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THE EFFECTS OF DIFFERENT ROW SPACING ON HERBAGE AND SEED YIELDS OF ANNUAL RYEGRASS (*LOLIUM MULTIFLORUM* CV. CARAMBA)

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Abstract

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This study has been carried out at the experimental area of the Field Crops Department of Cukurova University, Agricultural Faculty in 2003-2004, to determine the effects of different row spacing (sprinkle planting, 15, 20, 25, 30, 35, 40 and 45 cm row spacing) on the herbage and seed yields of and some agricultural characteristics of annual ryegrass cv. Caramba.

According the results, average of two years the different row spacing significantly affected both herbage and hay yields, crude protein rate and yield, seed yield, tiller number and its proportion, spike length and spike weight.

As a result, 20 cm row spacing 16.90% crude proteins, 30 cm row spacing 80754 kg ha^{-1} herbage and 14932 kg ha^{-1} hay and 235 kg ha^{-1} crude protein yields have been obtained. The highest tiller number has been obtained from sprinkle planting (877 item/m^2) and 15 cm row spacing (874 item/m^2), fertile tiller number (470 item/m^2) from 15 cm row spacing, percentage of fertile tiller (% 63.9) from 40 cm row spacing, seed yield from 35 cm (360 kg ha^{-1}) and 30 cm (341 kg ha^{-1}) row spacing.

It has been concluded that, for the highest herbage and seed yield, row spacing of 30 cm has been the best one.

Key words: Poaceae forages, herbage yield, protein yield, seed yield, and crude protein

Introduction

The issue of balanced and sufficient nourishment of humanity has been an important and challenging problem of many countries across the world including Turkey along with especially the underdeveloped countries. It has become a necessity to sustain the balanced nutrition of an ever-increasing world population with an effective utilization of limited natural resources provided that principle of sustainability and environmental pollution should be taken into consideration. The livestock breeding in Turkey is largely based on pasture. Total range or pasture areas of Turkey have been drastically reduced due to Agricultural Mechanization, especially use of farm tractors.

Although the amount of protein consumed per capita in Turkey is 96 g and is higher than the world average of 77 g, 75% of this amount is vegetable based while only 25% of it is of animal origin

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(FAO, 2008). In Turkey, at present the livestock reserves are equivalent to 9.8 million heads of cattle and in order to ensure livelihood requirements of these animals, annually 45 million tons of high quality coarse feed would be necessary on the average. Despite this, the amount of quality coarse feed obtained from range and pastures of 14.6 million ha is about 10 million tons. The amount of quality coarse feed obtained from fodder crops, which consist of the only 7.6% of total cultivated lands field crops cultivation, is about 21 million tons (Turkish Statistical Institute, 2009). This corresponds to about 14-15 million tons gap of a quality coarse feed. Setting the world's vegetation limits and having a rich range of species grasses supply the livestock with abundant green herbage, dry herbage, silage feed and grain feed which are rich in carbohydrates. They are grown mixture with legume grain crops, ensuring the production of a more balanced coarse feed in carbohydrate and protein content. They also play role in soil fertility. Creating a dense layer of grass, they prevent erosions and also increase the soil's water retention capacity.

Annual ryegrass is used as an important fodder crop in a very wide area including North America, Ireland, England, Europe, Mexico, Australia, New Zealand and South Africa (Hannaway et al., 1999). It can easily be used both as a good cover crop and as a preceding crop in rotation in our region as well as in other regions (Saglamtimur et al., 1998). It is also widely used for over-seeding purposes to meet the need for herbage in pasture lands during winter months. It is being grown on a land of about 3 million ha in USA, about 90% of which is used in the form of over-seeding to prolong the grazing or usage period of summer pastures, during the winter season in places where the warm season fodder crops grow more in the pasture lands located southeast of the country.

Cukurova Region Located south of Turkey and being one of the leading agricultural regions of Turkey has a great potential for fodder crop growing, because it has a production pattern consisting of rich and diverse products. It is possible to meet quality coarse feed requirements of livestock by mixed-cropping annual and perennial legumes with cereals for silage feed, green herbage, dry herbage and grain feed purposes. While the winter ecologic conditions in the region allow for growing many crops, the majority of the areas are allocated for summer crops, leaving land for fallow of 4-5 months (Saglamtimur, 1981). Winter annual legume, cereal grain and fodder crops of other families can be grown in these agricultural areas.

One of the most important of these fodder crops is annual ryegrass (*Lolium multiflorum* Lam.). Annual ryegrass is a cool season fodder crop and is suitable for quality herbage production. It is sensitive to cold, being damageable by cold climate between –6°C and –8°C, and the crops die in long-lasting cold weather. It is not resistant to drought. It likes rainy climate. When sown at the start of the flowering period, it is a rapidly drying species, with high digestion rate and desirably eaten by livestock (Saglamtimur et al., 1998; Acikgoz 2001). It realizes its best development at a temperature range of 20-25°C during early spring and autumn. It also has better resistance characteristics to high temperature than perennial ryegrass even when the amount of usable water is insufficient (Hannaway et al., 1999). There is a great need for nitrogen, phosphorus and potassium when high quality annual ryegrass growing is the target (Rechcigl, 1992). Under favorable conditions, more than 20 000 kg ha^{-1} dry herbage yield may be obtained (Basbug, 1990). It can be quickly established, showing a fast development after sowing and grazing. This is a suitable species for diminishing pasture lands although it has a high yield potential for livestock. Though annual ryegrass can be grown in all sorts of soil, it develops best in well-drained, sufficiently moist soils. In soil temperatures under 27°C, it can resist long-lasting flooding like 15-20 days. It can grow in areas with a soil pH range between 5.0 and 7.8.

