

Response of Growth, Yield and Oil of Rapeseed to Sowing Method and Seeding Rate

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Abstract: An experiment was conducted at Karda-Rasha /College of Agriculture-Erbil to evaluate the effect of different seeding rates using drill-row and broadcasting sowing methods on growth, seed and oil yields of rapeseed (*Brassica napus* L.) cv. Pactol. The results showed that drill-row sowing method produced seed and oil yields more than broadcasting method, particularly, at low seeding rates i.e. 4 kg ha⁻¹ seeding rate. Seeds grown by drill-row produced the highest number of plants m⁻², the highest plants height and took the longest period for their flowering and seed formation; and produced a greater number of siliques plant⁻¹ and greater weight of seed and then, higher seeds and oil yields. Seeds grown at higher seeding rates gave the higher number of plants m⁻² and higher silique surface area, with longest period for seed formation, the highest plants height bearing higher number of primary branches, higher harvest index and high oil percentage. However, seeds grown at low seeding rates, the period from sowing to flowering and flowering period were the longest. At 4 kg ha⁻¹ seeding rate produced higher number of siliques plant⁻¹, greater weight of seed and higher seeds and oil yields. In this study, there was significant and positive correlation between number of siliques plant⁻¹ and seed weight with total Yield. While there was a significant and negative correlation between harvest index and total yield. Also, positive and highly significant correlation between oil yield and total yield.

Keywords: Oil percentage, rapeseed, seeding rate, seed yield, sowing method

I. Introduction

Rapeseed (*Brassica napus* L.) is the important oilseed crops throughout the world which ranks third among the oilseed crops after soybean and oil palm in production of vegetable oils. (kauser *et al.*, 2006). Canola oil is considered healthy for human nutrition due to its lowest content of saturated fatty acids among vegetable oils (Starner *et al.*, 1999). Seed yield per hectare is of major importance to the production of any seed crop. The seed yield is a function of interaction between genetic and environmental factors including sowing method and seeding rate. The determination of a suitable sowing method and seeding rate for good agronomic performance is important. An understanding of the effects of the major agricultural practices which limits seed and oil yields of rapeseed is needed to develop improved technology relevant to Kurdistan conditions/Iraq. Seeding rate is considered an important factor to optimize plant production. The establishment of an adequate and uniform rapeseed stand is critical to achieve high grain yield. Seed yield of rapeseed is a function of population density, number of pods per plant, number of seeds per pod and seed weight. However, yield structure is very plastic and adjustable across a wide range of population (Diepenbrock, 2000). Some studied report that sowing method did influence of rapeseed, Nigussie *et al.*, (1996) denoted response of Tower Set-3 and S-67 varieties to method of sowing were not consistent, in 1986 it was possible to increase yields by 4% (S-67) and 30% for Tower-Sel-3 for row-sowing, while in 1990 broadcasting turned out to be more advantageous. Drill-seeded material yielded more than broadcast material seeded at the same rate especially at the lower seeding rate (Clarke *et al.*, 1978). Khan *et al.*, (2000) illustrated that rapeseed yield and yield components was greatly increased when seeds were grown with ridge sowing, grain yield was higher by 45, 31 and 28% than broadcast, drill and furrow sowing method respectively. In study by Shah and Rahman (2009) comprised six seeding rates from 2 to 12 kg ha⁻¹, they reported that the yield tended to increase with an increase in seed rate up to 10 kg ha⁻¹. Hanson *et al.*, (2008) referred that seed yield increased with increasing at four seeding rates (54, 108, 162 and 216) pure live seed m⁻². Angadi *et al.*, (2003) noted that population reduced from 80 to 40 plants m⁻² produced similar seed yield. Chen *et al.*, (2005) found a seeding rate of 32 to 65 seeds m⁻² was sufficient to produce optimum canola yield. Shahin and Valiollah (2009) found that an increase in seeding rate from 4 to 6 kg ha⁻¹ resulted in a decrease in number of pods plant⁻¹, the highest number of pods plant⁻¹ was obtained by applying 4 kg ha⁻¹ seeding rate. It was also observed that increasing seeding rate caused significant decrease in oil percentage (Naseralla, 2000). In contrast, seeding rates had no effect on yield seed and oil (Taylor and smith, 1992). The study was conducted to quantify the effects of sowing method and seeding rate on growth, seed and oil yields of rapeseed grown in Kurdistan Region/Iraq.

