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RESEARCH PAPER

Determination of the optimal plant population and rapeseed genotype (*Brassica napus* L.) in western Iran

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Abstract

A. Z. Siahbidi, & A. Asgari. 2023. Determination of the optimal plant population and rapeseed genotype (*Brassica napus* L.) in western Iran. Int. J. Agric. Nat. Resour. 1-11. This study was conducted to determine the most suitable plant population and genotype of rapeseed at the Eslamabad-e-Gharb Research Station in western Iran during 2018-2020. The experiment was a factorial based on a randomized complete block design (RCBD) with three replications. Factors included four plant populations (20, 40, 60, and 80 plants m^{-2}), and seven genotypes included four hybrids (Natalie, Rohan, Neptune, and Marathon) and three open-pollinated cultivars (Nafis, Nima, and Nilufar). The results show that the effect of the year was significant for all traits due to the difference in weather parameters over the two years of the experiment. ANOVA results shows that the effects of the plant population significantly affected plant height, the number of branches, the number of grains per pod, grain yield, grain oil, and oil yield. The effect of the genotype was also significant for all traits except oil yield. The effect of the interaction between the plant population and genotype on plant height, the number of branches, the number of grains per pod, the number of pods per plant, and 1000-grain weight was also significant. In general, open-pollinated cultivars at 60 plants m^{-2} and hybrid cultivars at 40 plants m^{-2} had higher grain yields.

Keywords: Grain yield, oil production, plant population, rapeseed, seed rate, yield component.

Introduction

Brassica belongs to the family *Brassicaceae*, which includes many economically important plants worldwide (Bailey et al., 2006). Rapeseed (*Brassica napus* L.) is one of the most important species of Brassica. In terms of total oilseed production globally, rapeseed is second after soybeans (USDA, 2015). The oilseed area under cultivation and oilseed production in 2017 amounted to 34.7 million hectares and 76.26 million tons, respectively (FAO, 2019). The harvested rapeseed area in Iran spanned approximately 3300 ha in 1998, but in 2017, it spanned 102568 ha and produced 181148 tons. Kermanshah Province's rapeseed oil production reached 4821 tons (Agricultural Statistics, 2018).

Crop production depends on varieties, environmental conditions, and agronomic factors, as well

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as the interactions between them (Zhang et al., 2012). The optimal use of environmental resources through agronomy and breeding techniques is essential for increasing crop production. The quantity and quality of plants are affected by various factors, such as plant population (Ara et al., 2007), which is a determinant of crop yield. Rapeseed growth, yield, and yield components are directly affected by plant population (Diepenbrock, 2000). The optimal plant population is a density that takes advantage of all environmental factors and where inter- and intraspecies competition is minimal. Several factors play a role in determining the appropriate plant population, including plant selection, growth conditions, crop prices, harvest time, and soil fertility. If the number of plants per unit of area is insufficient, production will be reduced due to inefficient resource use. On the other hand, a large plant population due to increased competition in growth stages leads to a sharp reduction in production. High densities reduce grain yield through shade and by reducing flower fertility. High densities reduce plant growth and yield by increasing plant competition and affecting photosynthesis and nutrient deficiencies (Hatutale, 2010). In general, crop yield increases to a certain extent by increasing the plant population per unit of area and then decreases by increasing the plant population (Akintoye et al., 2009).

The optimal plant population increases resistance to the falling and crushing of pods (Kuai et al., 2015) and mechanized harvesting efficiency (Liu et al., 2019). An optimal plant population is also a prerequisite to achieving a high grain yield (Gan et al., 2016; Ren et al., 2017). Maintaining a certain plant population level is necessary to achieve a high yield of winter rapeseed (Liu et al., 2019). Plant population is an important management factor affecting grain yield (Dong et al., 2010).

In recent years, different recommendations have been made for plant populations, which has made it difficult for farmers to determine the correct seed rate of rapeseed genotypes in Iran. Therefore, this study was conducted to investigate the responses of some genotypes to plant populations.

Materials and methods

This experiment was conducted at the Eslamabad-e-Gharb Research Station in western Iran from 2018-2020. The research station is located at a latitude and longitude of 34°07’N and 46°28’E, respectively, and 1348 m above sea level, and the climatic characteristics of the region are given in Table 1. Before performing field experiments to determine the physicochemical properties of the field soil, sampling was performed at a depth of 0-30 cm, and the given traits were determined in a soil science laboratory (Table 2).

