International Journal of PharmTech Research
CODEN (USA): IJPRIF, ISSN: 0974-4304, ISSN(Online): 2455-9563
Vol.9, No.12, pp 372-379, 2016

Growing Some Brussels Sprouts Cultivars in Two Planting Dates under North Sinai Conditions

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Abstract : Field experiments were conducted on Brussels sprouts at Rafah, North Sinai, Egypt in the winter season of 1998 – 1999 and 1999 – 2000. Four cultivars (Groninger, Sanda, Early half dwarf and Roger) were planted in two planting dates (15Oct. and 15 Nov.) in a sandy soil under drip irrigation system.

Results indicated that, later planting recorded higher values of vegetative growth expressed as plant height, leaves number, stem length and diameter as well as fresh weight of leaves, stems and total plant compared with early planting. Higher values of total yield of sprouts were recorded by the late planting date.

Plants of c.v. early half dwarf recorded the highest values of vegetative growth, fresh weight of total plant, leaves and stems as well as total sprouts, marketable and unmarketable yields in the first season, but Roger plants gave the highest values of these parameters in the second season. Groninger cv. plants recorded the lowest values of growth and yield. Plants of cv. sanda ranged in-between. Interaction of planting dates and cultivars was without clear trend.

Keywords : Brussels Sprouts Cultivars, North Sinai Conditions.

Introduction

The producing areas of late Brussels sprouts are restricted by the prevailing temperatures, which determine the first possible planting date, duration of the growing season and growth during this season and sprout formation. In Europe two partly overlapping sprout growing areas can be distinguished. A large area in north-western Europe and a smaller area near the Atlantic Ocean in southern England and western France and in north Italy. Outside Europe sprouts can be grown in parts of USA, Canada, Japan, Australia South Africa, New Zealand, Chile, Argentina and Paraguay (Kronenberg,[1]). This work is an attempt for cultivation and adaptation of Brussels sprouts in Rafah a moderate climate region in Sinai, north eastern Egypt.

Dietary antioxidants, such as water-soluble vitamin C and phenolic compounds, as well as lipid-soluble vitamin E and carotenoids, present in vegetables contribute both to the first and second defense lines against oxidative stress. As a result, they protect cells. Against oxidative damage, and may therefore prevent chronic diseases, such as cancer, cardiovascular disease, and diabetes-Brassica vegetables, which include different genus of cabbage, broccoli, cauliflower, Brussels sprouts and kale, are consumed all over the world (Podsedek, [2]). Brussels sprouts is a cruciferous crop rich in its mineral content and nutritional value. Sprouts contain also vitamins, provitamins, fats, proteins, amino acids and other anti-oxidant materials. Brussels sprouts is an important vegetable species. The possibility of Brussels sprouts cultivation on open field and influence of planting dates and varieties on growth, yield and quality under Sinai conditions were investigated. Many investigators reported that planting dates influenced vegetative growth, yield and quality of Brussels sprouts. Mirecki [3] reported that planting dates affected vegetative growth, yield and quality of Brussels sprouts plants. Kurtar,[4] added that planting had a significant effect on plant weight and height, number of leaves, fresh and

dry weight of leaves and stems, number of bud and bud weight. Akhilesh Sharma *et al*,[5] found that early planting (6 June) at narrow Spacing significantly increased the yield and yield attributing characters (plant height, sprout number plant , average sprout weight, sprout length, sprout diameter, sprout yield, net returns and benefit cost ratio. Mirecki,[6] studied the influence of planting dates (10^{th} of April, 10^{th} of May, 10^{th} of June, 10 July) on Chemical composition and yield of Brussels sprouts. Results indicated that earlier planting (April-May) provides higher yield and better quality of sprouts compared to later planting dates (June-July) He added that the planting date had a significant effect on contents of dry matter, sugar and vitamin C.

