Response of Yield, Yield Components and Seed Quality of Some Rapeseed Genotypes (*Brassica napus* L.) to Plant Density under Rainfed Conditions

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Abstract:

This study was conducted at the Sheikh Mohamed location which is far about (25 km) west north Mosul city during 2009-2010, 2010-2011 seasons. Three rapeseed genotypes (Tantal, Kroko and Rapol), were tested under three plant density (29629, 44444 and 88888 plants. hectar^{-1}) to determine the effect of plant density on the rapeseed (*Brassica napus L.*) seed yield, yield components and seed quality. The results showed that plant density of 29629 plants. hectar^{-1} gave the highest mean for characters stem diameter, number of primary branches, number of silique per plant, leaf area, number of seed per silique, weight of thousand seed, and oil, protein percentage in 2009-2010, 2010-2011 seasons, While the plant density of 88888 plants. hectar^{-1} gave a high mean for plant height in both growing seasons. The genotypes differed significantly in all the related characteristics, the Kroko genotype come over the other genotypes in plant height, stem diameter, number of branches/plant, leaf area, number of silique /plant, number of seed/ silique, 1000 seeds weight (g.) seed yield (ton.ha^{-1}), oil, protein percentage of seeds and oil, protein yield (ton.ha^{-1})in both growing seasons. The interaction between plant density and genotypes was significant in plant height in 2009-2010 season only, the Kroko genotype with plant density at 88888 plants.hectar^{-1} gave highest mean for plant height.

استجابة الحاصل ومكوناته ونوعية بذور بعض التراكيب الوراثية من السلجم (*Brassica napus* L.) للكثافة النباتية تحت الظروف الديمية

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ملخص البحث:

أجريت هذه الدراسة في موقع الشيخ محمد الذي يبعد حوالي (25 كم) شمال غرب مدينة الموصل أثناء العامين 2009–2010 و2010–2011. اختبرت ثلاثة تراكيب وراثية من السلجم (تانتل، كروكو ورابول) تحت ثلاث كثافات نباتية (29629، 44444 و88888 نبات/هكتار) لتحديد تأثير الكثافة النباتية في حاصل بذور السلجم (*Brassica napus L.*) ومكوناته ونوعية البذور. أظهرت النتائج بأن الكثافة النباتية 29629 نبات/هكتار أعطت أعلى متوسط لصفات: قطر الساق، عدد الأفرع/نبات، عدد الخردلات/نبات، المساحة الورقية، عدد البذور/خردله، وزن الألف بذرة/غم، ونسبة الزيت والبروتين للموسمين 2009–2010 و2010–2011، في حين أعطت الكثافة النباتية 88888 نبات/هكتار أعلى متوسط لصفة ارتفاع النبات في كلا موسمي الزراعة. اختلفت التراكيب الوراثية معنوياً في الصفات المدروسة جميعها، إذ تفوق التركيب الوراثي كروكو في صفات: ارتفاع النبات/سم،قطر الساق، عدد الأفرع/نبات، المساحة الورقية، عدد الخردلات/نبات، عدد البذور/خردله، وزن الألف بذرة/غم، حاصل البذور الكلي والزيت والبروتين (طن /هكتار) ونسبتي الزيت والبروتين في كلا موسمي الزراعة. كان التداخل بين الكثافة النباتية والتراكيب الوراثية معنوياً لصفة ارتفاع النبات في موسم الزراعة 2009–2010 فقط، أعطى التركيب الوراثي كروكو عند زراعته بكثافة نباتية 88888 نبات/هكتار أعلى متوسط لارتفاع النبات.