The present study involved a factorial experiment based on a randomized complete block design (RCBD) with three replications. Factors included four plant populations (20, 40, 60, and 80 plants m^{-2}), and the seven genotypes used included four hybrids (Natalie, Rohan, Neptune, and Marathon) and three open-pollinated cultivars (Nafis, Nima, and Nilufar.). Seeds were directly sown in the prepared rows for each plot on September 22, 2018-2020. Each plot consisted of six lines, and the individual plot area spanned 6.3 m^2 (1.5 m × 4.2 m). The plants were thinned at the 2-4 leaf stage to achieve the given plant population.

Nitrogen was applied at 200 kg ha^{-1} with three split applications using urea as a nitrogen source. Superphosphate and potassium sulfate were applied at 200 kg ha^{-1} and 100 kg ha^{-1}, respectively, at the time of planting. Weeds were controlled by hand weeding as needed. All sowings were sprayed with Primicarb and Chlorpyrifos to protect against pests. Irrigation was performed regularly. Irrigation water was intermittently applied with a sprinkler line source irrigation system.

Agronomic traits and yield component variables were recorded for each plot, the number of branches,

Table 1. Monthly and growing season climate factors in Eslamabad-e-gharb from 2018-2020

Months	Precipitation (mm)			Mean temperature (°C)			Min absolute temperature (°C)		Max absolute temperature (°C)		Number of frost days		
	2018-2019	2019-2020	Long period	2018-2019	2019-2020	Long period	2018-2019	2019-2020	2018-2019	2019-2020	2018-2019	2019-2020	Long period
October	20.4	16.1	9.7	19.3	19.3	17.3	7.4	5.8	33.0	34.0	0.0	0.0	0.0
November	122	43.9	73.5	10.5	9.2	10.5	-1.8	-6.4	24.6	23.8	2.0	12.0	7.3
December	172.1	88.8	61.8	5.6	4.5	4.8	-6.2	-6.8	15.4	16.8	10.0	16.0	19.0
January	89.5	41.2	64.2	2.2	2.7	1.7	-8.8	-7.8	14.4	15.0	23.0	23.0	23.3
February	113.3	33.1	79.1	2.9	2.5	1.6	-8.4	-12.4	15.6	17.6	23.0	26.0	23.4
March	96.4	146.4	73.7	4.8	8.5	5.8	-5.6	-2.4	17.2	19.8	20.0	10.0	16.9
April	198	63.3	64.1	9.9	8.5	10.7	-2.6	-1.4	23.8	21.8	4.0	1.0	7.4
May	21.4	17.3	37.8	15.5	15.8	15.5	-1.8	2.2	31.6	31.8	3.0	0.0	0.6
June	0.6	0.0	2.0	23.2	22.2	21.5	7.2	6.8	38.4	35.4	0.0	0.0	0.0

Table 2. Physical and chemical properties of soil from 2018-2020

Electrical conductivity (EC) $ds.m^{-1}$	pH	Saturation percentage	Organic carbon %	Nitrogen %	Phosphorous (ppm)	Potassium (ppm)	Texture	Sand %	Silt %	Clay %
0.8	8	57	0.7	0.11	10	400	Silty Clay Loam	12	55	33

the number of pods per plant, the number of grains per pod, and plant height. At the maturity stage, four middle lines of the plot were removed by removing half a meter from the beginning and end of the plot, and grain yield and 1000-grain weight were calculated. Plants were harvested when 30-40% of the grains changed color from green to brown in both years. The grain yield was adjusted to a 10.0% moisture basis. Additionally, to measure 1000-grain weight, grains were counted by a seed counter, and weight was measured using an electronic scale with an accuracy of 0.001 g. Nuclear Magnetic Resonance Spectrometry (NMR) was used to determine grain oil. SAS software ver 9.1 (SAS, 2002) was used to for an analysis of variance and mean comparison, Excel was used to draw graphs, and the means of the data were compared to the LSD test results at the probability level of 5%. In this analysis, growing seasons (year) were considered random effects. Genotype and plant population characteristics were considered fixed effects.

