The Effect of Different Seeding Rates on Grain Yield and Yield Components in SomeFlax (*Linumusitatissimum L.*) Varieties

Yasemin ERDOĞDU[1], Seviye YAVER[2], Fadıl ONEMLI[3]

Department of Field Crops, NKU University, TEKIRDAG-TURKEY

Abstract— *This study was carried out during the growing seasons of 2014/2015 and 2015/2016, in the Application and Experiment Fields of Namık Kemal University, Faculty of Agriculture, Department of Field Crops, according to the Split-Plot Experiment Design in Randomized Blocks with 3 replications. In the study, it was aimed to determine the effect of three different amounts of seeds (30-50 and 70 kg/ha) applied to the unit area on the grain yield and yield components in five varieties of flax (Selection, York, Nekoma, Pembina, Neche). In the first year of the experiment on these genotypes, the plant height was 70.91-77.46 cm, the number of axillary branches was 6.50-10.24, the number of capsules was 48.46-81.87, the thousand grain weight (TGW) was 5.51-5.85 g and the grain yield was 1260.00-1863.30 kg/ha; while in the second year, the plant height was 74.61-82.25 cm, number of capsules was 14.50-27.52, the TGW was 5.51-5.83 g and the grain yield was 1715.50-2071.10 kg/ha. Due to the increase in the sowing norm, the number of plants increasing in the unit area has also significantly increased the grain yield in both years. In addition, it was observed that the number of axillary branches, the number of capsules, and the weight of thousand grains significantly decreased with the increasing plant density, although there was no difference in plant heights between the two years in accordance with the increase in the number of seeds. While the number of seeds in the capsule was not affected by the number of seeds in the first year of the experiment, it decreased significantly in the second year when the number of seeds used in the unit area increased.*

Keywords— ***oilseed flax, seeding rate, grain yield, number of capsules, thousand grain weight.***

I. INTRODUCTION

Flax (*Linumusitatissimum L.*) is a multi-purpose annual industrial plant, whose seeds are used and fiber is obtained from its stems. The flax's fibers obtained from its stems, its seeds, oil, and residue have been used in different sectors. The oil, which is approximately found in the rate of 35-46% in the flaxseed, has been used in chemical industry areas such as paint and varnish production due to having high amount of linoleic (16-75%) and alpha-linolenic (17-59%) acids in it and due to being a polyunsaturated oil (M. Zuk et al., 2015).

The need for the oilseeds has been increasing every year throughout the world, and the flax has also been contributing to the production of the oilseeds in addition to the produced major oil plants. The flax, which is produced approximately 2.5 million tons in the world, is mostly cultivated in Canada, Kazakhstan, China, Russia, USA and India (FAO 2017). Considering the existence of agricultural areas in the world, since the horizontal growth is not possible, vertical growth should be considered; and selection of the plant types and agronomic applications should be emphasized to increase the yield in the unit area.

There are three major components of yield in the production of flaxseed, namely, number of capsules, number of seeds in capsules and seed weight (Lafond 2001). Knowing the amount of seed is one of the most important facts of the agronomic applications (Casa et al., 1999). It has also been confirmed in scientific studies that the grain yield varies depending on agronomic applications and environmental factors, i.e. while the yield was 3,310-4,360 kg/ha in England (Turner 1991), it was 950-2,795 kg/ha in Germany (Diepenbrock and Parksen 1992).

