Advances in Environmental Biology, 6(3): 1000-1005, 2012
ISSN 1995-0756

This is a refereed journal and all articles are professionally screened and reviewed **ORIGINAL ARTICLE**

Effect of Plant Density on Yield, Yield Components, Oil and Protein of Canola Cultivars in Hajiabad

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Mostafa Naghizadeh and Rohollah Hasanzadeh: Effect of Plant Density on Yield, Yield Components, Oil and Protein of Canola Cultivars in Hajiabad

ABSTRACT

A factorial testing was conducted in the form of complete random blocks design with four replications in crop year 2008-2009 in research field of Haji Abad city Agricultural Research Station, in order to study the impact of planting density on yield, yield components, oil and protein of four varieties of Brassica napus L.The first factor included planting density in four levels of (40, 60, 80 and 100 plants per square meter) and the second factor included four varieties of Brassica napus L. (Hayola 401, Sarigol, Hayola 308 and Option 501). The results showed that increase of planting density per unit area caused reduction of most under study traits, so that density of 40 plants per square meter would produce the maximum pods per plant (83.75), grain weight (4.61 g), seed yield and biological yield (4460 and 15,444 kg per hectare), oil content (42.12) and protein content (25.40). Among the studied varieties, the variety of Hayola 401 possessed the highest seed and oil yield, biological yield, grain weight and protein content and this variety can be considered in future researches. In the present study, the interaction of density and variety with some traits developed into significant. So that the highest seed and oil yield (5100 and 2275.6 kg per hectare) as well as the number of pods per plants (91) was obtained by the variety of Hayola 308 in the density of 40 plants per square meter and the highest biological yield (18800 kg per hectare) was obtained by the same variety in the density of 60 plants per square meter.

Key words: *Brassica napus L, Variety, Planting Density, Yield, Oil Content, Protein Content.*

Introduction

Brassica napus L. is one of the main agricultural plants cultivated across the world to extract oil and in terms of production it stands at the third rank after soybeans and palm oil [1]. Brassica napus L. is a new product with special traits which can exploit seasonal rainfall like winter Plants and can be an appropriate alternative for wheat and oats [8]. Brassica napus L. yield can be improved by observing plant propagation principles and eugenics principles. For this purpose, the maximum genetic capacity of the existing varieties should be also used in different weather conditions, while higher yield varieties are being introduced [6] and this goal can be achieved through practicing different managements such as proper planting density. One of the appropriate ways to increase yield per unit area is through application of suitable varieties compatible with climatic conditions of each region, so that there would be the least destructive competition between plants [10]. The impact of monotonous distribution per unit area on proper distribution of the light received is shown within the vegetation, so the main impact of planting density on the crop is mainly due to the differences in the distribution of solar radiation energy and increase of solar radiation absorption will lead to increase in performance. In excess of densities, creation of inappropriate microclimate and consequently risk of incidence of diseases and pests, decreases seed yield [2,10]. In optimum planting densities, plants will reach the phase of 8-leaf and approximately 2-cm diameter stem before stage of length growth of stem and will show good resistance toward cold of winter [2,13]. Increase of herb density is associated with increase of plant height as well as increase of stem internode length and decrease of stem diameter, and while forming the pod, weightiness of upper parts in the plant may cause decumbency and some problems in the mechanized harvest. If decumbency occurs when the plant is metabolically activate, it will be followed by direct loss of seed yield [16]. The researches by Gill and Narang [7] show that increase in plant density led to increase of intra-plant competition, canopy closure and lack of proper distribution of optical radiation in plant community and deficient in available nutrients which weakens the plant and prevents it from

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producing enough nourished sap to fill the seeds and consequently decreases the seed yield. The results of researches by Johnson and Hanson [9] show that by increase in plant density, oil content of seed is reduced due to decrease of assimilate distribution to seed and shortening of effective seed filling period. Also in extra desired planting densities, the number of subsidiary branches and the number of pods per plant is reduced as a result of which the seed yield of each plant will be decreased [12& 0]. Therefore, considering the above facts, it is worthy to conduct further studies in this respect; so the aim of this study is to determine the best density and appropriate variety of Brassica napus L. to achieve the highest yield and quality for practical use in Haji Abad city.