Results and discussion

The analysis of variance shows that the effect of the year, genotype, and plant population and the interaction between the genotype and plant population at the level of 1% on plant height were significant (Table 3). The mean data comparison shows that the Nima cultivar had the highest plant height (175 cm), and Rohan had the lowest plant height (161 cm). Additionally, the highest and lowest plant heights were observed at 80 plant m^{-2} and 20 plant m^{-2}, respectively (Table 3). Competition between plants at high densities increased their plant height. An investigation of the interaction between the genotype and plant population showed that the Nima cultivar had the highest plant height (199 cm) at 80 plants m^{-2} density, and Rohan had the lowest plant height (145 cm) at 20 plants m^{-2} density (Table 4). Plant height varied significantly through the interaction of year, plant population, and genotype effects (Table 3). Fanaei et al. (2005) attributed the difference in height between cultivars to plant genetics. Additionally, Li et al. (2014) showed that increasing the planting density for rapeseed increased the height of branches. For large plant populations, plant height increases due to reduced radiation penetration into the canopy and increases interplant competition (Xiao et al., 2008). An increasing plant population per unit of area increases competition between plants for nutrients and radiation by increasing their height to obtain more radiation (Shukla & Dixit, 2000).

Table 3. Mean comparison and ANOVA of the effects of the year, genotype, and plant population on the agronomic traits of rapeseed (*Brassica napus* L.) (2018-2020)

Sources	Plant height (cm)	Number of branches	Number of grains per pod	Number of pods per plant	1000 grain weight (g)	Grain yield (kg h^{-1})	Grain oil (%)	Oil yield (kg h^{-1})
Year (Y)								
2018-2019	170.48	8.92	20.84	203.35	3.68	2901.05	33.41	967.79
2019-2020	166.20	6.22	23.52	329.71	3.48	4504.7	35.20	1604.22
Genotype (G)								
Nafis	168.78	7.75	22.78	276.96	3.68	3761	35.21	1335.42
Rohan	160.66	7.14	22.11	250.09	3.53	3574	35.06	1265.32
Natalie	167.38	7.82	23.58	294.94	3.70	4111	33.86	1415.37
Neptune	170.92	7.25	21.12	242.33	3.70	3767	33.92	1289.72
Nima	174.5	7.59	21.33	258.94	3.70	3571	34.88	1265.79
Marathon	165.78	7.49	24.02	285.46	3.33	4158	33.43	1406.77
Nilofar	170.34	8.01	20.39	257.03	3.68	2977	33.78	1023.67
LSD(p≤.05)	4.67	0.46	1.01	15.64	0.15	322	0.97	112.6
Plant population (plants m^{-2}) (P)								
20	153.14	8.10	24.32	283.82	3.66	3475	34.26	1235
40	159.72	8.15	22.25	279.47	3.65	3848	34.64	1337
60	172.88	7.38	21.62	283.37	3.63	3939	34.84	1301
80	187.63	6.69	20.56	219.48	3.40	3549	33.50	1272
LSD (P≤0.05)	3.53	0.35	0.76	11.82	0.11	243	0.73	85.2
Y	**	**	**	**	**	**	**	**
G	**	**	**	**	*	**	*	ns
P	**	**	*	ns	ns	**	**	**
G×P	**	**	**	**	**	ns	ns	ns
Y×P	ns	ns	**	**	**	**	ns	**
Y×G	ns	ns	ns	ns	ns	ns	ns	ns
Y×G×P	**	ns	**	**	**	ns	**	ns
CV (%)	4.85	10.59	7.92	10.25	7.25	15.20	4.934	15.31

ns, * and ** denote no significance and significance at 5% and 1% levels of probability, respectively.

The results show that year, genotype, and plant population effects and effects of the interaction between the genotype and plant population were significant at the 1% level for the number of branches (Table 3). A mean comparison of the data shows that the largest number of branches belonged to the Nilufar cultivar (8.01 branches). The most branches were observed at 20 and 40 plants m^{-2}, and fewest were observed at 80 plants m^{-2} (Table 3). The interaction between the data shows that the Nafis cultivar at 20 plants m^{-2} had the most branches (9 branches), and the Niloufar cultivar at 80 plants m^{-2} had the fewest of branches (5.89 branches) (Table 4). Some researchers have shown that the number of branches per plant is reduced by increasing the plant population per unit of area (Kandil et al., 1996). Li et al. (2014) demonstrated that high planting densities reduced the number of branches per plant. Rapeseed partially compensates for plant deficiency by producing more branches per plant under low-population conditions (Zhang et al., 2012). Due to intraspecific competition, the number of branches per plant decreases by increasing the plant population. Malhi and Gill (2004) also reported that cultivars differ in the number of branches per plant due to genetic differences.

