivars (A)	Density (B) Plants/ Fe	2001-2002 Season							
		Planting dates (C)							
		10 Aug.	25 Aug.	10 Sep.	25 Sep.	10 Oct.	25 Oct.	15 Nov.	Mean
China Express F <sub>1</sub>	20000	35.73	35.87	35.97	36.77	36.03	35.80	36.33	36.06
	15000	35.43	35.63	35.90	36.23	36.03	35.93	35.73	35.84
	12000	35.63	35.80	36.07	36.30	35.97	35.80	35.43	35.86
	Mean	35.60	35.77	35.98	36.43	36.01	35.84	35.80	35.92
Tropical Delight F <sub>1</sub>	20000	35.40	35.63	35.90	36.27	36.07	35.97	35.67	35.84
	15000	35.70	35.90	36.13	36.47	36.10	36.07	35.63	36.00
	12000	35.77	35.90	36.20	36.37	36.07	35.87	35.67	35.98
	Mean	35.62	35.81	36.08	36.37	36.08	35.97	35.66	35.94
<b>2002-2003 Season</b>									
China Express F <sub>1</sub>	20000	37.57	37.77	37.87	38.50	38.70	37.87	37.00	37.80
	15000	37.80	38.33	38.60	39.03	38.90	38.50	38.30	38.50
	12000	38.23	38.77	38.90	39.33	38.80	38.70	38.37	38.73
	Mean	37.87	38.29	38.46	38.96	38.59	38.36	37.89	38.34
Tropical Delight F <sub>1</sub>	20000	36.10	36.40	38.57	36.97	36.30	36.07	35.80	36.31
	15000	33.47	33.57	34.17	34.77	34.50	34.00	33.80	34.04
	12000	34.73	34.93	35.17	35.63	35.40	35.00	34.67	35.08
	Mean	34.77	34.97	35.30	35.79	33.40	35.02	34.76	35.14

L.S.D at 5%		2001/2002	2002/2003		2001/2002	2002/2003
	A	N.S	N.S	A x B	N.S	0.5157
	B	N.S	0.3646	A x C	N.S	0.7877
	C	N.S	0.5570	B x C	N.S	0.9647
				A x B x C	N.S	1.364

Table (9): Effect of cultivars, density and planting dates on total carotenoids (mg/100g f.w) of Chinese cabbage during 2001-2002 and 2002-2003 seasons.

Cultivars (A)	Density (B) Plants/ Fe	2001-2002 Season							
		Planting dates (C)							
		10 Aug.	25 Aug.	10 Sep.	25 Sep.	10 Oct.	25 Oct.	15 Nov.	Mean
China Express F <sub>1</sub>	20000	27.50	27.80	28.10	28.50	27.47	27.50	26.47	27.62
	15000	27.00	27.37	28.23	28.50	27.37	27.17	25.63	27.32
	12000	26.87	26.97	27.17	27.47	26.90	26.77	26.40	26.93
	Mean	27.12	27.38	27.83	28.16	27.24	27.14	26.17	27.29
Tropical Delight F <sub>1</sub>	20000	27.17	27.37	27.70	28.03	27.93	27.40	27.07	27.52
	15000	27.63	27.83	28.03	28.20	27.90	27.57	26.87	27.72
	12000	26.87	27.20	27.57	28.03	27.87	27.57	26.40	27.36
	Mean	27.22	27.47	27.77	28.09	27.90	27.51	26.78	27.53
<b>2002-2003 Season</b>									
China Express F <sub>1</sub>	20000	24.20	27.47	25.03	25.60	25.43	25.10	24.80	24.95
	15000	25.07	25.27	25.47	25.97	25.70	25.30	24.50	25.32
	12000	23.90	24.03	24.27	24.60	24.03	23.77	23.50	24.01
	Mean	29.38	24.59	24.92	25.39	25.06	24.72	24.27	24.76
Tropical Delight F <sub>1</sub>	20000	21.83	25.57	26.17	26.93	26.50	25.83	25.63	25.50
	15000	23.57	23.83	24.17	24.77	24.37	24.00	23.70	24.06
	12000	22.87	23.07	23.60	23.83	23.57	22.90	22.63	23.21
	Mean	22.76	24.16	24.64	25.18	24.81	24.24	23.99	24.25