Studies have shown that the amount of seeds is important in flax and that the flax varieties can react differently to the plant density (Gabiana 2005). Studies on the number of seeds to be sowed in the unit area in the oilseed flax found the ideal rate as 200-400 plants/m^2 for the grain yield (Turner 1991; Diepenbrock and Parksen 1992; Gubbles and Kenaschuk 1989; Lisson and Mendham 2000) and reported that this plant density increased the photosynthesis capacity of the plant as a result of the length of the green leaf area during capsule and seed development (Diepenbrock and Parksen 1992). On the other hand, Hassan and Leitch (2000) reported that when the plant density increased, plants entered into competition with each other, resulting in fewer and shorter branches with smaller leaves, limited plant growth and decreased number of capsules. In another study, it was observed that high sowing norm increased plant height, leading to the problem of leaning in plants (Lisson and Mendham 2000). Leitch and Sahi (1999) reported that when the plant density in the unit area increased, the individual plant size decreased, while the total dry matter ratio obtained from the unit area increased. In some studies on flax, the difference between the numbers of plant parts in the unit area did not make a difference in both dry matter and grain yield as a result of plants' denser branching and filling the existing gaps due to increased plant size (Khan and Bradshaw, 1976).

It is observed that the effects of climate and soil factors are great on the difference found in terms of the effects of plant density on grain yield and yield components in the conducted researches. It is important to determine the most suitable plant frequency by carrying out studies in all of the ecologically different production areas. In this study, it was aimed to determine the ideal amount of seeds in Tekirdağ conditions, considering the yield and yield components of different flax varieties.

II. MATERIAL AND METHOD

This study was carried out during the growing seasons of 2014/2015 and 2015/2016, in the Application and Experiment Fields of Namık Kemal University, Faculty of Agriculture, Department of Field Crops. The total rainfall was 519.4 mm, the average temperature was 12.01°C during the growing season of 2014/2015, while the relative humidity was 78.8%, the total precipitation was 324.4 mm, the average temperature was 13.35°C, and the relative humidity was 79.2% during the growing season of 2014/2015, when the experiments were carried out. When the average of the flax growing seasons of the region for a long period of time, the season average of precipitation in 2014/2015 was the same as the average rainfall for many years, while, in 2015/2016 the precipitation was about 200 mm lower. When the temperature averages are examined, the figures are close to each other and the average temperature in 2015/2016 is found high. Regarding the relative humidity values, there was no difference between the average relative humidity values for a long period of years and no difference was found between the years when the tests were conducted.

In both years, the soil of the test site was found to be neutral, unsalted, with very little lime, poor in organic matter, and sufficient in terms of phosphorus and potassium as the result of the soil analysis.

Selection, York, Nekoma, Pembina and Neche varieties were used in the research. The experiments were carried out with 3 replications in the Split-Plot Experiment Design in Randomized Blocks, with the main parcels formed by the varieties and the seed quantities (30, 50 and 70 kg/ha) forming the sub-parcels. Each sub-parcel consisted of 5 rows with a length of 5 m. In sowing, the distance between rows was kept constant at 20 cm. The experiments were conducted manually on October 21, 2015 in the first year and on November 7, 2016 in the second year.

The test sites were given 20-20-0 compound fertilizer with 60 kg/ha of pure nitrogen and 60 kg/ha of pure phosphorus in both growing years. In addition, during the flowering period of the plants, urea (46%) fertilizer was given in the form of pure nitrogen of 30 kg/ha. Mechanical intervention was applied against weeds.

In the harvest carried out in June 11, 2015 in the first year and in June 20, 2016 in the second year, 50 cm of margins were left on the edge rows of each parcel, at the beginnings and the ends of the rows. In the research, plant height, number of axillary branches, number of capsules, number of seeds per capsule, thousand grain weight and grain yield were examined.

For the data obtained from the experiments, variance analysis was performed by dividing the years according to the Split-Plot Experiment Design in Randomized Blocks. The statistical significance of differences between the averages was determined according to the LSD test, and JUMP program pack was used during the evaluations.

III. RESULT AND DISCUSSION

Average values and significance groups of seeding rate and variety × seeding rate interaction, plant height, number of axillary branches, number of capsules, number of seeds per capsule, thousand grain weight and grain yield are given in Table 1 and Table 2.