Table 4. Mean comparison of the interaction of genotypes and plant population agronomic traits of rapeseed (*Brassica napus* L.) (2018-2020)

Genotype	Plant population (plants m^{-2})	Plant height (cm)	Branch number	Number of grains per pod	Number of pods per plant	1000 grain weight (g)
Nafis	20	149.60	9.00	26.41	298.42	3.67
	40	155.78	7.63	23.97	257.32	3.81
	60	176.33	7.35	19.50	302.11	3.71
	80	193.42	7.03	21.25	249.98	3.51
Rohan	20	145.49	7.10	24.49	333.92	3.71
	40	152.21	8.00	21.77	244.77	3.58
	60	169.83	7.08	22.25	230.65	3.49
	80	175.08	6.35	19.90	191.02	3.34
Natalie	20	159.87	8.83	24.33	280.87	3.90
	40	154.38	8.47	24.72	309.83	3.85
	60	170.67	7.05	23.90	309.10	3.39
	80	184.62	6.94	21.36	279.97	3.65
Neptune	20	152.97	7.27	23.01	248.28	3.84
	40	160.74	7.67	22.32	253.70	3.83
	60	174.17	7.32	19.54	263.73	3.56
	80	195.80	6.73	19.61	203.61	3.58
Nima	20	158.25	7.90	22.76	225.93	3.50
	40	166.94	8.57	21.06	292.75	3.51
	60	173.67	7.68	21.75	281.20	3.70
	80	199.28	6.36	19.73	235.86	3.27
Marathon	20	147.40	7.93	27.62	335.74	3.13
	40	165.08	7.87	23.12	299.63	3.37
	60	171.33	6.81	23.87	328.73	3.69
	80	179.30	7.38	21.48	177.75	3.11
Nilofar	20	158.40	8.80	21.51	263.59	3.87
	40	162.91	8.83	18.79	296.61	3.62
	60	174.17	8.34	20.55	268.08	3.86
	80	185.90	5.89	20.55	198.18	3.35
LSD ($p \leq 0.05$)		9.342	0.919	2.012	31.28	0.297

The analysis of variance shows that simple effects of the year, genotype, and plant population significantly affected the number of grains per pod. The mean data comparison shows that the maximum (24 grains) and minimum (20.39 grains) number of grains per pod were observed for Marathon and Nilufar, respectively. Additionally, the most and fewest grains per pod were obtained from 20 plants m^{-2} (24.32 grains) and 80 plants m^{-2} (20.56 grains), respectively (Table 3). The most grains per pod were found for the Nafis cultivar (26.41 grains per 20 plants m^{-2}), and the fewest were found for Nilufar (18 grains per pod), although the difference was not significant with 60 and 80 plants m^{-2} plant populations (Table 4). Singh et al. (2001) reported that the number of rapeseed grains per pod was affected by genotype. The ability of rapeseed genotypes to produce grain varies and is one of the main components of yield (Rao & Mendham, 1991). Additionally, the interaction of the year and genotype was significant. ANOVA results show that the interaction of the year and plant population significantly affected the number of grains per pod. In general, the number of grains decreased with an increasing plant population in the two years; the highest number were observed under 20 plants m^{-2} in the second year. The interaction between the year, plant population, and genotype for the number of grains per pod was significant (Table 3).

The analysis of variance shows a significant effect of the year and genotype and of the interaction between the genotype and plant population on the number of pods per plant (Table 3). Natalie had the most pods per plant (294.94 pods), and Neptune had the fewest pods per plant (242.33 pods). We observed the most pods per plant at 20 plants m^{-2} (283.32 pods); however, no significant difference was observed in the 40 and 60 plants m^{-2} plant populations. The fewest were obtained from 80 plants m^{-2} (219 pods) (Table 3). The interaction between the genotype and plant population shows that among all treatments, the Marathon hybrid (335 pods), followed by the Rohan hybrid (334 pods) coupled with 20 plants, produced the most pods. The results show that the number of pods per plant was reduced by increasing the plant population (Table 4). The number of pods per plant was significantly affected by the year and plant population, but the year had a more significant impact on this variable. The number of pods decreased significantly with an increasing plant population in the first year, but this trend was not observed in the second year. Table 3 indicates that the interaction of the year, plant population, and genotype significantly affected the number of pods per plant. It is well documented in the literature that the number of pods is a determinant of rapeseed yield (Hasanuzzaman, 2008; Yasari et al., 2008). Yasari et al. (2008) found that the number of pods per plant decreases by increasing the plant population. Other researchers have reported results similar to those of this study in that the number of pods per plant was reduced by increasing the plant population (Leach et al., 1998). The number of pods per plant decreases with increasing density due to more competition and a reduced zone. Genotype, soil, and environmental conditions affect the number of pods per plant (Sana et al., 2003). The number of pods per plant is one of the main components of yield. Rapeseed yield is primarily determined by the number of pods per unit of area (Morrison & Stewart, 2002). Taylor and Smith (1992) identified the number of pods as the most critical factor in the difference in yield of different rapeseed genotypes. Diepenbrock (2000) also reported that the number of pods per plant affects grain yield.

