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Effect of Growth Season on Forage Yields of Different *Brassica* Cultivars Under Ankara Conditions

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Abstract: This research was carried out at the experimental field of Ankara University, Faculty of Agriculture, Department of Field Crops in Turkey in 1997 and 1998. Spring and summer seedings were employed in both years. The introduced kale cultivars Vates, Siberian and Premier (*Brassica oleracea* L. var. *acephala*), forage rape cultivar Emerald (*Brassica rapa* L.) and Collard cultivars Vates, Champion and Georgia Southern (*Brassica oleracea* L.) were used as the research materials. The effect of the growth season on forage *Brassica* yields was evident, and generally the yields of summer-grown cultivars were higher. The highest forage yields and crude protein contents were obtained from the summer-grown forage rape cultivar Emerald. This cultivar can be seeded in July under irrigated conditions. The yield of the kale cultivar Premier was also high. It was concluded that the forage kale cultivar Premier can also be summer-seeded under irrigated conditions. It appears that July 15 is a suitable time for seeding these as a second crop, and that they can be grown successfully under irrigated conditions.

Key Words: Forage brassicas, kale, rape, collard, forage yields

Ankara Koşullarında Farklı *Brassica* Çeşitlerinin Yem Verimlerinde Yetiştirme Mevsiminin Etkisi

Özet: Bu araştırma Ankara Üniversitesi Ziraat Fakültesi Tarla Bitkileri deneme tarlasında ilkbahar ve yaz ekimi olmak üzere iki ekim mevsiminde ve 1997 ve 1998 yıllarında yürütülmüştür. Araştırmada materyal olarak yabancı kökenli *Brassica*lardan yem lahanası çeşitleri Vates, Siberian ve Premier (*Brassica oleracea* L. var. *acephala*), yemlik kolza çeşidi Emerald (*Brassica rapa* L.) ve yem lahanasının bir varyetesine ait çeşitlerden Vates, Champion ve Georgia Southern (*Brassica oleracea* L.) kullanılmıştır. Ekim mevsiminin *Brassica* çeşitleri üzerinde etkisi oldukça önemli olmuş ve genellikle yaz ekimlerinden daha fazla yem verimi elde edilmiştir. En fazla yem verimi ve ham protein oranı yemlik kolza çeşidi Emerald'ın yazlık ekimlerinden alınmıştır. Yemlik kolza çeşidi Emerald sulanan şartlarda Temmuz ayında ekilebilir. Yemlik lahana çeşidi Premier'de oldukça yüksek yem verimlerine sahip olmuş ve bu çeşidin de sulanan şartlarda yazlık olarak yem bitkisi amacıyla yetiştirilebileceğine karar verilmiştir. Sonuçta, *Brassica* yem bitkilerinin ikinci ürün olarak yetiştirilebileceği, bu amaçla en uygun ekim zamanının 15 Temmuz olduğu ve bu bitkilerin sulanan koşullarda başarılı bir şekilde tarımının yapılabileceği görülmektedir.

Anahtar Sözcükler: *Brassica* yem bitkileri, yemlik lahana, yemlik kolza, yem verimleri

Introduction

Brassica species have been used as forage for centuries. The exploitable features of *Brassica* crops include: (i) abundant forage at a time when most warm- and cool-season grasses are unproductive (Wiedenhoeft and Barton, 1994) and (ii) high yields of readily consumed energy and protein compared with cereals and perennial grasses (Kay, 1975). Most *Brassica* species are relatively low in dry matter content, although their total dry matter production per unit area is high relative to most cereals and forage grasses. Not only they are high-yielding crops, but they also have good nutritional quality (Rao and Horn, 1986). *Brassica* species include short-season (fast-maturing) crops such as forage rape (*B. napus*). Full-season *Brassica* species include kale (*Brassica oleracea* var. *acephala*) and collards (*Brassica oleracea*) (Koch and Karakaya, 1998).

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Depending on the farm, *Brassica* species can be planted as a second crop, following small grains, used as a break crop following the plowing down of alfalfa, and no-till seeded into permanent pastures or meadows (Koch and Karakaya, 1998).

Seasonal influences on *Brassica* growth, forage yield and quality characteristics need to be examined. Therefore, experiments were conducted to determine the effects of spring and summer growth conditions on the forage yield and quality of various *Brassica* crops.

Materials and Methods

This research was carried out at the experimental field of Ankara University, Faculty of Agriculture, Department of Field Crops in Turkey, during 1997 and 1998. The soil was a clay loam with alkaline properties. The levels of organic matter and $CaCO_3$ were approximately 1% and 5%, respectively. The total amounts of precipitation during 1997 (548 mm) and 1998 (442 mm) were both higher than the mean over a long period (343 mm). The means of the temperature and relative humidity during the experimental period were close to the mean of the same long period.