TABLE 1
AVERAGE VALUES AND SIGNIFICANCE GROUPS OF PLANT HEIGHT, NUMBER OF AXILLARY BRANCHES, NUMBER OF CAPSULES

Plantheight (cm)					
Year	**Varieties**	**Seedingrates kg/ha**			
		30	**50**	**70**	**Ort.**
2014-2015	Seleksiyon	70.76 de	69.40 e	76.45 ab	72.2bc
	York	71.00 de	70.13 e	71.60 cde	70.91 c
	Nekoma	75.70 abc	69.73 e	74.84 bcd	73.41 b
	Pempina	79.20 a	79.70 a	73.48 b_e	77.46 a
	Neche	71.20de	76.86 ab	75.83 abc	74.63 b
	Ort.	73.57	73.16	74.43	73.72
	LSD %: V= 2.47** S.R= ns V × S.R= 4.28** C.V. % = 3.47				
2015-2016	Seleksiyon	74.83	73.80	75.20	74.61 b
	York	77.90	74.23	74.90	75.67 b
	Nekoma	81.36	77.90	80.46	79.91 a
	Pempina	82.00	81.96	82.63	82.20 a
	Neche	82.40	82.03	82.33	82.25 a
	Ort.	79.70	77.98	79.10	78.93
	LSD %: V=2.46** S.R= ns V × S.R= ns C.V. % = 3.23				
Number of AxillaryBranches(perplant)					
Year	Varieties	Seedingrates kg/ha			
		30	50	70	Ort.
2014-2015	Seleksiyon	10.22 ab	6.59 efg	7.75 cde	8.19 b
	York	10.83 a	9.06 bc	10.83 a	10.24 a
	Nekoma	8.16 cd	6.80 d_g	5.60 g	6.85 c
	Pempina	6.55 efg	6.76 efg	6.20 fg	6.50 c
	Neche	7.62 de	7.07 def	5.65 g	6.78 c
	Ort.	8.67 a	7.26 b	7.21 b	7.71
	LSD %: V=0.79** S.R=0.61** V× S.R=1.38** C.V. % = 10.71				
2015-2016	Seleksiyon	6.60	4.75	5.15	5.50
	York	5.70	5.56	5.34	5.53
	Nekoma	5.44	4.82	5.30	5.18
	Pempina	5.98	4.85	4.63	5.15
	Neche	5.75	4.77	4.43	4.98
	Ort.	5.89 a	4.95 b	4.97 b	5.27
	LSD %: V=nsS.R=0.94 ** V× S.R=ns C.V. % = 10.75				
Number of Capsules (perplant)					
Year	Varieties	Seedingrates kg/ha			
		30	50	70	Ort.
2014-2015	Seleksiyon	68.37 c	51.70 ef	45.87 fgh	55.30 c
	York	98.97 a	63.25 cd	83.40 b	81.87 a
	Nekoma	77.30 b	81.33 b	34.25 ı	64.29 b
	Pempina	56.43 de	47.60 fg	41.35 ghı	48.46 d
	Neche	63.90 cd	59.75 d	38.86 hı	54.17 c
	Ort.	72.99 a	60.72 b	48.74 c	60.82
	LSD %: V=4.32** S.R=3.35** V × S.R=7.49** C.V. % = 7.36				
2015-2016	Seleksiyon	21.26 de	15.74 fgh	14.73 fgh	17.24 bc
	York	35.71 a	21.73 cd	25.13 bc	27.52 a
	Nekoma	17.93 ef	17.53 fg	14.40 gh	16.62 c
	Pempina	27.01 b	14.12 h	15.23 fgh	18.78 b
	Neche	17.99 ef	12.82 h	12.70 h	14.50 d
	Ort.	23.98 a	16.39 b	16.44 b	18.93
	LSD %: V=1.96** S.R= 1.52 ** V× S.R=3.40 ** C.V. % =10.73				

significant at p<0.05 probability level, ** significant at p<0.01 probability level ns: not significant, LSD: Least Significant Difference, C.V.: Coefficient of Variation