L.S.D at 5%		2001/2002	2002/2003		2001/2002	2002/2003
	A	N.S	N.S	A x B	0.1132	0.9326
	B	0.8007	0.6595	A x C	0.1730	1.425
	C	0.1223	1.007	B x C	0.2119	1.745
			A x B x C	0.2996	2.467	

**Table (10): Effect of cultivars, density and planting dates on total sugars concentration (mg/100g d.w) of Chinese cabbage during 2001-2002-2003 seasons.**

Cultivars (A)	Density (B) Plants/ Fe	2001-2002 Season							
		Planting dates (C)							
		10 Aug.	25 Aug.	10 Sep.	25 Sep.	10 Oct.	25 Oct.	15 Nov.	Mean
China Express F <sub>1</sub>	20000	24.90	25.13	26.10	26.50	26.40	25.87	25.70	25.80
	15000	25.00	25.40	25.90	26.20	26.40	26.00	25.80	25.81
	12000	25.30	25.47	26.10	26.70	26.40	26.00	25.90	25.98
	Mean	25.07	25.33	26.03	26.47	26.40	25.96	25.80	25.87
Tropical Delight F <sub>1</sub>	20000	24.70	24.90	24.97	26.00	25.90	25.50	24.80	25.25
	15000	25.20	25.50	25.90	26.20	26.00	25.80	25.00	25.66
	12000	26.03	26.03	26.67	26.20	26.17	25.80	24.90	25.97
	Mean	25.31	25.48	25.84	26.13	26.02	25.70	24.90	25.63
<b>2002-2003 Season</b>									
China Express F <sub>1</sub>	20000	22.13	22.43	22.53	23.07	23.23	22.83	22.50	22.68
	15000	24.33	24.60	24.70	25.10	24.90	24.03	24.70	24.53
	12000	22.00	22.40	22.60	23.00	22.90	21.43	21.90	22.32
	Mean	22.82	23.14	23.28	23.72	23.68	22.77	22.82	23.18
Tropical Delight F <sub>1</sub>	20000	22.60	22.77	22.90	23.40	23.03	22.83	21.90	22.78
	15000	24.00	24.20	24.60	25.30	25.00	24.90	24.50	24.64
	12000	23.50	23.70	23.90	24.50	23.90	23.80	22.90	23.74
	Mean	23.37	23.56	23.80	24.40	23.98	23.84	23.10	23.72
L.S.D at 5%		2001/2002	2002/2003		2001/2002	2002/2003			
	A	0.05421	0.1731	A x B	0.07267	0.1116			
	B	0.5138	0.07889	A x C	0.1110	0.1704			
	C	0.7849	0.1205	B x C	0.1359	0.2087			
				A x B x C	0.1923	0.2952			

### DISCUSSION

Regarding the yield and its components, it is obvious that the head length, width and weight were significantly increased by increasing the plant spacing. This may be due to the high competition between plants for light, minerals and water. From the horticultural point of view, the marketable yield is the important target from any plantation. However, under the conditions of our experiment there is no doubt that the period extended from September 10<sup>th</sup> to October 25<sup>th</sup> was the most suitable dates for planting Chinese cabbage. Planting in this period induced best head weight which led consequently to the heaviest yield. In our consideration, Chinese cabbage has its own temperature and light requirements which affect the various processes of photosynthesis, respiration, assimilation ... etc. and induced the peak capacity of production. The question of this exerted high yield may be accounted comparatively to the favorite temperature followed this dates which suit the growth and development of Chinese cabbage throughout the life cycle of plant building of the vegetative growth and yields (Wurr *et al.*, 1981).