Materials and Methods

A factorial testing was conducted in the form of complete random blocks design with four replications crop year 2008-2009 in Hajiabad city Agricultural Research Station of Hormozgan province (55° 55' N, 28° 19' E, 870 meters above sea level) in order to study the impacts of four planting densities of 40, 60, 80 and 100 plants per square meter on qualitative and quantitative characteristics of four varieties of Brassica napus L. (Hayola 401, Sarigol, Hayola 308 and Option 501). The varieties of Hayola 401, Hayola 308 and Option 501 are modified from Australia and the variety of Sarigol is from Germany; these varieties are spring crop type, adapted to temperate, warm and humid areas. Contexture of soil of the studied field was Loamy clay type with EC of 2.1 mill mouse per cm and PH of 8.2. Urea and ammonium phosphate fertilizers were added to the soil respectively by 50 and 150 kg per hectare during planting to compensate absence of nutrients in soil. Also 100 kg per hectare urea fertilizer was applied in the beginning of stem elongation and 50 kg per hectare was applied as surplus at flowering stage of each one of them. After implementing test plan in the field, seeds of Brassica napus L. were cultivated manually quite similar as salt marsh in 10 October 2009 within the basins, 5meters in length and 2 meters in width and 3 cm in depth with 30 cm row spacing. Basins were irrigated uniformly using a siphon. Weeds in the borders between the rows were weeded manually during the growing season. The desired density within each basin was obtained by thinning at the stage of 4-5 leaf of the plants. During the growing season, Brevicoryne brassica was combated against through manual spraying using Metasystox- R pesticides. Plant samples were dried for 48 hours at 70° C in oven to determine the final dry weight. At the end of maturity stage, plants of three middle rows of each basin were cut completely from the soil surface and were transferred to the laboratory to determine the seed yield and biological yield and its components. Seed protein content was measured using Kjeldahl method and seed oil content was measured using the direct method (by SOOKSELE APPARATUS). At the end, data obtained by SAS software were analyzed and the mean of data were compared according to Duncan test at 5% of probability level.

Results and Discussion

1 – The number of fertilizer pods per plant :

The effect of density, variety and interaction of density and variety at probability level of one percent on the number of fertilizer pod per plant, has become significant (Table 1). The variety of Hayola 308, in planting density of 40 plants per square meter and the varieties of Option 501 and Sarigol in planting density of 100 plants per square meter respectively produced the highest and lowest numbers of pods per plant (Table 3). In this study, increase of planting density significantly reduced the number of pod per plant, so that planting density of 40 plants per square meter with the average of 83.75 pods per plant produced the lowest number of pods per plant (Table 2). In Brassica napus L., the number of pods per plant, is one of the very important traits on which seed yield strongly depends [2]. After flowering stage, by reducing leaf area of the plants, pods have important role in plant photosynthesis. According to the results of Chapman *et al.* [4] increase in Brassica napus L. plant density reduces the penetration of light into plant canopy and consequently outbreak of the buds forming subsidiary branch is diminished. Reduction of the number of subsidiary branches is the main reason for reducing the number of pods per plant. According to the observations obtained during the growing season, it appears that in present study, in higher densities, due to abundance of canopy branches and leaves, adequate light has not influenced within the canopy of Brassica napus L. Therefore, fewer pods are formed per plant. Also in this study, the varieties of Hayola 308 and Hayola 401 possess the maximum and Sarigol and Option 501 possess the minimum number of pods per plant (Table 2).

2 – The Number of Seeds per Pod:

The increase of planting density caused no significant change in the average number of seeds per pod (Table 1). In other words, higher plant density affected seed yield through reducing the number of pods per plant, with no significant effect on the number of seeds per pod. Scarisbrick *et al.* [18] in a similar study on Brassica napus L. in the UK concluded that the reason for the absence of significant change in the number of seeds per pod at high densities is the compensatory effect of reduction in the number of pods per plant. Also, in this study, no significant effect was observed among the studied varieties in terms of the numbers of seeds per pod

(Table 2). Generally, as multiple researchers have also reported [12,14&18], in the present study, high density has applied its effect more through reducing the number of pods per plant and consequently drop in the number of seeds per pod has not been significant.