Introduction:

Rapeseed (*Brassica napus L.*) has become one of the most important sources of vegetable oil in the world. Its oil also has potentially developed in the biodiesel. In addition to oil production, the leaves and stems of rapeseed provide high quality forage matter because of their low fiber and high protein content (Wiedenhoeft and Bharton, 1994) and can be milled into animal feeds (Banuelos, *et al*., 2002). It has less than 2% erucic acid and its meal has less than 30 μg of glucosinolates. It contains 40-45% oil and 36-40% protein. Oil and meal are now very acceptable as alternatives to soybean oil and meal (Amin and Khalil, 2005; Muhammad, *et al*., 2007 and AL-Doori, 2012). In oilseed rape, plant density varies considerably worldwide, depending on the environment, production system and genotype (Ozer, 2003). Previous studies have shown that plant density is an important factor affecting rapeseed yield. Plant density in rapeseed governs the components of yield, and thus the yield of individual plants. A uniform distribution of plants per area unit is a prerequisite for yield stability (Diepenbrock 2000 and Ozer, 2003). Under Mosul city conditions, AL-Doori and Hasan (2010) investigated the effects of different row spacing (30-60 cm) in rapeseed, they concluded that number of silique per plant, seed weights and dry matter per plant, weight of thousand seed and oil yield increases as row spacing increased. Leach *et al*. (1999), also reported that plants grown at high density had fewer siliques bearing branches per plant but produced more branches, and that with an increase in population, weight of thousand seed increased. The same researchers also observed that there was no effect of density on seed oil content. Rapeseed has generally slight or inconsistent seed yield responses to various row spacing. Therefore, optimum densities for each crop and each environment should be determined by local research. The present study was undertaken to assess the effect of plant density on growth, yield and quality of three rapeseed genotypes *(Brassica napus L.).*

Materials and Methods:

Two filed experiments were carried out during two winter successive seasons 2009-2010, 2010-2011 at Sheikh Mohamed location which is far about (25km) to investigate the effect of three levels of plant density (29629, 44444 and 88888 plants.hectar^{-1}) on the growth, yield and quality of three rapeseed genotypes (Tantal, Kroko and Rapol). Sheikh Mohamed is located in the west north region of Mosul city at Nineveh province. Climatically, the region placed in the semiarid temperature zone cold winter and hot summer. Average rainfall is about 375 mm that most rainfall concentrated between winter and spring. Each experiment included twenty seven experimental units comprising the combinations of three plant populations and three rapeseed genotypes with three replications. Seeds of these genotypes were obtained from the industrial crops company, Baghdad. Each plot 22.5 m^2 (5*4.5), included six rows 75 cm apart and five meters long and the distance between hills were 45, 30 and 15cm apart to attain a plant density of 29629, 44444 and 88888 plants per hectar^{-1}, respectively. Super phosphate 50 kg.ha^{-1} (45%P_2O_5) and 30 kg.ha^{-1} potassium (48%K_2O) were applied to the soil during the sowing period, nitrogen fertilizers was applied in the form of urea 80 kg.ha^{-1} (46%N) in two equal doses, immediately after thinning (two weeks from sowing) and 20 days later.

The experimental design was factorial experiment in a Randomized Completely Block Design with three replications according to Snedecor and Cochran, 1982. Then Duncan's multiple range test (Duncan, 1955) was used to compare among means (SAS, 2001). A representative soil sample (0-30 cm depth) was taken before planting, (table 5) to determine some physical, chemical and nutritional properties using the methods description by Black, 1965, Jackson, 1973, Page *et al*., 1982. Sowing dates were on the 5th and 7th of October for 2009-2010, 2010-2011 seasons, respectively. After two weeks from sowing seedlings were thinned to one plant per hill according to populations needed. The plots were weeded twice, the first one after two weeks from sowing and the second after four weeks from sowing. The external two rows were left as border. Two of the remaining rows were devoted for estimating plant growth and some characteristics. Normal cultural practices of growing rapeseed were conducted in the usual manner followed by the farmers of the district. Sample of ten plants except guarded plants each was taken from each treatment, then the following data were record: plant height (cm): The height of the main stem from ground level to the tip of the plant, stem diameter (cm): measured by using a vernier (caliper) at the third node, number of branches/plant: was determined by counting the number of primary reproductive branches and leaf area $cm^2.plant^{-1}$ (Hunt,1982 and Morrison, *et al*.1990). At harvest, (when the color of seed coat presented in the lower zone of the terminal raceme was darkish at 147, 143, 145 and 142, 146, 144 days after sowing for each genotypes Tantal, Kroko and Rapol to both seasons 2009-2010, 2010-2011, respectively), ten plants except guarded plants were taken randomly from the two inner rows of each experimental plot, then the following data were measured; number of siliques per plant. Meanwhile, ten siliques were picked at random from these ten plants, and then the following characters were determined: Number of seeds per silique. The ten selected plants, mentioned above, were cut, put in an envelope and dried naturally in the lab. Their seeds were added to their respective seeds of the ten siliques in the small bags and weighed. Then weight of thousand seed (g) was estimated by counting thousand seeds at random from each plot and weighed using a sensitive balance. Oil seed content was determined using Soxhlet method (A.O.A.C., 1980), and seed nitrogen concentration was measured by microkjeldahl method, then, protein percentage was calculated by multiplying the nitrogen percentage by the converting factor 6.25 (Agrawal *et al*., 1980).