Growing annual ryegrass in the winter season

in temperate climates has many advantages. First of all, it can either address the feed requirement of livestock breeding developing in the region and be used as a measure against the problem of erosion increasing after winter rains in slope areas. On the other hand, its physical and chemical properties are improved by increasing the soil's organic matter content. Apart from all these, the field will not remain uncultivated and will be utilized for multi-purposes in periods with favorable climatic conditions. Even though fodder crops are grown for their herbage, they need seed productions for replanting and wide spreading them. It is also hard to make a plant hardly producing seeds widespread no matter how good is the herbage yield and quality. Plants grown for seed production remain longer on the field (Serin, 1999). Seed harvesting should be made in the yellow maturing period and a seed yield of 700-1000 kg ha^{-1} is obtained under normal growing conditions. 1000 grains weigh about 2 g (Genckan, 1983; Erac and Ekiz, 1985; Saglamtimur et al., 1998).

This study is conducted to determine particularly with the purpose of ensuring that livestock producers and businesses can supply their animals with abundant and delicious feed throughout the winter season both before main crop and second crop farming the herbage yield and seed yield and certain agricultural characters in the event of growing of Caramba, a species of annual ryegrass, in different row spacing in Cukurova Region which permits two crops a year from the farming field.

Materials and Methods

In this study, *Lolium multiflorum* cv. *caramba*, a cultivar of annual ryegrass, is used as the material (Anonymous, 2010 a,b). Cukurova Region, including the city of Adana, has the characteristics of Mediterranean climate. The summer season is warm and dry, and winters are temperate and rainy. In the Cukurova Region, 23rd of November is the first and 28th of February is the last frost date. Average rainfall is 625 mm. An average of 74 days of the year is rainy. Rainfall is 51% during the winter, 26% spring, 18% autumn and 5% summer season. Although the average relative humidity is 66%, it rises over 90% during the summer season. Average temperature of the last 37 years is 18.7ºC. January is the coldest month, and August is the hottest month. Average temperature in January is 9ºC, and average temperature in August is 28 ºC (Anonymous, 2007a).

During the 2003-2004 years when the field trials were conducted, average temperature values were parallel to average values for long years, with no observation of any value that would negatively affect the plant development. It was found that the rainfall was irregular in consideration of both the averages of the trial years and of long years (Anonymous, 2007b). When needed, crops were irrigated. Soils where the study was conducted are entisols brought by Seyhan River, formed of very young alluvial deposits. They are in almost flat and near-flat topographies. There are only A-horizons well-decomposed by external influences and rich in organic matters and humus and C-horizons formed of large pieces and located over the main rock. The trial area soil was generally loam.

The field trial was arranged in complete randomized block design with three replications. In both years, planting was made based on the calculation of 45 kg ha^{-1} seeds during the first week of October. In this study, 8 different row spacing (sprinkle planting, 15, 20, 25, 30, 35, 40, and 45 cm) were used. The plots received 80 kg N (nitrogen) and P_2O_5 (phosphorus) as base application. In addition, in order that plants can sufficiently grow in terms of above and below ground parts, pure 50 kg ha^{-1} N as top fertilizer was applied at after 30 days after the emergence, and after every cuttings. Harvesting in both years were made a total of 4 for each on different dates, at 5 cm of and at the start of flowering and harvestings were cancelled at the first week of May. There were no developments in the plants after this date. The initial 3 harvesting were made in plots allocated to obtain seeds, harvesting was finished in April,

then no harvesting was done in half of the plots, and both to be able to obtain seeds with high germination power and to allow for growing a second crop, seed harvesting was done in the second week of June when the ears of grain were in the yellow maturing period. Data was analyzed according to the randomized complete block design using the MSTAT-C statistical software. Where the difference between the treatments were significant, this difference was compared by Duncan multiple comparison method (MSTAT-C, 1991).

Results and Discussion

Herbage Yield Properties

Plant Height, Green Herbage and Dry Herbage Yield

Average plant height values are not statistically affected by different row spacing; however there was a reduction trend in plantings made in wider rows except for 25 cm row spacing (Table 1). It can be said that increase in the number of plants in unit area give rise to competition among the plants for the reduced water, light and nutritional elements. Ehlig and Hagenake (1982) reported that the plant height is 36-61 cm and the dry matter yield is 3500 kg ha^{-1} and Turemen (1988) reported that the plant height is 89.8 cm in average; the green herbage yield is 30670 kg ha^{-1} and the dry herbage yield is 7830 kg ha^{-1} in annual ryegrass. Saglamtimur et al. (1986) has found out that annual ryegrass (*Lolium multiflorum* Lam.) could successfully be grown in Cukurova Region during winter period and that the green herbage yield is 12250-17500 kg ha^{-1} and the seed yield is 301-480 kg ha^{-1}.