In Netherlands, Everaarts and Moel,[7] reported that the marketable yield of Brussels sprouts decreased with delay in planting from the end of April-early May to the end of June-early July. Sowing many cultivars of Brussels sprouts in April increased the processing yield of mid to late cultivars by up to 80% compared with May sowing date (Babik,[8]). Sciazko *et al.,*[9] reported that the protein and amino acids content were not affected by the sowing date but sowing earlier increased the amino acids content in total protein fraction. Results obtained by Kolota and Biesiada,[10] indicated that plants of Brussels sprouts from the early sowing gave higher total and commercial yields than those from the later sowing. Similar results of Gaye and Maurer, [11] indicated sowing Brussels sprouts early at 24 Mar. improved marketable yield compared with 17 to 14 Oct. In addition, Abuzeid and Wilcockson [12] found that early sowing recorded higher values of LAI and outyielded with more buds compared with those of the late sowing. On the contrary, Krieghoff, [13] indicated that early planting date in (late May) resulted in higher yields with higher quality sprouts, greater plant weight, longer stalks, more sprouts (plant and higher sprout weight with a planting date 10 or 20 days.

Varieties (cultivars) of Brussels sprouts were subjected to evaluation in many investigations under different climatic and geographic conditions all over the world. Many investigators dealt with cultivars. Babik, [8] reported that sowing in April increased the processing yield of mid to late cultivars by up to 80% compared with the May sowing date. Mirecki,[14] investigated the possibility of growing Brussels sprouts in the zeta valley in three years long experiments. Vlaswinkel *et al.,*[15] carried out field studies on seven Brussels sprouts cultivars (kundry, lauris, Ajax, philemon, Helemos, Stephen and Estate). Everaarts,[16] recommended criteria for choosing the best cultivar according to maturation criteria maturation time, planting date, plant density and stopping. Babik,[8] investigated the effects of sowing date and harvest date on the yield and quality of Brussels sprouts cultivars (Oliver, Rider, Roger, Predora, Boxer, Lunel, Citadel and Tardis) with different maturities. Krieghoff,[13] reported that Brussels sprouts cultivars namely Merkator and Barendrechter and a new line Bog 108/2 were planted in a diluvia soil on 3 dates. There were no significant differences between the cultivars, but BOG 108/2 outyielded Merkator planted on the earliest planting date.

Materials And Methods

Two field experiments were carried out in the Ideal farm of the developing Authority of North Sinai in Rafah, Egypt during two winter seasons of 1998-1999 and 1999-2000. Seeds of Brussels sprouts (*Brassica oleracea* Var. *Gemmifera* L.) were imported from Takii Company in Japan.

A. Nursery foam trays 208 eyes were filled with media consisting of sand and peat moss 1:1 by volume. Seeds were drilled in the trays one in every eye. Trays were sprayed with irrigation water and arranged together in six horizontal layers, then wrapped by plastic sheets and kept three days till seed emergence. Trays were arranged on the nursery tables. Recommendations of growing cruciferous transplants were followed till 35 days age and then trays were moved to the open field.

B. Field preparation: Ditches 20 cm width and 20 cm depth were built under the locations of drip irrigation lines. Poultry manure ($5m^3$/fed.) was carefully mixed with the recommended dose of superphosphate and spread along the ditches and covered with sand. Drip irrigation lines were spread over the ditches and irrigation took place three days before planting. Seedlings were transplanted with their peat moss cubic's one besides every irrigation eye (50 cm apart). Plot area was 22.5 m^2 contains three rows each 10 m. long and 75 cm. width. Drip irrigation lines (transplants rows) were 75 cm. apart. Recommendations of growing cruciferous plants, *i.e.,* "irrigation and fertilization as well as pests, diseases and weeds control were followed all over the growth season.

Experimental treatments:

A. **Planting dates:** Two planting dates: 15 October and 15 November.

B. **Cultivars:** Four cultivars: Groninger, Sanda, Early half dwarf and Roger H.F_1.

Every experiment included eight treatments which were the combinations of two planting dates and four cultivars with three replicates. Experimental design was split-plot design in which planting dates treatments were assigned in the main plots and cultivars were arranged in the sub-plots.