TABLE 2
AVERAGE VALUES AND SIGNIFICANCE GROUPS NUMBER OF SEEDS PER CAPSULE, THOUSAND GRAIN WEIGHT AND GRAIN YIELD

Number of SeedsPer Capsule

Year	Varieties	Seedingrates kg/ha			
		30	50	70	Ort.
2014-2015	Seleksiyon	9.33 ab	9.00 b	9.06 b	9.13
	York	9.40 ab	8.93 b	9.16 ab	9.16
	Nekoma	9.36 ab	9.16 ab	9.36 ab	9.30
	Pempina	9.63 a	9.30 ab	9.40 ab	9.44
	Neche	9.20 ab	9.40 ab	9.26 ab	9.28
	Ort.	9.38	9.16	9.25	9.26
	LSD %: V=ns S.R.= ns V× S.R=0.51* C.V. % = 3.30				
2015-2016	Seleksiyon	8.93	8.70	8.83	8.82
	York	8.80	9.46	8.53	8.93
	Nekoma	8.90	8.83	8.76	8.83
	Pempina	9.13	8.63	8.43	8.73
	Neche	9.26	9.06	8.96	9.10
	Ort.	9.00 a	8.94 a	8.70 b	8.88
	LSD %: V=ns S.R=0.22* V × S.R= ns C.V. % = 3.42				

ThousandGrainWeight (g)

Year	Varieties	Seedingrates kg/ha			
		30	50	70	Ort.
2014-2015	Seleksiyon	5.78 cde	5.57 g	5.51 gh	5.62 c
	York	5.51 gh	5.53 gh	5.50 gh	5.51 d
	Nekoma	5.72 ef	5.69 f	5.47 h	5.63 c
	Pempina	6.00 a	5.74 ef	5.81 c	5.85 a
	Neche	5.88 b	5.81 cd	5.75 def	5.81 b
	Ort.	5.78 a	5.67 b	5.61 c	5.68
	LSD %: V=0.037** S.R=0.029** V × S.R=0.065** C.V. % = 0.68				
2015-2016	Seleksiyon	5.64 e	5.54 fg	5.47 h	5.55 c
	York	5.52 fg	5.51 gh	5.50 gh	5.51 d
	Nekoma	5.71 cd	5.67 de	5.53 fg	5.64 b
	Pempina	5.94 a	5.81 b	5.75 c	5.83 a
	Neche	5.74 c	5.64 e	5.57 f	5.65 b
	Ort.	5.71 a	5.63 b	5.56 c	5.63
	LSD %: V=0.027** S.R=0.021** V × S.R=0.048** C.V. % = 0.51				

GrainYield (kg/ha)

Year	Varieties	Seedingrates kg/ha			
		30	50	70	Ort.
2014-2015	Seleksiyon	1760.00 c	1200.00 g	2043.30 a	1667.70 c
	York	906.60 h	1310.00 f	1563.30 d	1260.00 d
	Nekoma	1783.30 c	1746.60 c	2060.00 a	1863.30 a
	Pempina	1456.60 e	1643.30 d	1910.00 b	1670.00 c
	Neche	1610.00 d	1786.60 c	1786.60 c	1727.70 b
	Ort.	1503.30 b	1537.30 b	1872.60 a	1637.70
	LSD %: V=5.53** S.R=4.28** V × S.R=9.56** C.V. % = 3.49				
2015-2016	Seleksiyon	1840.00 de	1243.30 h	2123.30 bc	1735.50 b
	York	1893.30 d	1403.30 g	1850.00 de	1715.50 b
	Nekoma	2223.30 b	1610.00 f	2380.00 a	2071.10 a
	Pempina	1753.30 e	1446.60 g	2060.00 c	1753.30 b
	Neche	2160.00 bc	1880.00 d	2150.00 bc	2063.30 a
	Ort.	1974.00 b	1516.60 c	2112.60 a	1867.70
	LSD %: V=7.25** S.R=5.63** V × S.R=12.59** C.V. % = 4.03				

significant at p<0.05 probability level, ** significant at p<0.01 probability level ns: not significant, LSD: Least Significant Difference C.V.: Coefficient of Variation

