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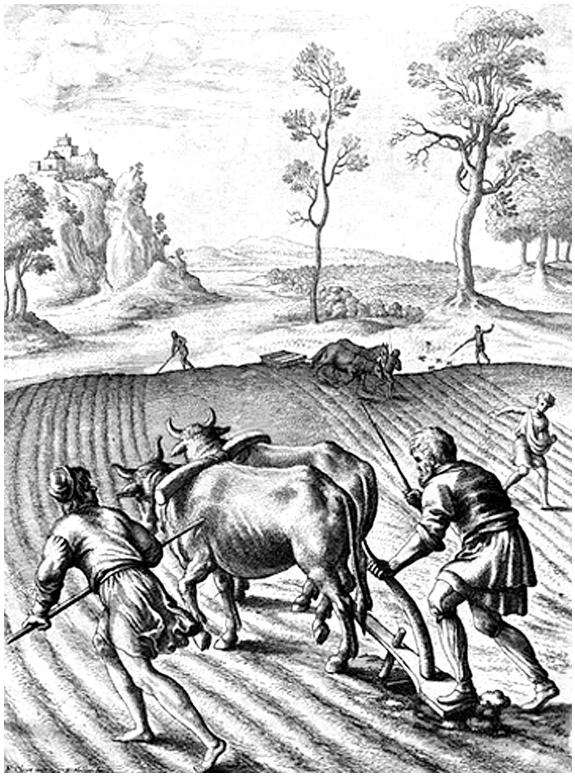

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The Effect of Planting Times on Some Vegetable Characters and Yield Components in Brussels Sprouts (*Brassica oleracea* var. gemmifera)

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Abstract: This study was carried out to determination of two planting times (July and August) on some vegetable characters as first sprout initiation time, sprout number, weight and size, the time from first sprout initiation to harvest, plant weight and height, fresh and dried weight of leaf, stem and root, stem diameter and yield components on Brussels sprouts (*Brassica oleracea* var. gemmifera cv. De La Halle) in terms of their response to temperature. +5°C was considered as critical temperature (base temperature) to calculate thermal time. Total yield per plant was found 307.9 and 308.5 g plant^{-1} for first and second planting times, respectively. Thermal time needed from planting to bud initiation was 1100-1300°C day^{-1}, thermal time needed from bud initiation to harvest was 390-460°C day^{-1}. The time from planting to bud initiation and from bud initiation to harvest were measured 119 day and 67 day in First Planting Ttime (FPT) and 105 day and 74 day in Second Planting Time (SPT), respectively.

Key words: Timing, Brussels sprouts, growth characteristics, thermal time

INTRODUCTION

Brussels sprouts (*Brassica oleracea* var. gemmifera) is a member of cruciferae family and researches on Brussels sprouts became dense on their cancer preventive effects, sowing and planting time, plant density, fertilizing, timing, stopping and relations between temperature and plant development.

Brussels sprouts have plant phytochemicals enhance the activity of the body's natural defense systems to protect against disease, including cancer. Epidemiological studies give evidence that cruciferous vegetables protect humans against cancer due to reduction of oxidative DNA damage with their glucosinolate content and also results from animal experiments show that they reduce chemically induced tumor formation (Steinkeliner *et al*., 2001; Zhu *et al*., 2000; Van Poppel *et al*., 1999; Verhagen *et al*., 1997; Anonymous, 2005).

Processing yield, total yield, final dry weight, Leaf Thickness (LT), Stein Weight (SW), Leaf Weight (LW), Root Weight (RW), Leaf Area (LA), Net Assimilation Rate (NAR) and Relative Growth Rate (RGR), Total Plant Dry Weight (TPDW) was influenced by planting times and plant densities in Brussels sprouts and broccoli (Everaarts and De Moel, 1998; Bravo *et al*., 1986; Babik and Rumpel, 1994; Kar and Uzun, 2000; Uzun and Kar, 2004; Everaarts *et al*., 1998).

Stopping increased both yield and sprout size compared with no stopping (Bortness, 1990).

There appeared to be fixed relation between the period from planting to bud initiation and the period from planting to optimum harvest date in Brussels sprouts. The time of optimum harvest can, thus, be predicted after bud initiation (Everaarts and Sukkel, 1999).

Plant development is affected by environmental conditions (especially temperature and light) and there is a quadratic relations between temperature and head size in broccoli (Grevsen, 1998). Optimum temperature for curd induction in cauliflower was estimated to be 12.8°C, the base temperature was estimated to be 0°C and the maximum temperature, therefore, is taken to be 25.6°C (Grevsen and Olesen, 1994). In cauliflower, effective temperature determined with an optimum of 14°C. Curd initiation occurred after the accumulation of 296 degree-days above a base temperature of 2.8°C (Pearson *et al*., 1994).