Results and discussion:

1- Effect of plant density:

In the two growing seasons, the attributes of rapeseed exhibited significant differences for the different plant density except seed yield, oil and protein yield in the two growing seasons. Data reported in table (1) indicate the effect of plant density on rapeseed attributes i.e. plant height, stem diameter, number of primary branches, leaf area (cm^2.plant), number of silique per plant, weight of 1000 seed (g) and oil, protein percentage in two seasons.

The low plant density (29629 plants. hectar^{-1}) had a larger stem diameter (2.22, 2.42cm), higher number of primary branches (13.41, 11.21), number of silique per plant (180.02, 170.18), leaf area (2447.01, 2169.88cm^{2}.plant), weight of 1000 seed (1.31, 1.62g) and oil (40.43, 40.65), protein (18.92, 20.49) percentage than the high plant density (88888 plants. hectar^{-1}), these results are true in the two growing seasons, respectively (table 2). This is in line with Sovero, (1993); Starner *et al*., (1996); Raymer, (2002); Lessani and Mojtahedi, (2006) who attributed this result to the better soil moisture availability, decreased plant competition and increased light penetration through plant canopy at a lower plant population. These results may be attributed to the competition between plants and between the different parts of the individual plant under high planting population. In the present study, planting density exerts significant effect on plant height. The plant height was positively response with increasing plant density up to 88888 plants. hectar^{-1}, these results are true in the two growing seasons. Similar results were reported by Ali *et al*.,(1990); Misra and Rana, (1992); Chauhan *et al*., (1993); Roy *et al*., (1993); Siddiqui, (1999); Yousaf and Ahmad, (2002); Alam, (2004) and AL-Doori, (2012) reported that high plant density (low row spacing) had significant effect on plant height. In contrast, Kuchtova and Vasak, (2004) found that high plant density had no significant effect on plant height. Also Fathi *et al*., (2002) showed that high plant density had decreased number of silique per plant and weight of thousand seed. Increasing plant density up to 88888 plants. hectar^{-1} decreased oil and protein percentage at the two growing seasons. Sharma, (1992) and Al-Doori and Hasan, (2010) found that high row spacing had increased oil percentage.

2- Effect of genotypes:

The significant variations in growth characters, yield components and some related traits were presented in table (1). Data in table (3) revealed that Kroko genotype had taller (124.64, 127.68 cm) and thicker plant (2.29, 2.31cm), higher number of primary branches per plant (13.05, 11.11) then those of Tantal and Rapol in both seasons 2009-2010, 2010-2011, respectively. The differences among the three genotypes in the plant height may be attributed to the general varietals differences in the number of internodes per plant (Singh and Kumar, 1990; Ozer, 2003; Sana *et al*., 2003; Biabani *et al*., 2008 and AL-Doori, 2012). Moreover, the differences in leaf area among the three genotypes may be attributed to the differences in leaves per plant. In this concern, Al-Doori and Al-Dulaimy, (2011) showed that taller genotypes had more leaves and leaf primordial than the others rapeseed genotypes. This might explain the consistent differences among the tested genotypes in all growth characters that were measured in this study. It can also noted that the number of silique.plant^{-1}, number of seeds per silique