3.1 Plant Height

According to the results of variance analysis, plant height differences between the varieties in both years were statistically significant at 0.1% level. The plant height values of varieties varied between 70.91 and 77.46 cm during the growing season of 2014-2015 (Table 1). In this winter growing season, the highest plant height was obtained from the Pempina variety while the lowest plant height was obtained from the York variety. During the growing season of 2015-2016, the plant height values of the varieties ranged from 74.61 to 82.25 cm and the highest plant height was obtained from the Neche variety. This variety was followed by Pempina and Nekoma varieties with an insignificant difference. The lowest plant height was measured in the selection range. The varieties studied in the experiment showed similar performance in both trial periods. The varieties with the highest plant height in both years were Pempina and Neche while the varieties with the lowest plant height were the Selection and York varieties. When the average plant height performances according to years are examined, the plant height of the varietiesis measured higher in the growing season of 2015-2016. This may be due to the difference in climate factors between years.

As the result of the variance analysis, the effect of the seeding rates on the plant height was found to be statistically insignificant in both growing season. Plant height values according to seed amount varied between 73.16-74.43 cm in the growing season of 2014-2015 and 79.10-79.70 cm in the growing season of 2015-2016 (Table 1).These results are similar to those of Gubbels and Kenaschuk (1989), R. Casa et al. (1999) who reported that the amount of seed and the size of the plant did not change. However, our study does not correspond with the studies of Dillman and Brinsmade (1938), Albrechtsen and Dybing (1973), Gubbels (1977), Lafond (1992), Agegnehu and Honermeier (1997), and Gabiana et al. (2005), which have shown that the plant height varies significantly according to the amount of seeds.

Regarding the plant height, variety ×seeding rate interaction was statistically significant in the 2014-2015 growing season. The lowest plant height was obtained with application of 50 kg/ha seeding in Selection variety and the highest plant height was obtained with application of 30 kg/ha seeding in Pembina variety. In the 2015-2016 growing season, the variety x seeding rate interaction was insignificant and the plant height values were measured as 73.80-82.63 cm (Table 1).

3.2 Number of Axillary Branches

According to the results of the variance analysis, the difference between the varieties in terms of the number of axillary branches were found to be statistically significant in the 2014-2015 growing season, and insignificant in the 2015-2016 growing season. When the average values of the varieties were examined, the highest number of the axillary branches in the first year was obtained in York variety with 10.24 pieces and the lowest number of axillary branches was in Pembina variety with 6.50 pieces (Table 1). In the second year, the average number of axillary branches was lower than the previous year. This may be due to the difference in climate factors between years.

The difference between the seeding rates in terms of the number of axillary branches was statistically significant for both of the growing seasons. In the first year, the highest number of axillary branches was obtained as 8.67 using 30 kg/ha seeds and the lowest number of axillary branches was obtained using 70 and 50 kg/ha seeds respectively. In the second year, the highest number of axillary branches was seen as 5.89 in the seed amount of 30 kg/ha, while the lowest number of axillary branches was determined in applications of 50 and 70 kg/ha seeds respectively (Table 1). When the seeding rates were evaluated according to years, the highest number of axillary branches was obtained from the amount of 30 kg/ha seeds in both years of the experiment and there was no significant difference in the number of axillary branches in 50 and 70 kg/ha seed application. These results show similarity to the findings of Dillman and Brinsmade (1938), Gubbels (1977), Gubbels and Kenaschuk (1989), Diepenbrock and Pörksen (1992), Stevenson and Wright (1996), Agegnehu and Honermeier (1997), Gabiana et al. (2005), who have stated that the number of axillary branches decrease significantly with the increase in the number of seeds.