II. Materials And Methods

A field study was conducted at the experimental farm, Gardrush/ College of Agriculture-Erbil/Kurdistan Region during winter season of 2011-2012 to study the response of growth, yield and oil rapeseed to sowing method and seeding rate. Split-plot based on randomized complete block design, with three replications. Experiment factors included two seeding method of drill-row and broadcasting (covered by hand) ranking as the main plots, five seeding rates: 4, 6, 8, 10 and 12 kg ha⁻¹ (with difference two kg between were tried each) as subplots. The subplot size was 5.4 m² (1.8 m x 3 m) containing five rows, three m long and 30 cm apart, at a depth of 2-3 cm was used. The *Brassica napus* cv. Pactol was sown on 25, October 2011. Plots were watered for minimum of three hours and excess of water was allowed to drain from the surface. Weeds were removed by manual weeding during the growth stages. Nitrogen fertilizer was applied at the rate of 240 kg ha⁻¹ in the form of urea (46% N) at two intervals, the first at sowing date, and the second at flowering stage. Also P₂O₅ at rate of 90 kg ha⁻¹ was applied in the form of triple superphosphate (46 % P₂O₅) were drilled with seeds. Data was collected on some characteristics; the number of plants per m² was taken at rosette growth stage (O.R.P.G., 2000) by randomly counting plants in one 30 cm row and 0.09 m² of each plot for drill and broadcasting methods respectively, this way later converted into plants per m². The number of days from sowing to the flowering was counted (flowering date was recorded as the day when 75% of the existing raceme were flowered. Daily observations were taken to obtain the number of days from sowing to the following growth stages to record both the period of flowering and seed formation.

- 1- First flower: It was recorded when 75% of the plants had at least three open flowers on the main raceme.
- 2- Last flower: It was recorded when 75% of the plants terminated flowering on the main raceme
- 3- Flowering period: Number of days from the first flower to the last flower.
- 4- Seed formation period; Number of days from the first flower to maturity of first pod (the plants had all black seeds in the lowest pod of the main raceme).

In the last flower, the measurement was made on surface area of pods, using the formula $2\pi rh$ (r = half of the width of the pod at its middle point and h = the distance between the base of the pod) (Tayo and Morgan, 1975). At the time of maturity of the first pod of main raceme per plant, plant height, number of primary branches and number of siliques plant⁻¹ were counted after harvest three plants per plot and then divided by three. Number of seeds silique⁻¹ was also determined from three plants sample, fifty pods from all three plants was taken, threshed and the number of seeds per silique were counted. The seed weight was recorded by counting 500 seeds from each silique sample, then seeds were dried at 30°C in a forced air dryer, weighed and then seed weight rate (mg) was counted. Actual harvest time was 2-4 days after maturity of first silique on the main raceme for each plot. Total yield was obtained by cutting the plants sample from the center row (30 cm x 300 cm) = 0.9 m² for drill-row and centered 2 m² for broadcasting seeding to count seed yield and then converted into yield per hectare. To record harvest index, harvested crop which included seeds + stems + leaves were weighed after drying by exposing it to sunlight to record biological yield in kilograms per hectare and the seed yield divided biological yield to record harvest index multiple 100. Oil content of the seed was determined by the Soxhlet and oil yield was recorded by percentage oil multiply by seed yield. The obtained data was subjected to variance analysis as a split-plot design using the statistical analysis system (SAS Institute, 2005). Least significant difference was the statistical method used to determine differences among means.

III. Results And Discussion

1- Effect of sowing methods on some characteristics of rapeseed

There were no significant differences among sowing methods for number of days from sowing to flowering, surface area of siliques, number of primary branches of plant, number of seeds of silique and harvest index, while sowing methods showed significant effect on rest traits of rapeseed (Table 1 and 2). Analysis of variance regarding number of plants m⁻² indicated significant effect of sowing methods, highest counts for number of plants m⁻² of rapeseed noted with drill-row sowing, while the lowest counts were recorded with broadcasting sowing (Table 1). This result is in agreement with the work of Khan *et al.*, (2000) and not in agreement with Khan and Muendel (2002) which they pointed out that the number of plant stand did not significantly differ with various sowing methods. The drill-row method had a significantly longer flowering and seed formation periods than broadcasting at four and eight days respectively. The tallest plants were produced in the drill-row sown plots. (129.5 cm), while the shortest plants were produced with broadcasting sowing (115.2 cm) (Table 1), this result is in agreement with Khan *et al.*, (2000) that the plants of broadcasting sowing are shorter (109.7 cm) than plants of drill sowing method (118.0 cm). Individual plants of drill-row sowing produced a higher number of siliques than those of broadcasting sowing (130.0) and (107.1) siliques 9plant⁻¹ respectively (Table 2), this result is not in agreement with results of Nigussie *et al.*, (1996) which illustrated that broadcasting significantly favored the pod-bearing capacity comparable with row sowing (301 and 233 pod plant⁻¹) respectively. Similar to number of pod plant⁻¹, weight of seed play a major role in yield. Crop grown with drill-row sowing method showed significantly highest seed weight as compared to broadcasting which