Ozel (1989) has found out that the plant height changed between 110.1 and 176.2 cm, the green herbage yield between 33791 and 89431 kg ha^{-1} and the hay yield 9221 and 18791 kg ha^{-1} in the conserved forage and Celen (1991) obtained 16460–39800 kg ha^{-1} of green herbage yield. Saglamtimur et al. (1993) obtained the highest green herbage yield as 61050 kg ha^{-1} and dry herbage yield was 13031 kg ha^{-1} and Sancak and Manga (1994) determined that the green herbage yield is 5861-11791 kg ha^{-1} and the dry herbage

Table 1

Plant height, green herbage and dry herbage yield average values and groups

Row spacing	Plant height, cm			Green herbage yield, kg ha^{-1}			Dry herbage yield, kg ha^{-1}		
	2003	2004	Average	2003	2004	Average	2003	2004	Average
Sprinkle	71.3	65.4	68.4	81917 bc	58487	70202 bc	15327 ac	1149.45	13411 ad
15 cm	71.1	63.6	67.4	78217 bc	60247	69232 cd	14066 bc	1202.85	13047 bd
20 cm	70.7	66.4	68.6	86940 ac	58740	72840 ac	15448 ac	1164.13	13545 ac
25 cm	70.4	66.1	68.2	95063 ab	62500	78782 ab	16854 ab	1213.41	14494 ab
30 cm	70.9	61.6	66.3	102144 a	59363	80754 a	18040 a	1182.41	14932 a
35 cm	72.1	61.9	67.0	82111 bc	54178	68144 cd	15320 ac	1124.88	13284 bd
40 cm	69.7	62.2	65.9	72319 c	54703	63511 cd	12912 c	1144.82	12180 cd
45 cm	71.1	60.3	65.7	71080 c	49210	60145 d	12596 c	1114.64	11871 d
Average	70.9	63.4	67.2	83724	57178	70451	15070	1162.07	13346
* LSD 5%	N.S.	N.S.	N.S.	16610*	N.S.	9450**	3002*	N.S.	1573**
C.V.	3.49	5.15	4.31	11.49	10.75	11.46	11.44	6.46	9.96

*, ** Significance at p≤ 0.05 and p≤ 0.01, respectively; NS, non-significant.

*** Means in a column followed by the same letter are not significantly different according to the LSD test.

yield is 1521-5730 kg ha^{-1}.

Orak and Uygun (1996) reported that plant height, the green herbage yield ranged from 89.7 to 103.7 cm and 9000 to 22330 kg ha^{-1}, respectively. The highest green herbage yield value is obtained from sowing rate of 30 kg ha^{-1} and at 30 cm row spacing. Ozdil (1996) found that the plant height is ranged from 104.0 to146.7 cm, the green herbage yield changed between 23051 and 59491 kg ha^{-1}, the dry herbage yield between 5031 and 19311 kg ha^{-1} and Serin et al. (1996) found that the highest dry herbage yield was 8220 kg ha^{-1}.

Kusvuran and Tansi (2005), working with herbage production, the found that the plant height, the green herbage yield, the dry herbage yield, the green leaf ratio and the dry leaf ratio ranged from 60.4 to 86.0 cm, from 27691 to 32441 kg ha^{-1}, from 6420 to 7301 kg ha^{-1}, is from 46.0 to 58.9%, from 43.1 to 50.0%, respectively. Parlak (2005) found that the plant height, the green herbage yield and the dry herbage yield were 95.6 cm, 45833 kg ha^{-1} and 12432.3 kg ha^{-1}, respectively. Kesiktas (2010) determined that the plant height, the green herbage yield and the dry herbage yield ranged from 60.3 to 71.6 cm, from 13346 to 18145 kg ha^{-1}, from 3987 to 5502 kg ha^{-1}, respectively.

Plant height values obtained from the study are similar to the values found by Kusvuran and Tansi (2005) and Kesiktas (2010). While the values found by Ehlig and Haganeke (1982) are lower than the study findings, the other values were higher than ones (Genckan, 1983; Turemen, 1988; Ozel, 1989; Orak and Uygun, 1996; Ozdil, 1996 and Parlak, 2005).

Average green herbage yield values vaguely increased up to 20 cm row spacing. Then, there has been a considerable yield increase, the yield value, rising to the highest value at 30 cm row spacing, with the increase of row spacing (Table 1). Herbage yield values obtained from the study were higher than to the most values Saglamtimur et al. (1986), Turemen (1988), Celen (1991), Sancak and Manga (1994), Ozdil (1996), Orak and Uygun (1996), Saglamtimur et al. (1998), Kusvuran and Tansi (2005), Parlak (2005), Parlak et al. (2007), Kesiktas (2010). Also, current values were similar to ones determined by Ozel (1989) and Saglamtimur et al. (1993). Different green herbage yield values compared to literature findings were attributed to various factors like variety, soil structure, climate conditions, planting time, growing techniques etc... Green herbage yield obtained from the study is at a satisfactory level for annual ryegrass.