3 - Grain Weight

The results from analysis of variance showed that there is a significant difference between the different plant densities and varieties for grain weight (Table 1). In the present study, increase of plant density reduced grain weight; so that the densities of 40 and 60 plants per square meter (respectively with means of 4.61 and 4.57 g) produced the highest and the densities of 80 and 100 plants per square meter (respectively 4.07 and 4 g), produced the lowest grain weight (Table 2). The researches by Zang and Sedum [21] show that increase in plant density, dry weight of seeds per plant has a decreasing trend; because the increase in plant density, due to increase of intra-planet competition, reduction of achievable nutrients and reduction of plant ability in using environmental conditions to perform photosynthesis to cause biological imbalance in the plant and creation of a tension for the plant; consequently, the plant to reduce the effects of this tension and to provide balance between photosynthesis materials, respiration and storage of materials, expedite seeds filling which shortens the duration of seeds filling and reduces grain weight. Among the subject varieties, the varieties of Hayola 401 and Hayola 308 possess the highest and the varieties of Option 501 and Sarigol possess the lowest grain weight (Table 2). One of the reasons for the difference between grain weights of different varieties is genetic differences [16].

4- Biological Yield :

Interaction of planting density and variety with biological yield at the probability level of one percent was significant (Table 1). So the variety of Hayola 0401 by the density of 60 plants per square meter (18,800 kg per hectare) produced the highest biological yield and the variety of Option 501 by the density of 100 plants per square meter (7000 kg ha) produced the lowest biological yield (Table 3). In the variety of Hayola 401, the biological yield increased by increasing density from 40 plants to 60 plants per square meter, so that biological yield in this variety significantly decreased by increasing density from 50 to 100 plants per square meter (Table 3). In general, in this study, biological yield decreased in different varieties by increasing density, so that the density of 40 plants per square meter, with mean of 15,444 kg per hectare and possessed the highest and the density of 100 plants per square meter, with mean of 9,325 possessed the lowest biological yield (Table 2). Relatively short and thick stems as well as increase of yield and its components, excess of dry material total plant density of 40 plants per square meter produced high biological yield in this planting density. In the study by Leach *et al.* [10] also increase in plant density reduced the biological yield in Brassica napus L; they also attributed the reason for increase at lower densities to production of short and thick stems. A significant difference was observed among the subject varieties in this study in terms of biological yield (Table 1) so that the variety of Hayola 401 produced the lowest and the variety of Option 501 produced the highest biological yield (Table 2); that this increase in yield in the variety of Hayola 401 can be attributed to the excellent consistency of this variety with the weather of Haji Abad area; therefore, those plants will have high yield that according to their own growing conditions, used the production factors in their extremities and accumulate more photosynthesis materials in their own limbs.

5- Seed Yield:

Interaction of planting density and variety on seed yield was significant at the probability level of one percent (Table 1); so that the varieties of Hayola 0401 and Hayola 308 in planting density of 40 plants per square meter (respectively with means of 5100 and 5050 kg/ha^2) produced the highest and the variety of Option 501 in density of 100 plants per square meter (1996 kg ha) produced the lowest biological yield (Table 3). By increase in planting density, seed yield significantly decreased which can be attributed to increase of intra-plant competition, canopy closure and absence of proper distribution of optical radiation in plant community and deficient in available nutrients which weakens the plant and prevents it from producing enough nourished sap. Generally, planting densities of 40 and 60 plants per square meter possessed the highest and the density of 100 plants per square meter possessed the lowest seed yield (Table 2). Increase of seed yield in the densities of 40 and 60 plants per square meter can be attributed to increase of production of more dry material as well as production of more pods per plant in these densities.The results of different studies [3,11&10] also shows a decrease in seed yield with increase in plant density. In this study, a significant difference was also observed among the studied varieties in terms of seed yield (Table 1) so that the varieties of Hayola 401 (4255 kg/ha^2) and Hayola 308 (3980 kg/ha^2) possessed the highest and the varieties of Option 501 (3084 kg/ha^2) and Sarigol (3245 kg/ha^2) possessed the lowest seed yield (Table 2). In this study, it was not unexpected to achieve the maximum yield in the varieties of Hayola 308 and Hayola 401, due to having the highest grain weight, the number of pods per plant as well as biological yield.