Data recorded:

Vegetative growth: Three plants of every experimental plot were collected and the following measurements were recorded:

1- Plant height cm. 2- Leaves number/ plant 3-Stem length cm.
4- Stem diameter cm 5-Stems fresh weight (G).
5- Total plant fresh weight (G).

Sprouts yield: Sprouts were handily picked at green mature stage.

1- Sprouts yield (kg/plot): Marketable, unmarketable and total sprouts yield.
2- Total yield (ton /fed).
3- Marketable yield (%).
4- Unmarketable yield (%).

Results and Discussion

1. Effect of planting dates:

Data tabulated in Table (1) indicated that the vegetative growth of Brussels sprouts plants expressed as plant height, leaves number, stem length and diameter were not statistically affected by planting dates in the first season. In the second season, increases in plant height, leaves number as well as stem length and diameter were recorded in plants of the later planting date (15 Nov.).

Fresh weight of leaves, stems and total plant was statistically influenced by planting dates. Higher values of fresh weight of Brussels sprouts plant and its parts, *i.e.* leaves and stems were recorded by later planting in the first season. In addition, stem fresh weights recorded lower values in the late planting date in the second season, consequently total plant fresh weight. Plants of the late planting (15 Nov.) recorded higher values of leaves, stems and total plant fresh weight in the first season. In the second season, leaves fresh weight were higher in the late planting compared with the early planting date. Differences in total plant and stem fresh weight between the two planting dates did not reach the level of significance in the second season. In general, it could be concluded that the vegetative growth of the plants of later planting and their fresh weight were higher than those of the early planting.

This enhancement in plant growth might be referred to the favorable conditions created by the suitable environmental conditions through the growth season of the later planting. These favorable conditions created more water and nutrients absorption, sunlight, consequently more photosynthetic activity and plant growth. Increases in vegetative growth obtained by late planting date (15 Nov.) might also be due to the low temperature prevailing in Rafah region during growth period which are more suitable to Brussels sprouts growing compared with the early planting (15 Oct.). On the contrary, many investigators in many countries recommended earlier planting dates. Kurtar [4] in Turkey, reported that planting date had a significant effect on plant weight and height, number of leaves, fresh and dry weight of leaves and stems of Brussels sprouts plants. Akhilesh Sharma *et al.*,[5] in India, found that early planting increased plant height. Babik,[8] recommended earlier planting date (early to midApril). Abuzeid and Wilcockson,[12] reported that early-sown sprouts achieved higher LAI value. Krieghoff,[13] recommended earlier planting date for obtaining greater plant weight and longer stalks of Brussels sprouts plants.

This contradiction between their results and our results might be referred to the different environmental conditions between their countries and our experiment environmental conditions.

Sprouts yield and its components, *i.e.* marketable and unmarketable sprouts yield were affected by planting dates. In the first season higher values of total, marketable and unmarketable yields were obtained by the late planting. Total yield of the late planting date (15 Nov.) was higher than that of the early one (15 Oct.) under Rafah conditions. Sowing Brussels sprouts at 15 November gave higher yields per plot and per feddan. Total yield of the late planting date, outyielded that of the early planting date by 0.546 and 0.994 ton per feddan which equals 16.4 and 31.4 %, for the first and second seasons, respectively. Similar and consistent results were obtained in the second season.