The patterns of dry herbage yield values as influenced by row spacing from the study were parallel to one of green herbage yield values. However, the reduction seen after the 30 cm row spacing, to which the highest yield was reached, is not as noticeable as in the green herbage yield (Table 1). Dry yield values obtained from the study were higher than to the values found by Turemen (1988), Celen (1991), Sancak and Manga (1994), Serin et al. (1996), Saglamtimur et al. (1998), Kusvuran and Tansi (2005), Parlak (2005), Kesiktas (2010). Meanwhile, values were similar to with by Ozel (1989), Saglamtimur et al. (1993) and Ozdil (1996).

Dry herbage yields are based on the principle of drying the mowed green herbage first in the open environment and under shadow and then at 78 ºC for 24 hours in a drying cabinet, as a result of which the water in their bodies is removed. As can be seen below, no statistical difference was seen in green herbage at different row spacing with regards leaf ratio. It is an expected result that the values are accordingly similar to the green herbage yield findings.

Leaf Ratio in Green Herbage, Crude Protein Ratio and Crude Protein Yield

No statistical differences were observed among leaf ratio values nearly close values were obtained in different row spacing. The values reduced at 15 cm and 25 cm row spacing, and then slightly increased (Table 2). Ozel (1989) has found out that the leaf ratio ranged from 20 to 32.4% and the stem ratio from 67.6 to 80.1% and Ozdil (1996) found

Table 2

Leaf ratio in green herbage, crude protein ratio and crude protein yield average values and groups

Row spacing	Leaf ratio in green herbage, %			Crude protein ratio, %			Crude protein yield, kg ha^{-1}		
	2003	2004	Average	2003	2004	Average	2003	2004	Average
Sprinkle	65.6	71.9	68.8	14.4	16.1	15.3 bc	2216 bc	1864	2040 bc
15 cm	66.9	70.6	68.7	15.9	16.3	16.1 ab	2233 bc	2030	2131 ac
20 cm	65.1	69.7	67.4	16.3	17.5	16.9 a	2513 ab	2133	2323 ab
25 cm	65.8	68.9	67.3	14.8	15.5	15.1 bc	2490 ab	2261	2376 a
30 cm	66.3	70.3	68.3	15.4	15.7	15.5 bc	2791 a	1926	2358 a
35 cm	64.7	71.9	68.3	14.0	15.7	14.9 c	2149 bc	1901	2025 bc
40 cm	66.0	70.2	68.1	15.5	15.7	15.6 bc	2004 bc	1954	1979 c
45 cm	63.5	70.2	66.9	15.3	15.6	15.4 bc	1924 c	1862	1893 c
Average	65.5	70.5	68.0	15.2	16.0	15.6	2290	1950	2120
* LSD 5%	N.S.	N.S.	N.S.	N.S.	N.S.	1.2*	518*	N.S.	300*
C.V.	2.64	3.08	2.89	5.99	6.49	6.26	12.91	7.34	11.10

*, ** Significance at p≤ 0.05 and p≤ 0.01, respectively; NS, non-significant.

*** Means in a column followed by the same letter are not significantly different according to the LSD test.

that the green leaf ratio, the green stem ratio, the dry leaf ratio, the dry stem ratio ranged from 20.1t to 31.8%, from 68.3 to 79.9%, from 27.9 to 32.9%, from 67.1 to 72.7%, respectively.

While leaf ratio in green herbage values were considerably higher than ones found by Ozel (1989) and Ozdil (1996), they were similar to ones found by Kusvuran and Tansi (2005). Although the leaf ratio in grasses is affected by many factors, it is mostly related to the harvest time. Leaf ratio in grasses reduces with the delaying of harvest time, but, stem ratio increases as a result of stem diameter increases. In this study, the fact that high leaf ratio was obtained at the flowering in annual ryegrass may be considered as an indication of a quality herbage.

Average crude protein ratios markedly increased up to 20 cm row spacing, and then no clear differences were observed in the wider row spacing (Table 2). Sancak and Manga (1994) determined that the crude protein ratio is 4.7-8.5% and Szyszkowska and Sowinski (2001) found that the crude protein ratio was 7.54-23.38%. Parlak (2005) found that the nitrogen ratio in dry herbage 1.27% and the nitrogen yield in dry herbage was 159.2 kg ha^{-1} and Serin et al. (1996) found that the crude protein was yield is 1411 kg ha^{-1} and the crude protein ratio was 17.8%. Parlak et al. (2007), working with Caramba cv. Annual ryegrass, for a high herbage yield in the conserved forage determined that the green herbage yield between 6263.4 and 11627.2 kg ha^{-1} and the crude protein yield changed between 237.8 and 798.9 kg ha^{-1} for a high herbage yield in the conserved forage.

Kunelius and Boswall (2009) explain that a total amount of 235-295 kg ha^{-1} of nitrogen should be given as split applications such as; 35-50 kg ha^{-1} at seeding, 35-50 kg ha^{-1} at tillering period, 65-80 kg ha^{-1} after first harvest and 50-65 kg ha^{-1} after subsequent harvests. Also, in herbage production, the crude protein ratio was 15.8% in vegetative period and was 5.8% in maturity period while, it was 15.2% in early vegetative period, was12.9% in early flowering period and was 6.6% in full flowering period, for dry herbage (Anonymous 2010). Kesiktas (2010) determined that the tiller number per plant, the crude protein ratio and the crude protein yield ranged from 11.0 to 13.1

numbers, is from 9.5 to 13.6% from 576 to 1070 kg ha^{-1}, respectively.