Table (11): The average monthly temperature ( $^{\circ}\text{C}$ ) in the two seasons of 2001/2002 and 2002/2003

Month / Year	Temp. ( $^{\circ}\text{C}$ )		
	Min.	Max.	Avg.
Sept.2001	16.84	33.00	24.92
Oct.2001	14.52	29.80	22.50
Nov.2001	10.32	24.16	17.45
Dec.2001	7.15	20.10	13.05
Jan.2002	5.27	18.88	12.07
Feb.2002	5.37	21.30	13.50
Mar.2002	7.62	23.15	16.35
Apr.2002	10.28	27.52	19.15
Sept.2002	16.72	32.85	25.10
Oct.2002	14.35	29.58	22.32
Nov.2002	10.10	24.15	17.32
Dec.2002	7.05	20.00	12.75
Jan.2003	4.78	18.32	11.58
Feb.2003	5.05	21.05	13.55
Mar.2003	7.10	22.35	15.48
Apr.2003	9.55	26.82	18.42

Source: Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Center, Ministry of Agriculture.

### CONCLUSION

From the overall results it can be concluded that:

- China Express plants produced heavier head weight compared with the Tropical Delight.
- The maximum head length and width were recorded from the spacing of  $70 \times 50 \text{ cm}^2$ .
- The heaviest heads were obtained from widest spacing ( $70 \times 50 \text{ cm}^2$ ).
- The maximum marketable yield was obtained from the closest spacing ( $70 \times 30 \text{ cm}^2$ ).
- The lengthest heads and widest resulted from those plants planted in September 25<sup>th</sup>, whereas the lowest were obtained from the latest date in November 15<sup>th</sup>.
- The highest head weight resulted from planting in September 25<sup>th</sup>, whereas lowest ones obtained from planting in November 15<sup>th</sup>.
- Significant highest marketable rates (%) was found at planting dates of September 25<sup>th</sup> and October 10<sup>th</sup>. The lowest marketable rate (%) was obtained from planting at August 10<sup>th</sup>.
- The highest bolting percentage was obtained from planting date of November 15<sup>th</sup>. Plant density had no effect on bolting (%).
- The highest marketable yield resulted from planting in September 25<sup>th</sup>. Marketable yield was greater of China Express compared to Tropical Delight.

## REFERENCES

- Anony, M. (1992): Chinese cabbage or pet-sai. Vegetable production in the sub-Tropical and Tropical. Overseas Technical Cooperation Agency, Japan, Text Book, 25: 146-157.
- Association of Official Analytical (1980): Official methods of analysis. The A.O.A.C., 13th ed. Published by A.O.A.C., Washington, D.C. 20044, U.S.A.
- Asian Vegetable Research and Development Center (AVRDC), (1981): Chinese cabbage. AVRDC. Shanhua, Taiwan. 300p.
- Dubois, M.; Gilles, K.A.; Hailton, J.K.; Rebers, P.A. and Smith, F. (1956): Colorimetric method for determination of sugars and related substances. Analytical Chemistry, 28: 350-356.
- Guttormsen, G. and Moe, R. (1985): Effect of day and night temperature at different stages of growth on bolting of Chinese cabbage. Scientia Horti, 25: 225-233.
- Keto, T. (1981): The physiological mechanism of heading of chinese cabbage under high temperature. N.S. Talekar and T. D. Griggs, (eds.). Chinese cabbage, AVRDC, Shanhua, Tainan, Taiwan. pp. 207-215.
- Manrique, L.A. (1993): Greenhouse crops – a review. Journal of Plant Nutrition 16: 2411-2477.
- Opena, R.T.; Kuo, C.G. and Yoon, J.Y. (1988): General botany and reproductive biology. In. Breeding and seed production on Chinese cabbage in Tropics and sub-Tropic AVRDC. Shanhua, Tainan, Taiwan. pp7-17.
- Robbelen, G. (1957): Quantitative analysis of chloroplast pigments. Untersuchngen an strahlenin du Zierten blatter-bumtanten Von Arabidopsis Thaliana (L) vere bung l ehre, 88:189.
- Sajjapongse, A. and Roan, Y.C. (1983): Effect of Shading and Leaf-Tying on Summer Chinese cabbage. Hort. Science 18(4): 464-465.
- Snedecor, G.W. (1956): Statistical Methods. 5<sup>th</sup> Ed. The Iowa State Univ. Press., Amer. U.S.A.
- Spiltstosser, W. (1984): Growing individual vegetable. Vegetable hand book. Conn. U.S.A. AVI Publishing. pp. 199-201.
- Thompson, H.C. and Kelly, W.C. (1957): Vegetable crop. New York, U.S.A. Mc Graw Hill Book Company. pp. 315.
- Tomkins, B. and Daly, P. (1998): Chinese cabbage. The New Rural Industries. Ed. K.W. Hyade. Canberra, Rural Industries Research and Development Corporation. pp166-171.
- Waters, C.T.; Morgan, W.C. and McGeary, D.J. (1992): How to identify, grow and use oriental vegetables. Melbourne, Agmedia. pp. 128.
- Weibe, H. J. (1990): Estimation of the raising temperature at the time of bolting of Chinese cabbage. Acta Horticulturac. 267: 297-303.
- Wurr, D.C.E.; Rosemary, H.K.; Allen, E.J. and Patel, J. C. (1981): Studies of the growth and development of winter-heading cauliflowers. J. Agric. Sci.Camb., 97:409-419.
- Yanazawa, T. and Fujii, S. (1976): Studies on the allowable range of accuracy in field seeding parameters for Daikon radish and Chinese cabbage. Journal of the Japanese Society for Horticultural Science 45(2): 143-152.