In this study, the effects of planting times and measuring days on some vegetable characters and yield components in Brussels sprouts were investigated. In addition, thermal time needed from planting to bud initiation and bud initiation to harvest were estimated.

MATERIALS AND METHODS

Materials: Open pollinated cultivar De La Halle used as plant material.

The experimental area: This experiment was carried out at Bafra conditions in 2001-2002. The experimental area is

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Table 1: Maximum, minimum and average temperatures between June and February 2002

	June	July	August	September	October	November	December	January	February
Maximum	28.2	33.0	32.1	30.6	23.8	26.0	19.0	14.5	22.2
Average	19.6	24.9	25.1	21.2	14.9	11.3	6.7	2.6	8.6
Minimum	11.9	14.2	16.6	12.8	5.0	0.0	0.0	- 6.8	-0.1

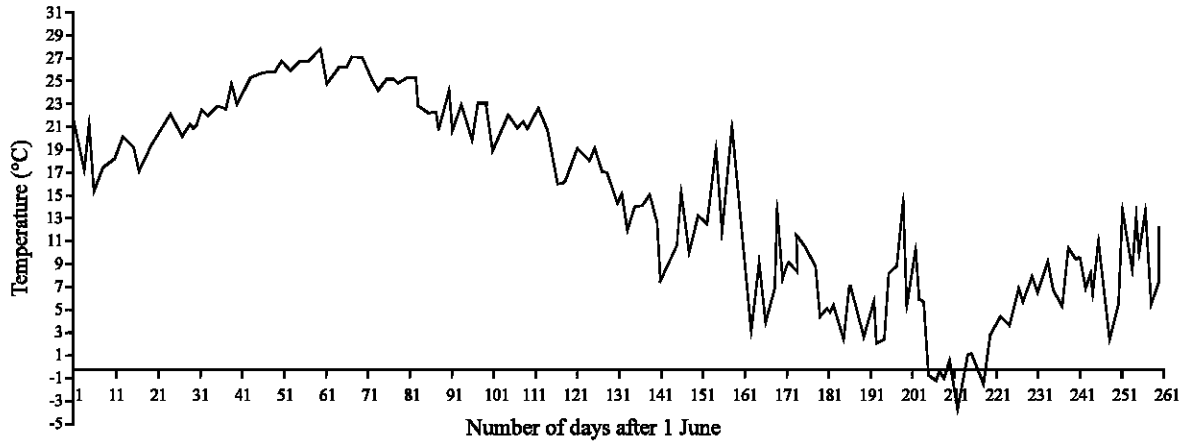

Fig. 1: Daily average temperatures between 01 June 2001 and 28 February 2002

located near the Adaköy an altitude of approximately 2 m. During the experimental period, annual precipitation was 744 and 710 mm for 2001 and 2002. Daily average temperatures and maximum, minimum and average temperatures (°C) between June 2001 and February 2002 were given Fig. 1 and Table 1.

Some major soil characteristics were found to be as follows; the soil texture is clay-loam, pH is 6.5, organic matter is 4.08%, extractable P is 4.8 mg kg^{-1}, exchangeable K is 56 mg kg^{-1} and EC is 1.64 mS cm^{-1} in soil saturation extract.

Experimental Design was a Randomized Block arrangement with three replications. Each treatment plot was 4x7 m with distance of 0.5 m each plot. Firstly, application field fertilized with appropriate rate of N:P:K according to soil analyses via Brussels sprouts requirements before planting. The other fertilizer applied two months later from transplanting time and beginning of bud initiation time.

Seeds of cultivar De La Halle were sown on 07 and 22 June and seedlings, reached 3-4 genuine leaf, were planted apart from 60x50 cm on 18 July and 03 August, respectively. Thermal time was estimated planting to bud initiation and bud initiation to harvest via minimum base temperature 5°C (Pearson *et al*., 1994).

Plant weight (g) and height (cm), leaf number $plant^{-1}$, fresh and dried weight of leaf (g), stem (g) and root (g), stem diameter (mm) was measured with 15 days intervals for 3 times, from 45th to 75th day after planting.

Bud number (number $plant^{-1}$), weight (g) and sizes (mm), the time from planting to bud initiation, from bud initiation to harvest (day) and yield (g $plant^{-1}$) were determined also.

Statistical analyses of the results were ascertained by means of ANOVA. Mean differences were determined by LSD test (Level of significance $p<0.01$).