In this study, the introduced kale cultivars Vates, Siberian and Premier, forage rape cultivar Emerald and collard cultivars Vates, Champion and Georgia Southern were used as the research materials. Two experiments were set up: spring seeding at the beginning of April as a first crop, and summer seeding on 15 July as a second crop, both in 1997 and 1998. The experimental design was a randomized complete block with three replications for each experiment. Two experiments were combined for each year and analyzed over the seasons, and season x cultivars interactions were measured accordingly. Each plot consisted of 10 rows, 4 m long. Plant spacing between the rows was 17.5 cm . The seeding rate was 4000 g/ha for all cultivars. 100 kg/ha nitrogen fertilizer was applied in the form of ammonium nitrate after seeding in each trial and year. Weeds were removed by hoeing as needed. Trifluralin was used in July-seeded plots. Plant height was measured before the harvests. Harvesting was carried out approximately 4 months later than seeding, at the beginning of July and mid-November, respectively. Plots were flood-irrigated twice in the April-seeded experiment and five times in July-seeded one. After the harvest, the green yield was determined for each plot and samples were dried in ovens at 70 ºC to a constant weight for dry matter content (Martin et al., 1990). Dried samples were ground into powder and the amount of nitrogen was established using the Kjehldal method. The amount of nitrogen from each sample was multiplied by 6.25 and the crude protein content calculated. The green yields obtained from each plot, dry matter and crude protein contents were calculated as fresh, dry matter and crude protein yields per hectare.

Data were analyzed by analysis of variance (SAS, 1989) at the $P \leq 0.05$ and 0.01 levels of significance, and means were compared using Duncan's multiple range test at the $P \leq 0.05$ level.

Results and Discussion

The significant sources of variation for measured parameters in spring- and summer-grown *Brassica* cultivars in 1997 are shown in Table 1. Effects due to the seasons were significant for most traits. In addition, significant season x cultivars interactions occurred for plant height and forage yield parameters, except for crude protein content (Table 1). In the 1997 April seeding, there were significant ($P \leq 0.01$) differences between the cultivars in terms of plant height and other variables, with the exception of crude protein content (Table 2). The rape cultivar Emerald was the most productive cultivar, with a fresh yield of 22,820 kg/ha.

In the 1997 July seeding, the plant height, forage yield and crude protein content of the cultivars were much higher than the April seeding (Table 2). Cultivar differences among the plant height and other variables were statistically significant ($P \leq 0.01$), with the exception of crude protein content. Again, the rape cultivar Emerald was the most productive cultivar in this seeding date. The plant height of Emerald was 73 cm, and this cultivar produced excellent yields with a fresh yield of 86,093 kg/ha under irrigated conditions when planted as a second crop. The yield of the kale cultivar Premier was also high, with a fresh yield of 41,347 kg/ha.

In 1998, similar to 1997, significant sources of variation for measured parameters in spring- and summer-grown *Brassica* cultivars were observed, with the exception of crude protein content (Table 1). Significant seasonal effects occurred for most measurements.

Table 1. Significant sources of variation for measured parameters of various spring and summer-grown *Brassica* cultivars during 1997 and 1998.

Source	Plant height (cm)	Fresh yield (kg/ha)	Dry matter yield (kg/ha)	Crude protein content (%)	Crude protein yield (kg/ha)
			1997		
Season	**	**	**	**	**
Cultivars	**	**	**	NS	**
Season x cultivars	**	**	**	NS	**
			1998		
Season	**	*	*	NS	NS
Cultivars	**	**	**	NS	**
Season x cultivars	**	**	**	NS	**

* , ** Significant at $P \leq 0.05$ and $P \leq 0.01$ levels, respectively. NS: Not Significant.

Table 2. Plant height, forage yields and quality characteristics of spring- and summer-grown *Brassica* cultivars in 1997.