## تأثير الكثافة النباتية والظروف المناخية علي بعض أصناف الكرنب الصيني

عبد المنعم أحمد محمد إسماعيل

المعمل المركزي للمناخ الزراعي، مركز البحوث الزراعية، وزارة الزراعة.

أجريت التجربه بمزرعة وحدة البوصيلي للزراعة المحمية-محافظة البحيرة- خلال موسمي 2001-2002 و 2002-2003، لدراسة صنفين هما تشينا أكسبريس وتروبىكا ديليت وسبعة مواعيد زراعة شملت زراعة البندرة لكلا الصنفين في الممثل أيام 5، 20 يوليو، 5، 20 أغسطس، 5، 20 سبتمبر، 5 أكتوبر. تم زراعة الشتلات في الحقل أيام 10، 25 أغسطس، 10، 25 سبتمبر، 10، 25 أكتوبر، 15 نوفمبر في كلا الموسمين. و الزراعة على ثلاث مسافات هي 30x70 سم<sup>2</sup> (2000 نبات/فدان)، 40x70 سم<sup>2</sup> (15000 نبات/فدان)، 50x70 سم<sup>2</sup> (12000 نبات/فدان) علي نمو ومحصول الكرنب الصيني.

اتضح أن المعاملة 30x70 سم<sup>2</sup> (2000 نبات/فدان) كانت افضل كثافة نباتية، حيث أدت إلى زيادة المحصول القابل للتسويق وقلّة نسبة الرؤوس غير الصالحة للتسويق. بالإضافة إلى أن مسافات الزراعة المختلفة (الكثافة العددية للنباتات) أثرت معنويًا على وزن الرؤوس. كما ان انطب مواعيد لزراعة الكرنب الصيني هي الفترة الممتدة من 10 سبتمبر الي 25 أكتوبر، حيث أدت الزراعة في هذا الموعد إلى الحصول على أكبر طول وقطر ووزن للرأس. وبالتالي الحصول على أعلى محصول وأقل نسبة من الرؤوس غير الصالحة للتسويق. وقد أعطت المعاملة صنف تشينا أكسبريس و مسافة الزراعة 30x70 سم<sup>2</sup> وميعاد الزراعة 25 سبتمبر أعلى محصول كما لوحظ أن أقل محصول نتج من المعاملة صنف تروبىكال ديليت ومسافة الزراعة 50x70 سم<sup>2</sup> وميعاد الزراعة 15 نوفمبر. بلاضافة لذلك وجد أن الأصناف و الكثافة النباتية ومواعيد الزراعة لم يكن لها تأثير معنوي على محتوى الرؤوس من حمض الاسكوربيك و الكلوروفيلات الكلية و الكاروتينات الكلية و السكريات الكلية.