6- Seed oil content:

Results from statistical analysis showed a significant difference for oil content among the different plant densities and the varieties (Table 1). In the present study, increase of planting density decreased seed oil content in a way that the density of 40 plants per square meter (42.12 percent) produced the highest and the density of 100 plants per square meter (37.63 percent) produced the lowest oil content (Table 2). Some researchers [5,10] considered reduction of distribution of assimilates to seeds and shortening of effective seed filling period as the reason for oil content decrease with increase of density. In the present study, a significant difference was observed in terms of oil content among the studied varieties (Table 1); in such a way that the variety of Hayola 308 possessed the highest and the variety of Sarigol possessed the lowest oil content (Table 2).

7- Oil Yield:

Interaction of planting density and variety with oil yield at the probability level of one percent was significant (Table 1). So that the variety of Hayola 308 by the density of 40 plants per square meter (2275.6 kg per hectare) produced the highest and the varieties of Option 501 and Sarigol by the density 100 plants per square meter (respectively 740 and 750 k/ha^2) produced the lowest oil yield (Table 3). In general, in this study, oil yield decreased in all varieties by increasing planting density which is more due to increase of seed yield per unit area, many researchers have also reported similar results [17,19&10]. In this study, a significant difference was also observed among the studied varieties in terms of oil yield (Table 1) so the varieties of Hayola 401 and Hayola 308 possessed the highest oil yield (Table 2), so that if excellence these varieties is still confirmed in further researches in terms of oil yield, recommendation of their cultivation to the farmers will be effective.

8- Protein Content:

The results from analysis of variance showed that there is a significant difference between the different plant densities and varieties for protein content (Table 1). In the present study, increase of plant density reduced seed protein content; so that the density of 40 plants per square meter (28.50 percent) produced the highest and the densities of 100 plants per square meter (21.13 percent) produced the lowest protein content (Table 2). The cause of this phenomenon can be attributed to greater availability of required nitrogen (during seed filling) in lower densities compared to higher densities [3 and 5]. In this study, a significant difference was observed among the studied varieties in terms of protein content (Table 1), in such a way that the variety of Hayola 401 possessed the highest and the variety of Sarigol possessed the lowest protein content (Table 2).

Conclusion :

This study showed that the highest seed yield, oil yield and the number of pods per plants is obtained in the variety of Hayola 308 by the density of 40 plants per square meter and the highest biological yield is obtained in the same variety by the density of 60 plants per square meter. Increase of plant density per unit area was associated with decrease in grain weight, biological yield, oil content and protein content. Reduction of intra-plant competition, proper distribution of optical radiation and production of enough nourished sap in low densities increased production of higher dry matter as well as production of greater number of plants per pod at low densities, and ultimately increased seed yield, oil and most of the yield components in low densities. Trait of the number of seeds per pod is of relatively stable components of seed yield and it does not seem to change significantly under influence of factors such as plant density and variety. In this study, the variety of Hayola 401 possessed the highest protein content (28.5) and the variety of Hayola 308 possessed the highest oil content (42.40) which is recommended to be considered in future researches.

Table 1: sum of squares and variables for assessable traits of varieties of Brassica napus L. at different densities

variables	Freedom degree	The number of pods per plant	The number of seeds per pod	Grain weight	biological yield	cultivation index	seed yield	oil content	oil yield	protein content	protein yield
repetition	3	647/28*	ns 24/42	ns 0/0075	* 2654951	ns 25/2	ns 173834	** 17/704	ns 22010	ns 1/47	ns 17968
density	3	6562**	ns 13/92	5/67**	** 309330830	** 130/5	** 37818132	73/51**	** 7764669	149*	** 1040591
variety	3	2093**	ns 10/3	9/26**	** 245142893	ns 17	** 21515644	/879** 52	** 3251589	567**	** 3551082