Crude protein values obtained from the study were higher than the values found by Sancak and Manga (1994), Parlak (2005), Kesiktas (2010). The values were similar to ones by Serin et al. (1996), Szyszkowska and Sowinski (2001), Anonymous (2010). As it is known, forage grasses are rich in carbohydrate, and forage legumes are rich in protein. While the protein ratio rises to the level of 30-35% in legumes, this ratio is at lower levels (10-15%) in grasses. the protein ratio obtained from the annual ryegrass in the current study is higher than the 12% as threshold value approved for livestock-raising. Depending on harvest frequency, it is possible that the leaf ratio increasing as a result of shortening of the period between the harvests contributes to this.

The crude protein yield is greatly affected by green and dry herbage yield values. The crude protein yield values markedly increased up to 30 cm row spacing as influenced by dry herbage yield, thereafter, decreased (Table 2). Celen (1991) obtained 470-1060 kg ha^{-1} of crude protein yield in the conserved forage and Parlak et al. (2007), working with Caramba cv. Annual ryegrass, for a high herbage yield in the conserved forage determined that the green herbage yield between 6263.4 and 11627.2 kg ha^{-1} and the crude protein yield changed between 237.8 and 798.9 kg ha^{-1} for a high herbage yield in the conserved forage. Crude protein yield values obtained from the study are higher than ones found by Celen (1991), Serin et al. (1996), Parlak et al. (2007), Kesiktas (2010).

Seed Yield Properties

Plant Height, Number of Tiller and Fertile tiller

Different row spacing studied has not affected the average plant height as in herbage trial of the study. Values were rather close to one another in all rows spacing (Table 3). Ozel (1989) has found out for the seed production, he has found out that the plant height is 123.5-231.0 cm, the spikelet number is 448-697 item/m^2, the spike length is 35.2-39.7 cm, the spikelet number per spike is 30.2-35.0 item/spike and the seed yield is 980-1640 kg ha^{-1}. Kusvuran and Tansi (2005),

Table 3

Plant height, tiller count and fertile tiller count average values and groups

Row spacing	Plant height, cm			Number of tiller, item/m^2			Fertile tiller, item/m^2		
	2003	2004	Average	2003	2004	Average	2003	2004	Average
Sprinkle	91.4	107.7	99.5	936 a	819 ab	877 a	413 a	469 cd	441 ab
15 cm	96.1	106.1	101.1	907 a	841 a	874 a	400 a	540 ab	470 a
20 cm	98.1	103.7	100.9	680 b	782 ab	731 b	387 a	493 bc	440 ab
25 cm	96.5	109.7	103.1	661 b	769 ab	715 b	247 b	556 a	401 cd
30 cm	96.5	105.4	100.9	492 c	761 b	627 c	260 b	535 ab	397 cd
35 cm	97.0	104.7	100.8	506 c	771 ab	639 c	242 b	579 a	411 bc
40 cm	96.3	109.9	103.1	472 c	644 c	558 d	208 c	532 ab	370 d
45 cm	93.8	106.7	100.3	339 d	598 c	469 e	182 c	416 d	299 e
Average	95.7	106.7	101.2	624	748	686	292	515	404
* LSD5%	N.S.	N.S.	N.S.	93**	74**	57**	33**	57**	32**
C.V.	4.92	4.63	4.77	8.49	5.65	6.98	6.49	6.33	6.61

*, ** Significance at p≤ 0.05 and p≤ 0.01, respectively; NS, non-significant.

*** Means in a column followed by the same letter are not significantly different according to the LSD test.

working with seed production they found that the plant height, the tiller number, the fertile tiller number, the spike length, the spikelet number per spike, 1000-seed weight, the total yield and the seed yield ranged from 56.6 to 59.9 cm, 366 to 473 item/m^2 from 85 to109 item/m^2, from 17.2 to 19.9 cm, from 18.4 to 20.0 item , from 2.72 to 2.92 g, from 3270 to 3500 kg ha^{-1} and from 200 to 360 kg ha^{-1} , respectively.

Plant heights before harvest for seed yield were found to be lower than ones by Ozel (1989) and Ozdil (1996) while they were higher than ones Kusvuran and Tansi (2005) and Parlak (2005). If the aim is to obtain seeds directly in annual ryegrass, then the plant is left for mature without harvesting and seed harvesting is done when the ears are in the yellow maturing period. So, the non-harvested plants show a good development and become higher. As in this study, if the aim is to obtain both forage and seeds, it is an expected result that plants left for seeding before the last harvesting do not become as high as those plants left directly for seed.

As far as the average tiller number were considered, they were markedly decreased with the increased row spacing, number of fertile tiller also decreased with the increased row spacing. A decrease was seen in row spacing in fertile tiller count obtained from unit area. However, this decrease is not very clear as in tiller number. Numbers of tiller and fertile ones obtained from the study were higher than the values found by Kusvuran and Tansi (2005).