Sprouts yield of the second season was higher in the late sowing (15 Nov.) compared with the early planting date. Higher yields were obtained by the late planting date in both seasons of the experiment. Higher yields of total sprouts and marketable percentage of the late planting date might be due to the favorable atmospheric conditions during the late plantation. Moderate atmosphere, sunshine and warm temperature prevailing region in Rafah region during the late plantation enhanced plant growth, photosynthetic activity and dry matter accumulation which increased sprouts yield. The superiority of the late planting yield might be also due to the increases in the vegetative growth, leaves number per plant intercepted by sunlight. These conditions created higher photosynthetic and biosynthetic activities, consequently higher levels of carbohydrates and dry matter accumulation. Since the total yield is the summation of all these components, higher yields were obtained by the later planting date. Many investigators all over the world studied the effect of planting dates on sprouts yield and quality. Akhilesh Sharma *et al*.,[5] reported that early planting (6 June.) at narrow spacing significantly increased the yield and yield attributing characters of Brussels sprouts. Babik, [8] reported that most favorable sowing time for early cultivars was early to mid April and for the medium-late ones, in early April. Vlaswinkel *et al*.,[15] came to similar results; they reported that early planting resulted in the highest yields of Brussels sprouts. In Netherlands, Everaarts,[16] found that the marketable yield of Brussels sprouts decreased with delay of planting. Babik,[8] reported that sowing Brussels sprouts in April increased the processing yield than May. Gaye and Aurer, [11] in Columbia found that marketable yield was improved by early sowing. Abuzeid and Wilcockson,[12] referred the high sprouts yield of the early sowing that the early-sown sprouts achieved an LAI of 3.5 earlier than late sowing. They stated a close relationship between total DW, but DW and intercepted radiation. In addition, they reported that early-sown crops produced more buds than late-sown ones because of their longer growing season. Krieghoff,[13] reported that late May plantation resulted in higher yields of high quality sprouts / plant and higher sprout weight compared with 10 or 20 days later. These results are in contradiction with our results. These contradictions might be referred to the differences in the environmental conditions between our experimental conditions and those all over the world. In addition, mean temperature and environmental conditions of the later plantation at Rafah was more suitable for growth and yield of Brussels sprouts plants compared with the early plantation.

2- Effect of cultivars:

Brussels sprouts cultivars varied significantly in their vegetative growth. Plant height, leaves number, stem length, stem diameter as well as fresh weight of leaves, stems and total plant were widely differed between the different cultivars. Early half dwarf cv. plants recorded the highest values of plant height, leaves number, stem length and diameter in the first season. The lowest values of plant height, leaves number, stem length and diameter were obtained by Groninger plants in the two seasons of the experiment. These characters ranged in-between Roger and Sanda in the first season. In the second season, the highest values of plant height, leaves number and stem length were recorded by Roger cv. plants. The lowest values were obtained by Groninger plants as the results of the first season. Early half dwarf and Sanda plants ranged in-between Roger and Groninger plants. Fresh weight of total plant and its parts *i.e.* leaves and stems recorded similar results. Their higher values were recorded by early half dwarf and roger plants in the first and second seasons, respectively. Groninger plants recorded lower values of fresh weight of total plant and its parts. Early half dwarf and Sanda ranged in-between Roger and Groninger plants. It could be concluded that the vegetative growth of Early half dwarf and roger plants was higher in the two seasons, respectively. The lowest vegetative growth was obtained by Groninger plants in the two seasons of the experiment. Vegetative growth values of Early half dwarf and Sanda plants ranged in-betweens Roger and Groninger, in the second season.

Total yield of sprouts was affected by cultivars. It could be concluded that Results of total yield followed the same trend of the vegetative growth. Total yield is the direct reflection of the vegetative growth, photosynthetic activities and bio-thensythesis. It could be concluded that plants of Early half dwarf and Roger outyielded those of Groninger and Sanda due to their taller plants with denser leaves and higher fresh weight of total plant, leaves and stems. The highest total yield was obtained by early half dwarf cv. in the first season. In the second season, the highest total marketable and unmarketable yields were obtained by Roger cv. plants. Lower yields were obtained by the other cultivars. Yields of total sprouts, marketable and unmarketable responded to cultivars without clear trend, in the two seasons of the experiment. Many investigators came to similar results. They studied variations of Brussels sprouts cultivars. Most investigators did not reflect clear trends for the vegetative growth and yields of the different cultivars. Vlaswinkel *et al*.,[15] evaluated seven Brussels sprouts cultivars (Kundry, Lauris, Ajax, Philemon, Helemus, Stephen and Estate). Babik,[8] studied the effect of sowing date on the yield and quality of many, Brussels sprouts cultivars (Oliver, Rider, Roger, Predora, Boxer, Lunel, Citadel and Tardis). These cultivars held over well in the field for two months without an increase in the number of overgrown sprouts (730 mm in diameter). This effect was not observed with the early cultivars and delayed harvest resulted in loss of yield. They reported that in Poland, the use of mid to late cultivars, sown in early Apr. for transplanting, is recommended for processing crops. Krieghoff,[13] reported that there were no significant differences between Merkator and Barendrethter cvs., but the line BOG 108/82 outyielded Merkator planted on the earliest planting date.