(8.76, 12.35), weight of thousand seed (1.35, 1.63 gm), yield and oil, protein yield (ton. hectar^{-1}) of Kroko genotype out weighed Tantal and Rapol in a descending order at both seasons, respectively. The superiority of Kroko genotype in the dry matter production may be attributed to having the tallest and thickest plants, and as well the highest area of photosynthetic leaves and this in turn increased the capacity of dry matter accumulation in the different plant parts. However, the differences in oil, protein percent of seeds may be attributed to genetic factors and their interaction with the prevailing environmental conditions. This increase in oil, protein yield (ton.ha^{-1}) from Kroko genotype may be due to their high seed yield. hectar^{-1} (table 3) rather than differences in seed oil content. Similar conclusion were reported by Singh and Kumar, (1990); Ozer, (2003); Sana *et al*., (2003); Biabani *et al*., (2008); Kargarzadeh *et al*., (2008). In this report, AL-Doori and Al-Dulaimy, (2011) reported that Emma genotype had highest plant height, number of primary branches per plant than the Topas and Monty genotypes. The superiority of Kroko genotype in the most seed characters may be due to that Kroko genotype had better vegetative growth and hence photosynthetic area which led to more carbohydrates which was translocated from the leaves and stem to the seeds (Mengel and Kirkby, 1982).

3- The interaction effect between plant density and genotypes:

Mean values of interaction between plant density and genotypes are presented in table (4). The interaction between the studying factors showed significant effects on plant height in 2009-2010 season only (table 1). Kroko genotype reflected the greatest response to plant density at 88888 plants. hectar^{-1} for plant height, with this regard, Hassan and El-Hakeem (1996) found that high plant density produced higher plant height. The interaction between the plant density and genotypes for the other investigated traits were not statistically significant in both seasons, therefore the data were not discus. The insignificant effect between plant density and genotypes on other characteristic showed that each of these two factors acted independently on these traits.

Table -1-

Analysis of variance F values for some growth characters, yield and yield components and quality in 2009-2010 and 2010-2011 seasons.

S.O.V	D.f	M.S. for 2009-2010 season											
		Plant height (cm)	stem diameter (cm)	no. of primary branches. $plant^{-1}$	no. of silique. $Plant^{-1}$	leaf area (cm^2\plant)	number of $seeds.silique^{-1}$	weight of 1000 seed (g)	seed yield ($ton.ha^{-1}$)	oil (%)	oil yield ($ton.ha^{-1}$)	protein (%)	protein yield ($ton.ha^{-1}$)
Replications	2	218.92651	0.370848	2.303125	1035.615	70041.024	5.19147778	0.1875444	0.4679094	3.0116	0.0849382	9.96691	0.0222868
P	2	2007.75**	0.6000**	9.5290**	2269.7**	1511822 **	8.198677**	0.34241**	0.01623 n.s.	10.42**	0.00161 n.s.	13.76**	0.00069 n.s.
G	2	594.072**	0.9751**	5.6606**	1047.7**	182513**	4.193633**	0.36537**	0.227978*	43.83**	0.06179**	24.21**	0.01661**
P × G	4	26.5016**	0.0160 n.s.	0.6961 n.s.	89.723 n.s.	3845.6 n.s.	0.309061 n.s.	0.02268 n.s.	0.00636 n.s.	0.44 n.s.	0.00137 n.s.	0.401 n.s.	0.00034 n.s.
Error	16	4.231481	0.017081	0.537392	39.85648	1812.093	0.29195278	0.0152777	0.0376439	0.5551	0.0077495	0.67604	0.0016325
Total	26												
S.O.V	D.f	M.S. for 2010-2011 season											
Replications	2	563.46151	2.882914	5.390880	887.2174	118857.38	1.11662933	0.3074545	2.2349127	33.203	0.3959353	19.1011	0.0980923
P	2	1207.77**	0.8223**	12.550**	1243.9**	581493**	8.795381**	0.35102**	0.01635 n.s.	26.3**	0.00024 n.s.	22.98**	0.00052 n.s.
G	2	574.525**	1.1677**	11.517**	1630.7**	180705**	6.552225**	0.39223**	0.193159*	48.96**	0.05899**	20.74**	0.01740**
P × G	4	24.1512 n.s.	0.0167 n.s.	0.7431 n.s.	51.991 n.s.	3431.86 n.s.	0.3476037 n.s.	0.01234 n.s.	0.00093 n.s.	1.29 n.s.	0.00010 n.s.	0.566 n.s.	0.00003 n.s.
Error	16	32.277778	0.028475	0.462494	38.61111	18104.778	0.37013704	0.0132787	0.0331395	0.6846	0.0063165	0.29408	0.0016311
Total	26												