Fertile Tiller Ratio, 1000 Grain Weight, Spike Length

Although row spacing showed a marked decrease in average tiller and fertile tiller numbers obtained from study, it was found that the ear emergence ratio of these tillers, that is their productivity, showed a relative increase with increased row spacing. It can be considered that plants find a less competitive environment in wider row spacing and therefore the fertile tiller ratios increased in wider row spacing. The effect of different row spacing on average 1000 grain weights was not statistically significant. However, a slight decrease was observed to 20 cm row spacing, then it was started

Table 4

Fertile tiler ratio, 1000 grain weight, and spike length average values and groups

Row spacing	Fertile tiller ratio, %			1000 grain weight, mg			Spike length, cm		
	2003	2004	Average	2003	2004	Average	2003	2004	Average
Sprinkle	44.2 cd	57.6 c	50.9 d	1.90 ac	2.40 bc	2.15	31.8	33.2 a	32.5 a
15 cm	44.2 cd	64.5 bc	54.3 cd	1.82 bc	2.38 bc	2.10	32.1	32.8 a	32.5 a
20 cm	57.2 a	63.1 bc	60.2 ac	1.99 ab	2.12 d	2.06	30.9	28.3 d	29.6 b
25 cm	37.4 d	72.3 ab	54.8 bd	1.97 ab	2.71 a	2.34	32.1	32.9 a	32.5 a
30 cm	52.8 ab	70.9 ab	61.9 ab	1.73 bc	2.56 ab	2.14	32.7	30.4 c	31.6 ab
35 cm	48.9 bc	75.1 ab	62.0 ab	1.85 bc	2.54 ab	2.19	28.2	32.4 ab	30.3 ab
40 cm	44.4 cd	83.3 a	63.9 a	1.62 c	2.67 a	2.15	30.2	31.3 bc	30.8 ab
45 cm	53.8 ab	69.3 bc	61.7 ab	2.15 a	2.28 cd	2.21	29.7	28.7 d	29.2 b
Average	47.9	69.5	58.7	1.88	2.46	2.17	31.0	31.2	31.1
*LSD 5%	7.6**	13.0*	7.2**	0.29*	0.22**	N.S.	N.S.	1.5**	2.4*
C.V.	9.12	10.66	10.36	8.36	5.08	6.04	8.86	2.74	6.54

*, ** Significance at $p \leq 0.05$ and $p \leq 0.01$, respectively; NS, non-significant.

*** Means in a column followed by the same letter are not significantly different according to the LSD test.

Table 5
Number of spikelet per spike, spike weight, seed yield average values and groups

Row spacing	Number of spikelet per spike, item			Spike weight, mg			Seed yield, kg ha^{-1}		
	2003	2004	Average	2003	2004	Average	2003	2004	Average
Sprinkle	29.3	26.9 a	28.1	0.253 a	0.375de	0.314 b	297.7 a	317.8 c	307.7 bc
15 cm	29.4	26.6 a	28.0	0.242 ab	0.381cd	0.311 b	266.3 ac	349.9 c	308.1 bc
20 cm	30.2	23.0 c	26.6	0.269 a	0.321 e	0.295 b	255.0 bc	313.8 cd	284.4 c
25 cm	31.5	26.6 a	29.0	0.253 a	0.517 a	0.385 a	233.7 cd	440.2 b	336.9 ab
30 cm	27.5	25.1 ab	26.3	0.262 a	0.372de	0.317 b	281.1 ab	412.2 b	346.7 a
35 cm	29.0	26.8 a	27.9	0.190 b	0.436bc	0.313 b	198.4 de	521.6 a	360.0 a
40 cm	28.5	26.5 ab	27.5	0.234 ab	0.483ab	0.359 a	198.9 de	421.4 b	310.2 bc
45 cm	31.9	24.6 bc	28.3	0.241 ab	0.342de	0.292 b	159.8 e	256.4 d	208.1 d
Average	29.7	25.8	27.7	0.243	0.403	0.323	236.4	379.2	307.8
* LSD5%	N.S.	2.0**	N.S.	0.055**	0.055**	0.037**	39.7**	60.9**	34.7**
C.V.	9.70	4.39	7.89	6.81	8.87	8.83	9.59	8.27	6.75

*, ** Significance at $p \leq 0.05$ and $p \leq 0.01$, respectively; NS, non-significant.
*** Means in a column followed by the same letter are not significantly different according to the LSD test.

to increase and then to decrease again, showing a stable pattern (Table 4). While the study findings were similar to values found by Genckan (1983), they were lower than ones found by Kusvuran and Tansi (2005). Average spike lengths decreased up to 20 cm row spacing, and then markedly increased at 25 cm row spacing. However, it increased again at 40 cm row spacing, and then decreased (Table 4). While the study findings were lower than values found by Ozel (1989), they were higher than the values found by Kusvuran and Tansi (2005).

Spikelet Count per Spike, Spike Weight, Seed Yield

As far as the two-year average values were considered, different row spacing has not significantly influenced. However, average values showed an uneven graph (Table 5). The number of spikelet were similar to the spike lengths, while the study findings were lower than ones found by Ozel (1989) they were higher than ones by Kusvuran and Tansi (2005). Average spike weight fluctuated in the different row spacing. It showed a stable pattern up to 20 cm row spacing; then, it undulated, showing an increase again at 40 cm row spacing, but then to decrease (Table 5).