The analysis of variance shows that the effect of the year and plant population and their interaction at the level of 1% and the effect of the genotype at the level of 5% on 1000-grain weight were significant. Additionally, the 1000-grain weight was mainly affected by the interaction of the year, plant population, and genotype (Table 3). Natalie and Neptune hybrids at 20 and 40 plants m^{-2} and the Nilufar cultivar at 20 and 60 plants m^{-2} had the highest 1000-grain weight (4 g), and the Marathon hybrid at 20 and 80 plants m^{-2} had the lowest 1000-seed weight (3 g) (Table 4). Fathi et al. (2008)

also showed that increasing the plant population reduces the 1000-grain weight. Increasing the plant population increases interplant competition and the closure of canopies and reduces the number of subbranches. Under such conditions, a lack of factors such as radiation and nutrients weakens the plant and does not produce enough sap to fill the grains. As a result, the number of grains per pod and 1000-grain weight decrease (Gill & Narang, 1993).

The results show that the effect of the year, genotype, and plant population at the level of 1% on grain yield was significant (Table 3). The mean data comparison shows that the Marathon and Natalie hybrids had the highest grain yields (4158 and 4111 kg ha^{-1}, respectively), and the Nilufar cultivar had the lowest grain yield (2977 kg h^{-1}). We reported the highest grain yield at 60 and 40 plants m^{-2} (3939 and 3848 kg h^{-1}, respectively) and the lowest seed yield at 80 and 20 plants m^{-2} (3549 and 3475 kg h^{-1}, respectively) (Table 3). Significant interactions between the year and plant population were found for grain yield (Table 3). The grain yield varied significantly with changes in the plant population and by year. For the same plant population, grain yield increased in the second year, whereas the seed yield per hectare increased. Among all of the treatments, 60 plants m^{-2} produced the highest grain yield, while 20 plants m^{-2} produced the lowest grain yield in both growing seasons (Table 3).

There are different recommendations for hybrid and open-pollinated cultivars in Australia (French et al., 2016). The recommended plant population in areas with low precipitation is from 20 to 25 plants m^{-2} for hybrids and 30-40 plants m^{-2} for open-pollinated cultivars (DAFWA, 2015). The optimal plant population for hybrids is usually lower than that of open-pollinated cultivars (French et al., 2016), which is consistent with the results of the present study. Mahli et al. (2007) stated that hybrid cultivars produce more biomass and grain yield than open-pollinated cultivars; in the present study, hybrids also had a higher yield than open-pollinated cultivars. Rapeseed yield usually does not change significant at a plant population of more than 50 plants m^{-2}, even in high-yield media (Angadi et al., 2003; Kutcher et al., 2013), although some researchers in North America have reported increased yields for larger plant populations (Hanson et al., 2008; Harker et al., 2012). On the other hand, some other researchers have observed yield reduction in response to increased density (Roques & Berry, 2016).

Plant populations can affect canopy growth, radiation absorption, soil water evaporation, dry matter production, fungal and viral diseases, weed competition, and grain yield (López-Bellido et al., 2005). As a result, we can expect an increase in the final grain yield per unit of area relative to the yield of each plant for the optimal plant population (Lin et al., 2009; Dong et al., 2010). Researchers have shown that an optimal plant population can effectively increase grain yield (Momoh & Zhou, 2001). On the other hand, with an excessive increase in density, the yield decreases due to competition for radiation and nutrients (Malhi & Gill, 2004). Another reason for the reduced yield of large plant populations is the placement of flowers in the stem due to a dense canopy and increase in disease (Hanson et al., 2008; Roques & Berry, 2016). For small plant populations, the remaining plants can partially compensate for the reduction in yield (Mujtaba & Haidar, 2003). Rapeseed can regulate its yield in various plant populations (Angadi et al., 2003).