3- Effect of interaction (planting dates x cultivars):

The effect of interaction of planting dates and cultivars on the vegetative growth was without clear trend. The tallest plants were those of early half dwarf and the shortest were plants of Groninger in the first season. In the second season, the tallest plants were those of Roger and the shortest were those of Groninger. Plants of early half dwarf were the denser leaves and those of roger were the lower leaves in the two seasons. Stem length and diameter were higher in early half dwarf in the late planting and the lowest with Groninger plants in both seasons of the experiment.

Fresh weight of total plant and its leaves and stems were higher in early half dwarf of the early planting date plants. The lowest fresh weight of total plant and its parts were obtained by the interaction of roger cv. in the late planting dates.

Plants of early half dwarf in the early planting date recorded higher values of total, marketable and unmarketable yields. In addition higher yields of total sprouts, marketable and unmarketable were obtained by the interaction of Roger cv. and late planting.

Table (1): Effect of planting date on vegetative growth, sprouts yield and quality of Brussels sprouts plants

Planting date	Plant height (cm)	Leaves number /plant	Stem length (cm)	Stem diameter (cm)	Fresh weight (G)			Sprouts yield (kg/plot)			Total yield (ton/fed)	Market-able yield (%)	Unmark eatable yield (%)
					Leaves	Stems	Total plant	Marketable	Unmarketable	Total			
1998-1999													
15 Oct.	48.5	52.9	38.4	2.2	279.6	175.0	454.6	12.438	4.853	17.791	3.326	82.1	17.9
15 Nov.	45.6	36.7	40.3	2.63	486.4	189.9	676.3	15.022	5.682	20.704	3.872	88.7	11.3
L.S.D	NS	NS	NS	NS	35.0	35.0	215.0	NS	NS	0.402		-	-
1999-2000													
15 Oct.	47.9	42.7	24.3	1.8	389.6	73.7	463.3	13.750	2.818	16.568	3.167	83.0	18.4
15 Nov.	70.9	51.8	33.4	3.1	402.6	58.4	461.0	12.448	2.350	22.250	4.161	81.0	19.0
L.S.D	1.6	3.0	NS	0.2	32.0	NS	NS	4.479	1.348	0.215	-	-	-

Table (2): Effect of cultivars on vegetative growth, sprouts yield and quality of Brussels sprouts plants

Cultivar	Plant height (cm)	Leaves number /plant	Stem length (cm)	Stem diameter (cm)	Fresh weight (G)			Sprouts yield (kg/plot)			Total yield (ton/fed)	Market able yield (%)	Unmark eatable yield (%)
					Leaves	Stems	Total plant	Marketable	Unmarketable	Total			
1998-1999													
Groninger	34.2	35.4	35.5	1.9	398.3	189.4	587.7	14.109	5.208	19.317	3.612	73.7	26.3
Sanda	45.9	43.3	34.3	2.6	477.9	145.7	623.6	16.040	5.02	21.060	3.938	76.2	28.8
Erly half dwar F	61.1	57.2	50.0	2.5	608.5	279.5	888.0	16.213	7.009	23.222	4.342	69.8	30.2
Roger H. F1	47.2	43.3	37.5	2.1	547.4	170.2	777.0	9.559	4.022	13.582	2.540	60.3	29.7
L.S.D	2.6	2.2	12.0	0.2	46.8	10.7	215.5	6.079	1.507	1.308	-	-	-
1999-2000													
Groninger	34.2	51.5	34.7	2.8	329.1	68.6	397.7	9.050	16.550	25.650	4.797	35.5	64.5
Sanda	61.5	50.2	37.4	3.0	349.8	62.2	412.0	13.000	19.250	32.250	6.031	40.3	59.7
Erly half dwar F	54.9	51.4	31.3	2.7	370.3	74.3	444.6	13.20	18.150	31.350	5.114	42.1	57.9
Roger H. F1	63.5	55.5	37.0	2.7	835.3	89.1	874.4	17.145	31.900	41.045	8.050	34.9	65.1
L.S.D	4.5	NS	1.2	0.4	81.1	18.6	221.5	7.759	2.336	1.588	-	-	-