Average seed yield values showed a more different pattern when compared to other properties. It was nearly constant up to 20 cm row spacing, and then decreased. After that, seed yield clearly increased up to 35 cm row spacing, and then decreased (Table 5). Celen (1991) obtained from 340-630 kg ha^{-1} of seed yield in seed production and Ozdil (1996) found that the seed yield between 181 and 931 kg ha^{-1} in annual ryegrass.

The seed yield from the current study were lower than the values found by Genckan (1983), Erac and Ekiz (1985), Saglamtimur et al. (1986), Ozel (1989), Celen (1991) and Saglamtimur et al. (1998) while they were similar to the values found by Ozdil (1996) and Kusvuran and Tansi (2005). Despite the average spike weight and number of fertile tiller increased at about 40 cm, the fact that yield values were low showed that this character was also affected by number of tiller. So number of tiller decreased in sparse plantings.

In crop for merely seed production, plants have the change to develop along the year. Because they are not exposing to any harvest, they develop both above and underground parts. They continue to develop even after spike emergence and mature. In this study, because the aim is to obtain both forage and seed, plants are harvested several times during the year. After each harvesting, they use water, light, nutritional elements and reserve carbon hydrates in order to redevelop. This continues until the last harvesting, and then matures their seeds. If so, there is a short time until maturity. Therefore, the seed yields obtained from the study remained low compared to growing made merely for seed production purposes. Here, the purpose is not only growing seeds, but the primary goal is to supply the livestock with feed during winter seasons, followed by the second goal of producing seeds.

Conclusion

In this study the annual ryegrass (*Lolium multiflorum* Lam.) cultivar, Caramba, which is a potential fodder species was studied to determine the herbage yield and seed yield and certain agricultural characters in different row spacing, for livestock business in Cukurova Region. It can be used as grazing, if not, as cutting throughout the winter season.

Two-year average values showed that while different row spacing practice had significant effects on green and dry herbage yield, crude protein ratio and yield, which are properties about herbage yield, it had significant effects on numbers of tiller and fertile tiller and ratios, spike height, spike weight and seed yield, which are properties relating to seed yield.

As a result, considering the region's climate conditions, it is concluded that 4-5 harvesting could be obtained, with a satisfactory herbage yield during winter planting, it is has enough nutritive value for animals, Also, it is possible to obtain seed for next sowing provided that the last harvesting is delayed for seed production, and row spacing of 30 cm is the most suitable row spacing both for herbage yield and seed yield as a result of examination of studied properties.

References

Acikgoz, E., 2001. Forages. (Renewed third edition). *Amplification Foundation of Uludag University* Issue No: 182, Vipaþ Inc. Issue No: 58. Istanbul, 584 pp. (Tr).

Anonymous, 2007a. General Climate Characteristics of Cukurova Region. Adana.
http://adana.cukurova.edu.tr/cografya.as, (Access date: 27.11.2007).

Anonymous, 2007b. Turkish state meteorological service, Meteorological District Office of, Record of Climate Data, Adana.

Anonymous, 2010. Annual & gulf annual ryegrass. Oregon Ryegrass Growers Seed Commission. http://www.ryegrass.com/Annual_Rye_brochure.pd.

Anonymous, 2010a. Agricultural characteristics and farming of annual ryegrass (*Lolium multiflorum* cv. Caramba) http://www.ulusoyseed.com.tr/urunler_incele.php?id=Mj=

Anonymous, 2010b. Guide to seed varieties. *DlfT Trifolium Seed & Science*. http://www.dlf.com/upload/seed_varieties_web_003.pd

Basbug, S., 1990. The researches on herbage yield and quality of some annual and perennial forage grasses under the Bursa conditions. Uludag University Applied and Natural Science Institute (*M.Sc. Thesis*), Bursa.

Celen, A. E., 1991. Possibility of benefit from annual ryegrass (*Lolium multiflorum* var. westerwoldicum) under the Aegean region conditions. Proceedings of *2nd* National *Meadow*-Range and Forage Crops Congress, 28-31.05.1991, Izmir, pp. 424-429 (Tr).

Ehlig, C. F. and R. W. Haganeke, 1982. Nitrogen management for irrigated annual ryegrass in southwestern United States. *Agronomy Journal,* **74** (5): 820-823.

Erac, A. and H. Ekiz. 1985. Forage cultivation. *Ankara University Agricultural Faculty Publications*, p. 964. Lecture Note: 16, Ankara (Tr).

FAO, 2008. FAO Statistical Yearbook.

Genckan, M., S., 1983. Agriculture of forage. *Ege University Press*, Bornova/Izmir, p. 517 (Tr).

Hannaway, D., S. Fransen, J. Cropper, M. Teel, M. Chaney, T. Griggs, R. Halse, J. Hart, P. Cheeke, D. Hansen, R. Klinger

and W. Lane, 1999. Annual ryegrass, (*Lolium multiflorum* Lam.) http://extension.oregonstate.edu/catalog/pdf/pnw/pnw501.pd

Kesiktas, M., 2010. Effects of sowing time and nitrogen doses on forage yield of annual ryegrass (*Lolium multiflorum westerwoldicum*-Caramba) in Karaman. Cukurova University Applied and Natural Science Institute (*M.Sc. Thesis*), Adana. (Tr).