RESULTS AND DISCUSSION

According to the results of the varience analyses, plant weight and height, leaf number, fresh and dry weight of leaf and stem, bud number and weight, the time from planting to bud initiation and bud initiation to harvest affected by treatments, on the contrary fresh and dry weight of root, stem diameter, sprout sizes and yield was not affected by treatments tested ($p<0.01$).

Because of, in First Planting Time (FPT), the beginning stage of plants growth, temperature was lower than in Second Planting Time (SPT), plant weight, plant height, leaf number and fresh and dry weight of leaf values in FPT were found higher than SPT. On the other hand, fresh and dry weight of stem in SPT were found higher than FPT (Table 2).

Previous experiments clearly demonstrated that Brussels sprouts are cool season crop that grows best between 7 and 24°C with optimal growth at 16-18°C (extremes 7 and 29°C) (Akinci *et al*., 2003; Anonymous, 2002; Vural *et al*., 2000).

With late planting, both growth and development tended to be more rapid than with early planting and the yield was lower. The final Dry Weight (DW) declined from 12-14 t ha^{-1} with early planting to 7-9 t ha^{-1} with late

Table 2: The effects of planting times and measuring days on some vegetable characters in Brussels sprouts

Panting times	Days	Plant weight (g)	Plant height (cm)	Leaf number plant^{-1}	Leaf weight (g)		Stem weight (g)		Root weight (g)		Stem width (mm)
					Fresh	Dried	Fresh	Dried	Fresh	Dried	
	45	307.0a*	33.1a	39.0a	253.7a	29.3a	36.0b	5.0b	17.3	4.4	13.8
FPT	60	695.3a	40.2a	50.0a	509.3a	64.3a	83.7b	10.3b	32.3	8.7	17.5
	75	1050.7a	65.3a	52.7a	646.0a	81.3a	174.0b	29.0b	67.3	21.3	20.7
	45	220.3b	22.4b	25.0b	156.0b	18.3b	46.3a	7.7a	18.0	5.0	12.2
SPT	60	495.0b	32.7b	35.0b	396.0b	45.3b	104.0a	14.6a	35.0	9.3	16.7
	75	814.0b	60.0b	39.3b	540.0b	73.3b	200.0a	38.7a	74.0	22.0	22.0

*Values followed by different small letter in columns are significantly different ($p<0.01$)

Table 3: The effects of planting times and measuring days on some yield components in Brussels sprouts

Planting times	Bud number	Bud weight plant^{-1} (g)	Bud width (mm)	Bud height (mm)	The time from planting to bud initiation (day)	The time from bud initiation to harvest (day)	Yield (g plant^{-1})
FPT	65.8a*	4.68b	22.83	30.05	119a	67b	307.9
SPT	56.6b	5.45a	22.60	31.08	105b	74a	308.5

*Values followed by different small letter in columns are significantly different ($p<0.01$)

Table 4: Thermal time needed in Brussels sprouts

Planting times	Thermal time needed from planting to bud initiation (°C-days)	Thermal time from bud initiation to harvest (°C-days)	Thermal time needed from planting to harvest (°C-days)
FPT	1300a	460a	1760a
SPT	1100b	390b	1490b

*Values followed by different small letter in columns are significantly different ($p<0.01$)

planting. The final sprout DW decreased as planting was delayed, but was unaffected by plant density. A combination of high plant density and late planting resulted in the fewest sprouts plant^{-1}. The average yield decreased with later planting from 29.4 to 17.4 t ha^{-1} (Everaarts and De Moel, 1998).

Jade Cross F_1, Isla and Emerald Ball transplanted on 15 February yielded 20.46, 14.89 and 17.09 t ha^{-1}, respectively, whereas the same hybrid and cultivars transplanted on 15 March yielded 11.41, 12.57 and 13.33 t ha^{-1}, respectively. No commercial yields were obtained from plants transplanted on 15 April. The cultivars Valiant, Camelot, Merlon and Lunet transplanted on 25 January yielded 11.8, 11.82, 12.85 and 11.84 t ha^{-1}, respectively. The same cultivars transplanted on 17 February yielded 11.49, 9.85, 12.16 and 11.69 t ha^{-1} and transplanted on 10 March yielded 4.06, 4.15, 3.54 and 4.13 t ha^{-1}, respectively. The period from transplanting to harvesting was shorter with the later planting dates (Bravo *et al*., 1986).

Sowing in April increased the processing yield of mid to late cultivars by up to 80% compared with the May sowing date. These cultivars also held over well in the field for 2 months without an increase in the number of overgrown sprouts (>30 mm in diameter). This effect was not observed with the early cultivars and delayed harvest resulted in loss of yield (Babik and Rumpel, 1994).

Total yield per plant was higher for the plants (550 g plant^{-1}) grown in March than in May and June because of the vegetation period and having higher side shoots per plant in broccoli (Kar and Uzun, 2000).