*, ** significant at the 0.05 and 0.01 probability level, respectively

N.S. not significant.

Table -2-

mean values of some growth characters, yield, yield components and quality as affected by plant density in both seasons.

seasons	plant density (plants.ha^{-1})	Plant height (cm)	stem diameter (cm)	no. of primary branches. Plant^{-1}	no. of silique. Plant^{-1}	leaf area (cm^2\plant)	Number of seeds. silique^{-1}	weight of 1000 seed (g)	seed yield (ton.ha^{-1})	oil (%)	oil yield (ton.ha^{-1})	protein (%)	protein yield (ton.ha^{-1})
2009-2010	29629	103.37c	2.22a	13.41a	180.02a	2447.01a	9.00a	1.316a	0.766	40.43a	0.313	18.92a	0.149
	44444	111.74b	1.91b	12.25b	160.15b	2312.66b	8.05b	1.148b	0.849	39.23b	0.338	17.69b	0.154
	88888	132.39a	1.70c	11.35c	148.62c	1679.55c	7.09c	0.927c	0.821	38.28c	0.316	16.44c	0.137
2010-2011	29629	108.75c	2.42a	11.21a	170.18a	2169.88a	12.46a	1.626a	0.829	40.65a	0.346	20.49a	0.176
	44444	116.56b	1.91b	9.93b	157.86b	2043.31a	11.44b	1.383b	0.846	38.88b	0.337	18.52b	0.163
	88888	131.54a	1.62c	8.86c	146.68c	1680.19b	10.49c	1.235c	0.910	37.23c	0.346	17.32c	0.163

* The means values within column followed by the different letter are significant at 0.01 and 0.05 probability levels, respectively.

Table -3-

mean values of some growth characters, yield, yield components and quality as affected by rapeseed genotypes in both seasons.

seasons	Genotypes	Plant height (cm)	stem diameter (cm)	no. of primary branches. Plant^{-1}	no. of silique. Plant^{-1}	leaf area (cm^2\plant)	Number of seeds. silique^{-1}	weight of 1000 seed (g)	seed yield (ton.ha^{-1})	oil (%)	oil yield (ton.ha^{-1})	protein (%)	protein yield (ton.ha^{-1})
2009-2010	Tantal	114.24b	1.91b	12.48a	163.69b	2163.72b	7.98b	1.086b	0.741b	38.88b	0.288b	17.33b	0.129b
	Kroko	124.64a	2.29a	13.05a	173.32a	2279.36a	8.76a	1.351a	0.994a	41.70a	0.417a	19.47a	0.195a
	Rapol	108.62c	1.63c	11.48b	151.78c	1996.14c	7.40c	0.955c	0.701b	37.35c	0.262b	16.25c	0.115b
2010-2011	Tantal	117.17b	1.85b	10.05b	154.96b	1958.81b	11.38b	1.381b	0.796b	37.98b	0.306b	18.26b	0.148b
	Kroko	127.68a	2.31a	11.11a	173.04a	2108.90a	12.35a	1.639a	1.030a	41.58a	0.436a	20.48a	0.217a
	Rapol	112.00c	1.60c	8.85c	146.72c	1825.67b	10.65c	1.225c	0.760b	37.20b	0.287c	17.58c	0.135b

* The means values within column followed by the different letter are significant at 0.01 and 0.05 probability levels, respectively.