Density* error variety	9	1717**	ns 22/01	ns 0/72	** 19931573	ns 42/2	** 2437368	ns 6/305	** 490498	4/36 ns	ns 152937
	45	2666	214/32	1/93	12351345	176/2	1254818	46/54	305679	556	887198
Variation coefficients		10/81	12/11	4/9	4/04	7/11	4/6	2/5	5/6	15/22	16/62

**: Significant at probability level of 1%, * significant at probability level of 5%, ns: not significant

Table 2: Comparison of means of effects of density and variety on measurable traits at probability level of 5% using Duncan method*

attendance		The number of fertile pods per plant	The number of seeds per pod	Grain weigh (gr)	biological yield (Kg ha)	cultivation index (Percentage)	seed yield (Kg ha)	oil content	oil yield (Kg ha)	protein content	protein yield (Kg ha)
Density	40 plants	**83/75** a	**17/8** a	**4/61** a	**15444** a	**28/87** a	**4460** a	**42/12** a	**1878/9** a	**25/40** a	**1132/84** a
	50 plants	**78** a	**18/1** a	**4/57** a	**15262/5** a	**26/96** b	**4115** a	**41/13** b	**1692/5** b	**23/9** b	**983/48** b
	70 plants	**67/37** b	**18/2** a	**4/07** b	**11807/5** b	**28/41** a	**3355** b	**40/90** b	**1372/5** c	**21/97** c	**737** c
	100 plants	**55/6** c	**17/7** a	**4** b	**9325** c	**28/24** a	**2634** c	**37/63** c	**991/25** d	**21/13** c	**556/56** d
variety	Hayola 401	**76/87** a	**18/70** a	**4/70** a	**15636/5** a	**27/21** b	**4255** a	**40/83** b	**1737/5** a	**28/50** a	**1212/67** a
	Sarigol	**66/37** b	**18/15** a	**3/81** b	**11500** c	**28/21** b	**3245** b	**39/21** c	**1272/5** b	**22/1** c	**717/14** c
	Hayola 308	**77/97** a	**18/57** a	**4/64** a	**14395** b	**27/64** b	**3980** a	**42/40** a	**1687/65** a	**24** b	**955/2** b
	Option 501	**63/5** b	**17/68** a	**3/73** b	**10307/5** d	**29/91** a	**3084** b	**40/12** b	**1237/5** b	**17/79** d	**548/64** d

*: In each column, the means with at least one common letter are not significantly different at probability level of 5%.

Table 3: Comparison of the means of interaction of density × variety with the studied traits of Brassica napus L. using Duncan method*

Fertilizer × density		The number of pods per plant	biological yield (Kg ha)	seed yield (Kg ha)	oil yield (Kg ha)
40 plants per square meter	Hayola 401	ab **85**	c **16746**	a **5050**	b **2090**
	Sarigol	ab **81**	de **14100**	de **3880**	d **1600**
	Hayola 308	a **91**	b **17700**	a **5100**	a **2275/6**
	Option 501	bc **78**	ef **13230**	e **3810**	de **1550**
60 plants per square meter	Hayola 401	ab **85**	a **18800**	b **4800**	b **2100**
	Sarigol	bcd **73**	fg **12800**	ef **3760**	ef **1490**
	Hayola 308	ab **83**	c **16750**	c **4200**	c **1750**
	Option 501	b-e **71**	fg **12700**	f **3700**	f **1430**
80 plants per square meter	Hayola 401	c-f **69**	d **14700**	d **3970**	def **1520**
	Sarigol	def **65/5**	i **11000**	h **2860**	g **1250**
	Hayola 308	bcd **75**	ef **13230**	ef **3760**	ef **1490**
	Option 501	f **60**	k **8300**	h **2830**	g **1230**
100 plants per square meter	Hayola 401	c-f **68/5**	gh **12300**	g **3200**	g **1240**
	Sarigol	g **46**	k **8100**	i **2480**	h **750**
	Hayola 308	ef **62/9**	j **9900**	h **2860**	g **1235**
	Option 501	g **45**	l **7000**	j **1996**	h **740**

*: In each column, the values with at least one common letter are not significantly different at probability level of 5%.