Cultivars	Plant height (cm)	Fresh yield (kg/ha)	Dry matter yield (kg/ha)	Crude protein content (%)	Crude protein yield (kg/ha)
			Spring		
Kale-Vates	20 d*	7300 cd	2197 bc	10	211 bc
Kale-Siberian	30 bcd	12933 b	2773 b	11	313 b
Kale-Premier	23 cd	11350 bc	2916 b	12	339 b
Rape-Emerald	44 a	22820 a	5527 a	10	524 a
Collard-Vates	36 ab	10660 bcd	2370 b	10	230 bc
Collard-Champion	32 bc	6297 d	1304 c	9	122 c
Collard-Georgia Southern	35 ab	7863 cd	1996 bc	9	185 bc
Mean	31 B	11318 B	2726 B	10 B	275 B
C.V. (%)	17.5	22.5	18.2	26.3	32.2
			Summer		
Kale-Vates	30 d	13310 d	2558 d	25	651 bc
Kale-Siberian	37 bcd	18027 cd	2815 d	26	732 bc
Kale-Premier	42 b	41347 b	6140 b	20	1237 b
Rape-Emerald	73 a	86093 a	11529 a	28	3178 a
Collard-Vates	33 cd	19713 cd	2969 cd	22	663 bc
Collard-Champion	29 d	10947 d	1774 d	28	504 c
Collard-Georgia Southern	39 bc	24607 c	4149 c	24	1011 bc
Mean	40 A	30578 A	4562 A	25 A	1139 A
C.V. (%)	12.0	15.0	14.6	17.5	26.9
Mean (%)	36	20948	3644	18	707
C.V. (%)	14.5	17.7	16.1	20.6	31.8

* Means of each *Brassica* cultivar in a column followed by the same lower case letters and means of main seeding seasonal effects, followed by the same upper case letters, are not significantly different according to Duncan's Multiple Range Test.

In addition, cultivars x season interaction was significant in terms of plant height and forage yield parameters, with the exception of crude protein content (Table 1).

In the 1998 April seeding, significant ($P \leq 0.01$) differences among the cultivars were observed in all traits (Table 3). The fresh yield of the collard cultivar Georgia Southern was the highest (28,353 kg/ha). The plant height of this cultivar was also the highest. In the 1998 July seeding, significant ($P \leq 0.01$) differences among the cultivars were observed, with the exception of crude protein yield (Table 3). The fresh yields of the rape cultivar Emerald and kale cultivar Premier were higher than other cultivars, with fresh yields of 42,970 and 33,840 kg/ha, respectively. The plant height of Emerald rape was the highest (44 cm). In both years, forage yields obtained from summer seedings were higher than those from spring seedings.

Forage-based livestock systems are often limited by seasonal growth or deficient supplies of forage yield (Guillard and Allinson, 1988). Seasonal effects can have marked influences on crop production. Yields obtained over the summer were consistently higher than those obtained in spring conditions. Some *Brassica* species need longer growth periods to reach full production, and the decreasing temperatures and light intensities in autumn seemed to affect dry matter production (Guillard and Allinson, 1988). In addition, depending on the farm,

Table 3. Plant height, forage yields and quality characteristics of spring- and summer-grown *Brassica* cultivars in 1998.

Cultivars	Plant height (cm)	Fresh yield (kg/ha)	Dry matter yield (kg/ha)	Crude protein content (%)	Crude protein yield (kg/ha)
			Spring		
Kale-Vates	32 b*	19857 b	4423 b	16	688 b
Kale-Siberian	12 d	1790 c	497 d	18	93 d
Kale-Premier	22 c	6437 c	1533 d	22	342 c
Rape-Emerald	32 b	4220 c	1000 d	21	212 cd
Collard-Vates	40 b	16953 b	3693 bc	25	918 b
Collard-Champion	36 b	13947 b	3081 c	22	681 b
Collard-Georgia Southern	57 a	28353 a	7439 a	20	1490 a
Mean	33 A	13080 B	3095 B	21	632
C.V. (%)	15.7	28.2	19.5	18.0	21.0
			Summer		
Kale-Vates	12 c	7283 c	1688 b	20	352 b
Kale-Siberian	27 b	31667 b	5552 a	20	1105 a
Kale-Premier	20 b	33840 ab	6453 a	20	1326 a
Rape-Emerald	44 a	42970 a	7060 a	22	1549 a
Collard-Vates	22 b	10217 c	2100 b	18	374 b
Collard-Champion	21 b	14347 c	2685 b	21	560 b
Collard-Georgia Southern	27 b	16667 c	3327 b	18	588 b
Mean	25 B	22427 A	4124 A	20	836
C.V. (%)	16.5	25.6	27.0	13.8	29.5
Mean (%)	29	17753	3609	21	734
C.V. (%)	16.2	27.2	24.8	16.1	27.0

* Means of each *Brassica* cultivar in a column followed by the same lower case letters and means of main seeding seasonal effects, followed by the same upper case letters, are not significantly different according to Duncan's Multiple Range Test.