The analysis of variance shows a significant effect of the year and plant population at the level of 1% and an effect of the genotype at the level of 5% on grain oil (Table 3). The mean comparison of the two-year data shows that the oil content of the Rohan, Nafis, and Nima genotypes (approximately 35%) was higher than that of the other genotypes. The oil content at 40 and 60 plants m^{-2} was greater than that of the other two plant populations, but their difference at 20 plants m^{-2} was insignificant. Grain oil was affected by the interaction of year, plant population, and genotype characteristics (Table 3). Sharief et al. (2002) reported that the highest oil content is obtained from the smallest plant population. On the other hand, some researchers believe that the effect of the plant population on rapeseed oil content is still unclear (Zhang et al., 2012).

The analysis of variance shows that the effect of the year and plant population on oil yield was significant at the level of 1% (Table 3). The mean data comparison shows that the oil yields of the 40 and 60 plants m^{-2} plant populations (1337 and 1301 kg oil per hectare, respectively) were slightly higher than those of the 20 and 80 plants m^{-2} plant populations (oil yields of 1235 and 1272 kg oil per hectare, respectively) (Table 3). This difference is more greatly affected by grain yield.

Conclusions

In this study, the effect of the year, plant population, and genotypes and their interactions influenced many rapeseed traits. Due to weather conditions prevailing in the years of the experiment, differences between the given traits occurred. As a result, the effect of the year was significant for most traits, which are affected by weather conditions. Most of the studied traits in the second year of the experiment had higher values than those in the first year, indicating the presence of optimal weather conditions in the second year of the experiment. Adverse weather is often associated with canola yield reduction. The present studies demonstrate the negative impacts of high temperatures and low precipitation and, to a lesser extent, cooler-than-average nighttime temperatures. On the other hand, each growth stage has unique environmental requirements, from soil temperature and light availability to optimal air temperature and water supply. Thus, ideal weather conditions for one growth stage are not necessarily ideal for another. On the other hand, plant population was identified as an effective trait, and the highest grain yield was obtained from plant populations of 40 and 60 plants m^{-2} (approximately 3900 kg h^{-1}). However, open-pollinated cultivars with 60 plants m^{-2} and hybrids with 40 plants m^{-2} had higher yields, as recommended for farmers in the region. Of course, rapeseed offers a considerable degree of flexibility for different plant populations and can maintain its yield through adjusted branching under different conditions. However, considering agricultural conditions and economic issues, 60 plants m^{-2} can be recommended because sometimes, due to undesirable conditions during sowing, seed loss may reduce the plant population per unit of area. Additionally, the genotypes studied were different from each other in terms of traits. The highest yield was obtained from the Marathon and Natalie hybrids (4158 and 4111 kg h^{-1}). Additionally, the genotypes of Neptune, Nafis, Rohan, and Nima had acceptable yields. The use of climate-friendly cultivars in each region increases yield per unit of area. In addition to environmental compatibility, economic issues or the cost of purchasing seeds should also be considered.

Resumen

A. Z. Siahbidi, y A. Asgari. 2023. Determinación de la población vegetal óptima y el genotipo de colza (*Brassica napus* L.) en el oeste de Irán. Int. J. Agric. Nat. Resour. 1-11. Este estudio se realizó con el objetivo de determinar la densidad de plantas y el genotipo de colza más adecuados en la Estación de Investigación Eslamabad-e-Gharb en el oeste de Irán durante 2018-2020. La densidad de plantas incluyó cuatro niveles de 20, 40, 60 y 80 plantas m^{-2}, y los genotipos incluyeron los híbridos de Natalie, Rohan, Neptune y Marathon y los cultivares de polinización abierta Nafis, Nima y Nilufar. Los resultados experimentales mostraron que el efecto del año en todos los rasgos fue significativo y la diferencia en los factores climáticos en los dos años del experimento causó un efecto significativo en los rasgos estudiados. La densidad de plantas tuvo un efecto significativo sobre la altura de la planta, el número de ramas, el número de semillas por vaina, el rendimiento de semillas, el aceite de semillas y el rendimiento de aceite. El efecto del genotipo también fue significativo en todos los rasgos excepto en el rendimiento de aceite. La interacción entre la densidad de la planta y el genotipo en la altura de la planta, el número de ramas, el número de semillas por vaina, el número de vainas por planta y el peso de 1000 semillas también fue significativa. En general, se utilizan cultivares de polinización abierta Nima, Nafis y Nilufar a una densidad de 60 plantas m^{-2}; e híbridos Natalie, Rohan, Neptune y Marathon a una densidad de 40 plantas m^{-2}, se obtuvo mayor rendimiento de semilla.

Palabras claves: *Brassica napus* L, componente de rendimiento, consumo de semillas, producción de aceite, rendimiento de semillas.

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