Kunelius, T. and P. Boswall, 2009. Producing annual ryegrasses for pasture, silage and seed. *Agriculture and Forestry Farm Extension Services*, Canada, http://www.gov.pe.ca/photos/original/ag_ryegrass_bul.pdf

Kusvuran, A. and V. Tansi, 2005. The effects of various harvest densities and nitrogen doses on herbage and seed yield of annual ryegrass variety caramba (*Lolium multiflorum* cv. Caramba) Under the Cukurova Conditions. VI. Field Crops Congress of Turkey, 5-9 Seprember 2005, Antalya, **II:** 797-802 (Tr).

MSTAT-C, A., 1991. Microcomputer program for design management and analysis of agronomic research experiments. Michigan State University East Lansing, MI, USA.

Orak, A. and V. Uygun, 1996. Some important morphological characters and green fodder yield of berseem clover (*Trifolium alexandrinum* L.) and Italian ryegrass (*Lolium multiflorum* Lam.) mixtures which have different sowing norms row spacing and mixture rates**.** 3. Pasture and Forage Crops Meeting of Turkey. 17-19 June 1996, Pp. 369-375 (Tr).

Ozel, A., 1989. Effects of sowing time on forage and seed yield of annual ryegrass (*Lolium multiflorum* Lam.) in Cukurova Conditions. Cukurova University Applied and Natural Science Institute (*M.Sc. Thesis*), Adana.

Ozdil, O., 1996. The effects of different sowing time and seeding rate on herbage and seed yields and some agricultural characteristics of annual ryegrass (*Lolium multiflorum* cv. Caramba) in Cukurova conditions. Cukurova University Applied and Natural Science Institute (*M.Sc. Thesis*), Adana (Tr).

Parlak, E. L., 2005. A research on the determination of biomass production of mixtures of faba bean with cerealls wheat, barley and triticale annual ryegrass under Cukurova conditions. Cukurova University Applied and Natural Science Institute (*M.Sc. Thesis*), Adana (Tr).

Parlak, A. O., F. Akgul and A. Gokkus, 2007. The effects of different row spacing and nitrogen doses on herbage yield and quality of Annual Ryegrass (*Lolium multiflorum* cv. Caramba) in Ankara conditions. VII. Field Crops Congress of Turkey, 25-27 June, pp. 139-142 (Tr).

Rechcigl, J. E., 1992. Response of ryegrass to limestone and phosphorus. *Journal of Production Agriculture,* **5** (4): 602-607.

Saglamtimur, T., 1981. Farming of forage and issues in Cukurova. Modern agriculture techniques. *Guney Press*, Adana, pp. 9-11 (Tr).

Saglamtimur, T., H. Gulcan, T. Tukel, V. Tansi, A E Anlarsal and R. Hatipoglu, 1986. The adaptation experiments of Forage in Cukurova conditions. 1: Poaceae Forages. *Cukurova University, Journal of Agricultural Faculty,* **1** (3): 26-37 (Tr).

Saglamtimur, T., A. Ozel, H. Baytekin and V. Tansi, 1993. The effect of sowing time on herbage yields and some agricultural characters of annual ryegrass (*Lolium multiflorum* Lam.) in Cukurova conditions. *Cukurova University, Journal of Agricultural Faculty*, **8** (1): 167-176 (Tr).

Saglamtimur, T., V. Tansi and H. Baytekin, 1998. Forage cultivation. *Cukurova University Agricultural Faculty Press*. No: C-74, Adana. p. 238.

Sancak, C. and I. Manga, 1994. A research on the determination of the effects of different harvest times on herbage yield and some commodities quality of forage crops which sowed pure and mixed in Samsun ecological conditions. *OMÜ Journal of Agricultural Faculty*, **9 (**2): 159-173.

Serin, Y., 1999. Seed production of forage. management of meadow-pasture and culture. *Education and Application Handbook of Pasture Principle* –1. *Matsa Press,* Ankara, pp. 103-117.

Serin, Y., M. Tan and H. Seker, 1996. The effects of nitrogen application and sowing date on herbage yield, crude protein yield and crude protein ratio of annual ryegrass (*Lolium multiflorum* Lam.). 3. Pasture and Forage Crops Meeting of Turkey. 17-19 June 1996, Erzurum, pp. 732-738 (Tr).

Szyszkowska, A. and J. Sowinski, 2001. Botanical composition and nutritional value of two–component mixtures containing red clover and different grass species. Wydawnictwo Akademii Rolniczej we Wroclawiu, ISSN 1505-0297.

Tuik, 2008. The statically of vegetable and animal production. Turkish Statistical Institute.
http://www.tuik.gov.tr

Turemen, S., 1988. Researchers of the possibility mixed cropping as an intermediate product with some leguminous forage of annual ryegrass (*Lolium multiflorum* Lam.). Cukurova University Applied and Natural Science Institute (*Ph.D. Thesis*), Adana.

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