Leaf Weight Ratio (LWR) decreased with time after planting while Stein Weight Ratio (SWR) increased with time. Generally, later planting times resulted in higher SWR and LWR while early planting times had higher Root Weight Ratio (RWR). Both Leaf Area Ratio (LAR) and specific leaf area SLA declined with ontogeny. Earlier planted plants had higher LAR and SLA. Net Assimilation Rate (NAR) and Relative Growth Rate (RGR) were found to be lower with earlier plantings. Leaf Area (LA) and Total Plant Dry Weight (TPDW) varied with planting times and ontogeny. Both LA and TPDW increased with time after planting and plants from earlier plantings had lower LA and TPDW values. Leaf Thickness (LT) was higher at later planting times and increased with time (Uzun and Kar, 2004).

Decreasing degree of earliness, or optimum harvest date, the time of bud initiation was determined during two seasons in Brussels sprouts. Fifty percent of the plants had initiated buds between 60 and 75 Days After Planting (DAP) in 1994 and between 70 and 86 DAP in 1995. The sequence of cultivars in time of bud initiation was the same as for the time of optimum harvest date. There appeared to be fixed relation between the period from planting to bud initiation and the period from planting to optimum harvest date. The time of optimum harvest can, thus, be predicted after bud initiation. One day delay in bud initiation delayed optimum harvest date by 2.4 days (Everaarts *et al*., 1998).

The cultivars Jade F_1, Lunet F_1 and Dorema F_1 were each raised from 3 sowing dates (3, 15 and 28 April) and planted in the field on 15 May, 21 May and 1 June,

respectively. Three different planting densities were compared for each cultivar; these were, respectively, 3419, 4396 and 6154 plants day^{-1}; 2564, 3077 and 3846 day^{-1} and 3077, 3846 and 5128 day^{-1}. The influence of the planting date on yield was mainly related to the duration of the growing period. Plant density had no significant effect on the yield of Class 1 sprouts, but a low density increased the sprout size. With Jade F_1 and Lunet F_1, stopping increased both yield and sprout size compared with no stopping (Bortness, 1990).

Bud number determined 65.8 number plant^{-1} in FPT and 56.6 number plant^{-1} in SPT. Early sown plants produced more buds than late sown ones because of their longer growing season (Abuzeid and Wilcockson, 1989). But, yield was found similar both of planting times (307.9 g plant^{-1} in FPT and 308.5 g plant^{-1} in SPT). Because, high temperatures in FPT caused low bud weight than in SPT (4.68 g and 5.45 g). Bud weight influenced negatively from high temperatures. Bud width (22.83 mm and 22.60 mm) and height (30.05 mm and 31.08 mm) weren't affected of FPT and SPT, respectively (Table 3). Compact brussels sprouts occur best in the coolest part of the growing season. In warm weather, sprouts become loose, forming more open heads, while cool weather firms the sprouts and leads to a milder flavor (Anonymous, 2002).

The time from planting to bud initiation, thermal time needed from planting to bud initiation and thermal time needed from bud initiation to harvest values in first planting time (FPT) (119 day, 1300°C-day and 460°C-day) were higher than second planting time (SPT) (105 day, 1100 and 390°C-day) also, respectively (Table 4).

These results proved that high temperature had a negative effect on bud initiation in brussels sprouts and thermal time needed for vegatative growth was higher than bud initiation to harvest. Brussels sprouts requires a period of low temperature (12-17°C) for proper bud initiation. If the cold-requirement is not fullfilled, period of bud initiation get longer (Vural *et al*., 2000). Likewise, thermal time needed from planting time to head initiation was found 1200 and 700-1200°C-days for vegetative growth and thermal time needed from curd initiation to harvest was found 200 and 300-400°C-days in cauliflower and in broccoli, respectively (Kar and Uzun, 2000; Uzun and Pekşen, 2000).

A common optimum temperature for curd induction in cauliflower was estimated to be 12.8°C, the base temperature was estimated to be 0°C and the maximum temperature, therefore, is taken to be 25.6°C (Grevsen, 1998). In cauliflower, effective temperature determined with an optimum of 14°C. Curd initiation occurred after the accumulation of 296°C days above a base temperature of 2.8°C (Grevsen and Olesen, 1994).

Temperature was determined high in FPT than in SPT in bud maturation period, for this reason, bud maturation became rapidly and the time from bud initiation to harvest determined lower in FPT (Table 4).

As a result of this study, planting times in cool season found very useful practice to enhance quality of buds in Brussels sprouts. Thats why, the most suitable planting times should be determined in further studies on the basis of thermal time and photoperiod interaction for all growing season.

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