When the varieties × seeding rates interaction was examined in terms of the number of axillary branches, statistically significant differences were found in 2014-2015, while the difference in the 2015-2016 growing season was not significant. As can be seen in Table 1, the highest number of axillary branches (10.83) in the variety × seeding rate interaction during the

2014-2015 growing season and the lowest number of axillary branches (5.60) in the application of 30 and 70 kg/ha of York variety seed, while the lowest number of axillary branches was seen in 70 kg/ha seeding rate application of Nekoma variety.

3.3 Number of Capsules

When the variance analysis results regarding the numbers of capsules were examined, the difference between the varieties was significant for both growing seasons. When the variety average was examined in 2014-2015, the highest number of capsules was determined in the York variety with 81.87 and the lowest number of capsules was found in the Pembina variety with 48.46. In 2015-2016, the highest number of capsules was obtained in the York variety with 27.52 and the lowest number of capsules in the Neche variety with the number of 14.50. With regard to the number of capsules, the average of varieties decreased in the second year of the experiment. In both years, the highest number of capsules was determined in the York variety, while the lowest number of capsules was obtained in Pembina in the first year and in Neche in the second year (Table 1). For flax plants, the number of capsules is one of the most important characters in terms of grain yield (Lafond 2001). The fact that the capsule numbers of the varieties handled in the experiment are different may be due to the different genetic structure of the varieties and their different responses to the applied seeding rate.

The effects of the different seeding rates on the number of capsules were significant for both growing seasons. According to 2014-2015 data, the most capsules were counted as 72.99 in the application and 30 kg/ha seeds, followed by 60.72 capsules for 50 kg/ha seeds, 48.74 capsules for 70 kg/ha seeds, respectively. In the growing season of 2015-2016, the highest number of capsules was obtained as 23.98 from the application of 30 kg/ha seeds, and the lowest number of capsules was obtained as 16.39 capsules from the application of 50 kg/ha seeds (Table 1). In both years of the experiment, the highest number of capsules was obtained from the application of 30 kg/ha seeds. When the two-year results of the experiment were evaluated together, the number of capsules decreased with the increasing amount of seeds. This is due to the fact that plants are not able to make enough use of the sunlight because of the increase in the number of seeds, resulting in less capsule growth (Diepenbrock and Parksen, 1992) and a decrease in the number of leaves and leaf size when the plant density is high and the branches are shorter (Hassan and Leitch 2000). The results of this study show similarity with the results of the studies of Dillman and Brinsmade (1938), Albrechtsen and Dybing (1973), Elsahookie (1978), Diepenbrock and Pörksen (1992), Agegnehu and Honermeier (1997), Casa et al. (1999), and Gabiana et al. (2005), which stated that the number of capsules decreased significantly with the rise in the number of seeds, in addition to this our result differed from the study of Gubbels (1977), who stated that there was no significant difference in the number of capsules after an increase in the number of seeds.

When the results of variance analysis were examined, the varieties × seeding rates interaction was statistically significant for both growing seasons. The highest number of capsules (98.97) obtained from the varieties × seeding rates interaction during the 2014-2015 growing season was determined in the application of 30 kg/ha seeding rate in York variety and the lowest number of capsules (34.25 pieces) was determined in application of 70 kg/ha seeding rate in Nekoma variety. In the growing season of 2015-2016, 35.71 capsules were obtained from the application of 30 kg/ha seed in York variety, and the lowest number of capsules was taken as 12.70 pieces in Neche variety with the application of 70 kg/ha seeds (Table 1).

3.4 Number of Seeds in the Capsule

According to the results of the variance analysis, the differences between the varieties were statistically insignificant for both of the growing seasons (Table 2). When the seed numbers in the capsules of varieties were examined, a slight decrease was observed in the second year. This may be due to the fact that the second year was rather dry compared to the first year.