Table (3A): Effect of interaction of planting dates and cultivars on vegetative growth and sprouts yield of Brussels sprouts plants

Cultivar		Plant height (cm)	Leaves number /plant	Stem length (cm)	Stem diameter (cm)	Fresh weight (G)			Sprouts yield (kg/plot)			Total yield (ton/fed)	Marketable yield (%)	Unmarkeatable yield (%)
						Leaves	Stems	Total plant	Marketable	Unmarketable	Total			
1998-1999														
15 Oct.	Groninger	33.7	42.0	34.7	1.7	425.3	109.0	534.3	13.650	4.597	18.247	3.412	74.80	25.2
	Sanda	51.0	54.3	31.3	2.4	678.0	162.7	840.7	14.880	4.223	19.103	3.572	77.9	22.1
	Erly half dwa F	61.3	68.0	66.3	3.1	655.0	214.0	1269.0	13.177	7.593	20.770	3.884	63.4	36.6
	Roger H. F1	48.0	47.3	21.3	1.7	560.0	215.0	775.1	10.047	3.000	13.050	2.440	77.0	23.0
15 Nov.	Groninger	34.7	28.7	36.3	2.0	371.3	160.7	532.0	14.568	5.818	20.386	3.812	71.5	28.5
	Sanda	40.7	32.3	37.3	2.7	477.7	128.7	606.4	17.200	5.443	22.643	4.742	76.0	24.0
	Erly half dwar F	60.7	46.3	33.7	3.3	562.0	345.0	907.0	19.250	6.425	25.675	4.801	75.0	25.0
	Roger H. F1	46.3	39.3	53.7	2.5	534.7	125.3	660.0	9.070	5.043	14.113	2.639	64.3	35.7
L.S.D		4.5	NS	NS	0.4	81.1	18.6	221.5	7.759	NS	1.389	-	-	-

Table (3B): Effect of interaction of planting dates and cultivars on vegetative growth and sprouts yield of Brussels sprouts plants

Cultivar		Plant height (cm)	Leaves number /plant	Stem length (cm)	Stem diameter (cm)	Fresh weight (G)			Sprouts yield (kg/plot)			Total yield (ton/fed)	Marketable yield (%)	Unmarkeatable yield (%)
						Leaves	Stems	Total plant	Marketable	Unmarketable	Total			
1999-2000														
15 Oct.	Groninger	44.0	41.7	25.0	21.3	232.9	78.2	311.1	8.900	2.020	10.920	2.042	81.5	18.5
	Sanda	52.7	37.0	27.0	21.0	347.5	63.9	411.4	15.000	2.350	17.850	3.338	86.5	13.5
	Erly half dwar F	44.0	44.0	22.3	22.7	362.6	85.9	448.5	14.100	2.330	16.430	3.072	85.8	1.4
	Roger H. F1	51.0	48.0	22.7	23.7	615.5	66.7	682.2	17.000	4.570	21.570	3.099	72.4	27.6
15 Nov.	Groninger	71.7	41.3	34.3	29.3	325.3	59.0	384.3	9.200	1.290	10.440	1.952	87.7	12.3
	Sanda	70.3	43.3	37.7	36.7	352.0	60.5	412.5	11.000	1.500	12.500	2.338	88.0	13.9
	Erly half dwar F	65.7	58.7	30.3	31.7	378.0	62.7	540.7	12.300	1.600	13.900	2.038	88.5	11.5
	Roger H.F1	76.0	63.7	31.3	29.7	555.0	51.4	606.4	17.290	1.810	19.100	2.263	90.5	9.5
L.S.D		13.9	8.7	9.0	6.8	45.5	NS	25.5	NS	1.100	0.393	-	-	-

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