References

1. Al-Barrak, Kh.M., 2006. Irrigation interval and nitrogen level effects on growth and yield of canola (*Brassica napus* L.). Scientific Journal of King Faisal University. Al-Hassa, Saudi Arabia., 7(1): 87-102.
2. Appelquist, L.A. and R. Ohlson, 1972. Rapeseed. Pub. Elsevier.Com. Amsterdam London New York. pp: 394.
3. Buttar, G.S. and C.S. Aulakh, 1999. Effect of sowing date, nitrogen and row spacing on growth, yield attributes and yield of Indian mustard (*Brassica juncea L.*). Indian J. Agron., 44(4): 813-815.
4. Chapman, J.E., R.W. Daniels and D.H., Scarisbrick. 1984. Field studies on C assimilation fixation and movement in oil-seed rape (*B. napus L.*). Journal of Agricultural Science Cambridge, 102: 22-31.

5. Diepenbrock, W., 2000. Yield analysis of winter oilseed rape (*Brassica napus L.*): a review. Field Crops Res., 67: 35-49.
6. Epplin, F.M., I. Hossain and E.G. Krenzer, 2000. Winter wheat fall winter forage yield and grain yield response to planting date in dual-purpose system. Agricultural Systems, 63: 161-173.
7. Gill, M.S. and R.S. Narang, 1993. Yield analysis in Gobhi Sarson (*Brassica napus*) to plant density and nitrogen. Indian. J. Agron., 38: 257-265.
8. Johnson, A.M., D.L. Tanaka, P.R. Miller, S.A. Brandt, D.C. Nielsen, G.P. Lafond and N.R. Riveland. 2002. Oilseed crops for semiarid cropping systems in the Northern Great Plains. Agron. J., 94: 231-240.
9. Johnson, B.L. and B.K. Hanson, 2003. Row spacing interactions on spring canola performance in the Northern Great Plains. Agron. J., 95: 703-708.
10. Leach, J.E., H.J. Stevenson, A.J. Rainbow and L. Mulled, 1999. Effect of high plant population on the growth and yield of winter oilseed rape (*Brassica napus* L.). Journal of Agricultural Science, 132: 173-180.
11. Makay, K.R., A.A. Schneiter, B.L. Johnson, B.K. Hanson and B.G. Schatz, 1992. Influence of planting date on canola and Crambe production. North Dakota farm Research, 49: 23-26.
12. Mendham, N.J. and R.K. Scott., 1975. The limiting effect of plant size at inflorescence initiation on subsequent growth and yield of oilseed rape. Journal of Agricultural Science Cambridge. 84: 487-502.
13. Moore, M.K. and O.G. Stephen. 1997. Agronomic response of winter rapeseed to rate and date of seeding. Agronomy of Journal., 89: 521-526.
14. Morison, M.J., P.B. Mcverry and R. Scarth, 1990. Effect of altering plant density on growth characteristics of summer rape. Can. J. Plant Sci., 70: 139-149.
15. Ozer, H., 2003. The effect of plant population densities on growth, yield and yield components of two spring rapeseed cultivars. Plant Soil Envirement, 49(9): 422-426.
16. Potter, T.D., J.R. Kay and I.R. Luding, 1999. Effect of row spacing and sowing date on canola cultivars with varying early vigor. South Australian Research and Development institute, pp: 635-641.
17. Prakash, P.W. and Z.H. Irdormader., 1981. The effect of Gobhi Sarson (*Brassica napus*) to nitrogen and plant population. Can. J. Plant Sci., 34(7): 320-330.
18. Scarisbrick, D.H., R.W. Daniels and A.B. Nor Rawi., 1982. The effect of varying seed rate on the yield and yield components of oil-seed rape. Journal of Agricultural Science Cambridge., 99: 561-568.
19. Shaberi, Q.P. and H.J. Komar, 1981. The response of nitrogen level and row spacing on the rape. Can. J. Plant Sci., 73(8): 581-589.
20. Tayo, T.O. and D.G. Morgan, 1979. Factors influencing flower and pod development in oil-seed rape. Journal of Agricultural Science Cambridge, 92: 363-373.
21. Zang, P.H. and P.J. Sedum, 1995. Interactions among phosphorous, nitrogen and growth in oilseed rape. Can. J. Plant Sci., 74(3): 173-181.