In terms of the number of seeds in the capsule, the differences between the seeding rates appeared insignificant in the first year of the experiment, whereas in the second year it was statistically significant. In the period of 2015-2016, the maximum number of seeds was obtained as 9.00 seeds with 30 kg/ha seed application, and the lowest value with 8.70 seeds with 70 kg/ha seed application (Table 2). In flaxseed production, the number of seeds in the capsule is an important criterion (Lafond 2001). Findings from the first year were similar to the studies of Albrechtsen and Dybing (1973), Gubbels (1977), Elsahookie (1978), and Casa et al (1999), which reported that the number of seeds in the capsule did not change after a change in the amount of seeds. The findings of the second year were similar to those of Diepenbrock and Pörksen (1992), Agegnehu and Honermeier (1997), and Gabiana et al. (2005), which reported that the number of seeds in the capsule changed significantly after a change in the amount of seeds. Despite the fact that there was no significant change in the first year of the experiment, the significant change in the second year indicates that this character was affected by climate factors, especially drought.

In terms of the number of seeds in the capsule, the varieties × seeding rates interaction was found to be insignificant in the first year of study and significant in the second year. The highest number of seeds in the capsule (9.63) in the varieties × seeding rates interaction was found in the application of 30 kg/ha seeding rates of the Pembina variety, and the lowest seed number in the capsule (9.00) was found in the application of 50 kg/ha seeding rate of the Selection variety in 2014-2015 (Table 2).

3.5 Thousand Grain Weight

As can be seen in Table 2, the difference between one thousand grain weights of the varieties used in the study was statistically significant for both growing seasons. In both growing seasons, the highest seed weight was found in the species of Pembina (5.85 g in the first year, 5.83 g in the second year) and the lowest seed weight was found in the species of York with 5.51 g for both of the growing seasons.

According to the results of variance analysis, the differences in the amount of seeds regarding the thousand grain weight were significant for both growing seasons. In the period of 2014-2015, the highest thousand grain weight was determined as 5.78 g in the application of 30 kg/ha seed, the lowest thousand grain weight was determined as 5.61 g in the application of 70 kg/ha seed. In the period of 2015-2016, the highest thousand grain weight was obtained as 5.71 g in the application of 30 kg/ha seed and the lowest thousand grain weight was obtained as 5.56 g in the application of 70 kg/ha seed (Table 2). When the seeding rates are evaluated, the increase in the amount of seed per two years decreases the thousand grain weight. The thousand grain weight in flax seed production is an important yielding factor (Lafond 2001) and it is desirable to be high. As in our research, findings from previously conducted studies indicate that the thousand grain weight is a highly influenced character affected by the genotype as well as the cultivating techniques such as the genotype and seeding rates (Gubbels 1977). These findings show similarities with the findings that were obtained by Gubbels and Kenaschuk (1989) and Diepenbrock and Pörksen (1992); while this study does not correspond with the findings of Albrechtsen and Dybing (1973), Elsahookie (1978), and Casa et al (1999), who reported that the thousand grain weight did not change after a change in the amount of seeding.

According to the results of the variance analysis on the thousand grain weights, the varieties × seeding rates interaction was found to be statistically significant. When the varieties × seeding rates interaction obtained in the 2014-2015 growing season was examined, the highest thousand grain weight was found in 30 kg/ha seed application of Pembina as 6.00 g, and the lowest thousand grain weight was found in 70 kg/ha seed application of York as 5.50 g. When the varieties × seeding rates interaction obtained in the growing season 2015-2016 was examined, the highest thousand grain weight was found in 30 kg/ha seed application of Pembina as 5.94 g, and the lowest thousand grain weight was found in 70 kg/ha seed application in the species of Selection as 5.47.g (Table 2).