Table -4-

mean values of some growth characters, yield, yield components and quality as affected by genotypes and plant density in 2009-2010 and 2010-2011 seasons respectively.

plant density (plants.ha^{-1})	Genotypes	Plant height (cm)	stem diameter (cm)	no. of primary branches. Plant^{-1}	no. of silique. Plant^{-1}	leaf area (cm^2\plant)	nber of seeds.siliq 1	weight of 1000 seed (g)	seed yield (ton.ha^{-1})	oil (%)	oil yield (ton.ha^{-1})	protein (%)	protein yield (ton.ha^{-1})
2009-2010 season													
29629	Tantal	102.45f	2.20	13.47	177.28	2482.12	9.00	1.326	0.716	39.80	0.286	18.83	0.138
	Kroko	113.49d	2.51	14.55	196.50	2550.12	9.92	1.556	0.920	42.80	0.397	20.41	0.191
	Rapol	94.18g	1.94	12.20	166.28	2308.79	8.09	1.066	0.661	38.68	0.258	17.50	0.118
44444	Tantal	108.93e	1.83	12.73	164.17	2352.82	8.03	1.150	0.734	38.52	0.283	16.93	0.125
	Kroko	122.77c	2.25	12.82	169.41	2440.32	8.86	1.306	1.091	41.70	0.459	19.60	0.215
	Rapol	103.51f	1.65	11.20	146.87	2144.85	7.26	0.990	0.724	37.46	0.271	16.52	0.121
88888	Tantal	131.33b	1.69	11.25	149.63	1656.22	6.91	0.783	0.772	38.32	0.295	16.23	0.125
	Kroko	137.66a	2.11	11.77	154.05	1847.65	7.51	1.190	0.972	40.60	0.395	18.39	0.179
	Rapol	128.18b	1.31	11.04	142.20	1534.77	6.86	0.810	0.719	35.92	0.258	14.71	0.105
2010-2011 season													
29629	Tantal	108.16	2.18	11.44	164.88	2168.30	12.28	1.574	0.777	39.80	0.316	20.02	0.160
	Kroko	118.53	2.55	12.58	190.11	2289.70	13.53	1.924	1.003	42.59	0.436	21.94	0.227
	Rapol	99.56	1.95	9.63	155.55	2051.70	11.57	1.381	0.709	39.56	0.285	19.50	0.141
44444	Tantal	113.98	1.79	10.12	155.44	2065.70	11.64	1.384	0.782	37.81	0.298	17.53	0.141
	Kroko	127.14	2.32	11.12	171.68	2176.50	12.36	1.541	1.015	41.66	0.432	20.60	0.215
	Rapol	108.56	1.63	8.56	146.47	1887.70	10.31	1.224	0.743	37.18	0.281	17.42	0.132
88888	Tantal	129.37	1.59	8.58	144.57	1642.40	10.23	1.184	0.829	36.34	0.304	17.22	0.145
	Kroko	137.37	2.05	9.63	157.32	1860.50	11.16	1.451	1.073	40.48	0.440	18.91	0.210
	Rapol	127.89	1.21	8.35	138.14	1537.60	10.07	1.071	0.829	34.87	0.295	15.83	0.133

* The means values within column followed by the different letter are significant at 0.01 and 0.05 probability levels, respectively.

Table -5-
The physical and chemical characters of soil filed experiments in both seasons.

seasons	2009-2010	2010-2011
physical characters		
Sand (%)	66.00	42.00
Silt (%)	20.00	38.00
Clay (%)	14.00	20.00
Texture	Sandy Loom	Silty Sandy
Chemical characters		
O.M. (%)	0.11	0.20
Available N (ppm)	33.02	30.18
Available P (ppm)	7.12	5.20
Available K (ppm)	80.20	100.40
Total $CaCo_3$ ($g.kg^{-1}$)	2.40	2.22
pH	7.40	7.20
E.C. mmhos/cm	0.34	0.65

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