Brassica species can be planted as a second crop, following small grains, used as a break crop following the plowing down of alfalfa, and no-till seeded into permanent pastures or meadows. After small grains have been harvested as hay, grain or silage in many irrigated areas it is possible to produce a second crop. *Brassica* species establish quickly and produce high-quality autumn and winter forage (Koch and Karakaya, 1998), as happened in our study. However, in our study the forage yields of summer-grown *Brassica* cultivars were higher.

Kale has the greatest tolerance to cold of the *Brassicas*, and can survive temperatures as low as -13 ºC. Varieties vary greatly in terms of the rate of establishment, stem development, days to maturity and winter hardiness. Varieties with stems can grow to 152 cm in height with 5 - cm stems and require 150-180 days to attain maximum production (Thompson and Duncan, 1997). Gowers and Armstrong (1994) examined the yield potential of six kale cultivars in New Zealand. They found that the average dry matter yield was between 1220 and 9400 kg/ha. Kale also has potential as a high protein, high digestibility alternative forage source. Karakaya et al. (1995) found that the average dry matter yield was 3630 kg/ha for the kale cultivar Premier when they seeded it on 13 June. In our trials, kale varieties performed well in terms of plant height and forage yield parameters in both growing season and the two years concerned. Premier had the highest dry matter yield, among the kales, 2916 kg/ha in spring and 6140 kg/ha in summer 1997 and 6453 kg/ha in summer 1998. The crude protein contents of all kale cultivars were high (average 20%), except spring-grown kales in 1997.

Forage rape, which should not be confused with oil seed rape, is a short-season leafy brassica whose stem and leaves are ready for grazing 60 days after establishment. Rape produces high amounts of green parts in a short time, and its palatability and digestibility are high. For these reasons, forage rape is grown in many countries, especially in Northern Europe. The protein content of leaves can reach 20-25%. For green forage it is planted in early spring or autumn (Açıkgöz, 2001). According to Jung et al. (1984), with adequate nitrogen and phosphorus fertilizer rape produced amounts of digestible energy equivalent to approximately 7200 kg/ha of corn. Guillard and Allinson (1988) found that summer-seeded rape cultivar had the highest dry foliage yield (5080 kg/ha) among the *Brassica* species. However, the yield was lower when it was seeded in autumn (3640 kg/ha). Rape also had the highest dry matter concentrations associated with foliage tissues, followed by kale and swede. Wiedenhoeft and Barton (1994) seeded the rape cultivar Emerald. Seeding dates were 31 May, 28 June and 29 July in 1988 and 1 June, 29 June and 1 August in 1989. They found that the contribution of leaf dry weight to the total initial herbage dry weight increased with delayed seeding dates. The cooler temperatures occurring in late summer should result in less stem lignification. These studies were in agreement with our study, that resulted in higher forage yields with summer-seeded rape. Emerald showed great forage potential under irrigated conditions in terms of summer seeding. The fresh and dry matter yields of Emerald summer seedings were 86,093 kg/ha and 11,529 kg/ha in 1997 and 42,970 kg/ha and 7060 kg/ha in 1998, respectively. In addition, in summer seedings, the crude protein content and crude protein yield of Emerald rape were as high as 28% and 3178 kg/ha in 1997 and 22% and 1549 kg/da in 1998. It appears that the rape cultivar Emerald can be grown as a second crop and can provide a fresh alternative forage under irrigated conditions.

Most of the *Brassica* species includes vegetables that are commonly grown, one of which is known as collard. According to Spence (1988), Champion and Vates are collard varieties recommended for growing in Maryland. Generally, collard varieties are grown as vegetables, although in some cases they are also used as fodder. Koch (1990) seeded collard cultivars as forage on 2 August and measured the dry matter yields of the cultivars Vates, Champion and Georgia Southern as 3780 kg/ha, 4640 kg/ha and 5350 kg/ha, respectively. In our trials, the dry matter yield of summer-grown collards was lower than the study above. Their forage yields were generally low in comparison to kale and rape cultivars, except for spring-grown collards in 1998. Collard crude protein levels were between 18 and 24%, except for spring-grown plants in 1997, as with other *Brassica* species. In 1997, various environmental factors may have been responsible for these lower protein results.

Conclusion

Brassica crops have the potential to provide additional or supplemental forage with high fresh yields. The nutritional characteristics of these crops would place them into a category of high-moisture and concentrate

feeds. Generally, the forage yields of summer-grown cultivars were higher than the forage yields of spring-grown cultivars. Most seasonal differences occurred in the rape cultivar Emerald, and its forage yields were superior. According to our results, the rape cultivar Emerald could be seeded in July as a second crop after the main crop is harvested and could be a good source of alternative forage. In addition, the yield of the kale cultivar Premier was high. This cultivar could also be grown as an alternative forage crop.

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