3.6 Grain Yield

In both years of the study, the differences between the grain yields of the flax varieties were statistically significant. In 2014-2015, the highest grain yield was obtained in the Nekoma variety with 1863.30 kg/ha, while the lowest grain yield was obtained in the York variety with 1260.00 kg/ha. In the period of 2015-2016, the highest grain yield was determined in the Necoma with 2071.10 kg/ha and Neche varieties with 2063.30 kg/ha, being in the same statistical group; while the lowest grain yield was respectively in York species with 1715.50 kg/ha, in Selection species with 1735.50 kg/ha and in Pembina species with 1753.30 kg/ha, again being in the same statistical group (Table 2). When the two-year results of the experiment were evaluated together, the highest grain yield was obtained in the Nekoma variety and the lowest grain yield was obtained in the York variety in both years. When the results were examined, it was seen that the average of varieties is higher in the growing season of 2015-2016. This may be due to the difference in climate factors between years.

According to the results of the variance analysis, the differences between the amounts of seeds were found to be significant for both years, with regard to the grain yield. When the grain yields of the year 2014-2015 are examined, the highest grain yield was obtained by applying 1872.60 kg/ha with 70 kg/ha of seed and the lowest grain yield was obtained by applying

1503.30 kg/ha with 30 kg/ha of seed and by applying 1537.30 kg/ha with 50 kg/ha of seed, which are in the same statistical significance group. In 2015-2016, the highest grain yield was obtained from the application of 70 kg/ha seed with 2112.60 kg/ha and the lowest grain yield was obtained from the applying 1516.60 kg/ha with 50 kg/ha of seed (Table 2). When the two-year results were evaluated together for the amounts of seeds, the highest grain yield was obtained at a rate of 70 kg/ha seed for both of the years. In the production of flaxseed, there are three major yield components, namely the number of capsules, the number of seeds in the capsule and the seed weight (Lafond 2001). In our study, the highest grain yield was obtained from the application of 70 kg/ha seeds, while the highest number of capsules, number of seeds in capsule, and the thousand grain weight were obtained from 30 kg/ha seed application. This can be explained by the large number of plants in the unit area. Findings obtained were similar to those of Lafond (1992), Agegnehu and Honermeier (1997), Gubbels and Kenaschuk (1989), Diepenbrock and Pörksen (1992), which reported that the yield increased with seeding rate. However, Gabina (2005) reported that the yield decreased with the increase in the seeding rate, while Albrechtsen and Dybing (1973), Elsahookie (1979), Stevenson and Wright (1996), Casa et al (1999), and Easson and Molloy (2000) stated that the yield was not affected by changes in the amounts of seeds.

According to the results of variance analysis of the grain yield, the varieties × seeding rates interaction was found to be statistically significant for both of the years. When the varieties × seeding rates interaction for the 2014-2015 growing season was examined, the highest grain yield was 2060.00 kg/ha from the application of Nekoma seeding rate with 70 kg/ha and the lowest grain yield was 906.60 kg/ha from the application of York seeding rate with 30 kg/ha. In the 2015-2016 growing season, the highest grain yield was 2380.00 kg/ha from the application of Nekoma seeding rate at 70 kg/ha and the lowest grain yield was taken as 1243.30 kg/ha from Selection variety with 50 kg/ha seed application (Table 2).

IV. CONCLUSION

The research findings show that the genotype has a significant effect on the yield and yield components of the flax plant, and the highest grain yield was obtained with a seeding rate 70 kg/ha, which was the highest seeding amount during the experiments. When we look at the interactions between the two factors, it was seen that the varieties reach the highest yields with the application of 70 kg/ha of seed. Although the measured yield components were adversely affected by the increase in plant density, there has been a significant increase in yield statistics due to the increase in the number of plants in the unit area. If we apply new interrow spaces such as twin rows which will ensure that the yield elements are minimally affected, it may be possible to reach even higher yields. In this respect, it is deemed necessary to investigate new seed norms which can reduce the competition between plants and increase the unit field yields with new interrow applications by taking the application of 70 kg/ha of seed, which is determined as the optimal norm in our research, as the lowest sowing norm.

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