produced lowest seed weight (Table 2), this result is in agreement with the work of Khan *et al.*, (2000). Similarly, maximum total yield of 1091.9 kg ha⁻¹ was obtained when crop was grown by drill-row sowing, which was significantly higher than broadcasting of 140.9%, similar results were reported by Khan *et al.*, (2000). Oil percentage was not significantly affected by sowing method, but oil yields were significantly affected, it increased by 148.9% for drill-row, the decline in the total yields of broadcasting was due to its lower oil yields (Table 2), similar result was reported by Nigussie *et al.*, (1996).

2- Effect of seeding rates on some characteristics of rapeseed

Although the number of plants m⁻² was increased by the seeding rate treatments (Table 3), the number of plants m⁻² was mainly greater in the high seeding rates plots, for example, 244.45 and 268.52 plants m⁻² were recorded for treatments 10 and 12 kg ha⁻¹ respectively as compared with the rest of seeding rates, this result is in agreement with the results of Scarisbrick *et al.*, (1982), Taylor and Smith (1992) and Hanson *et al.*, (2008). At 12 kg ha⁻¹ seeding rate resulted in the fewest days to first flower (149 days) as comparable of the rest of seeding rates (Table 3). The number of days from seeding to flowering (first flower) seems to be good indication of maturity of first silique. Seeds sown by highest seeding rates, led to shortening and prolonged flowering and seed formation periods, respectively, for example, the 12 kg ha⁻¹ seeding rate shortened to 34.2 and prolonged to 49.2 days respectively comparing with the lowest seeding rates (4 and 6 kg ha⁻¹). Increased seeding rates resulted in a reduction of days to growth stages subsequent to first flower and duration of flowering and increased seed formation periods (Degenhardt and Kondra, 1981b). On all traits, surface area of siliques, plant height and number of primary branches of plant differed over seeding rates, at 10 kg ha⁻¹ seeding rate, surface area of silique, plant height and the number of primary branches of plants increased (928.33 mm², 141.0 cm and 5.5 branch plant⁻¹) respectively compared with the total seeding rates (Table 3). The result of plant height is not in agreement with results of Hanson *et al.*, (2008); Shah and Rahman (2009) and Shahin and Valiollah (2009) which showed that seeding rates did not significantly affected plant height. The obtained results indicated that number of siliques plant⁻¹ was influenced by different seeding rates (Table 4), the number of siliques plant⁻¹ decreased 47.1% as the seeding rate increased from 4 to 12 kg ha⁻¹, the number of siliques plant⁻¹ is the most responsive of all the yield components in rapeseed, this result agrees with those of Scarisbrick *et al.*, (1982); Leach *et al.*, (1999) and Shahin and Valiollah (2009). It is noted from (Table 4) that there is no differences between the seeding rates 4, 6, 8 and 10 kg ha⁻¹ among them in seeds/silique trait, however the four previous seeding rates were different from 12 kg ha⁻¹ seeding rate which the number of seeds/silique decreased to 19.13 seed/silique. For the same table, it is noted that there is no differences among the seeding rates 6, 8, 10 and 12 kg ha⁻¹ in seed weight, however the seed weight at 4 kg ha⁻¹ seeding rate has increased 18% compared to the higher four seeding rates, that is due to the increase of the number of plants m², plant height, number of primary branches plant⁻¹ (Table 3), which led to increase of competition between plants over growth factors, consequently led to decrease of number of siliques plant⁻¹ and seed weight. Rate of seeding showed significant effect on total yield (table 4). The low seeding rate (4 kg ha⁻¹) resulted in the highest average yield (1037.3 kg ha⁻¹), which is not in agreement with the previous work of Taylor and Smith (1992), Jambor (2007), Shahin and Valiollah (2009) who concluded that seeding rates were not influenced on seed yield and not agrees with Hanson *et al.*, (2008) and Shah and Rahman (2009) who illustrated that seed yield increased with increasing seeding rates. There was a significant decrease and increase in harvest index at the 4 and 12 kg ha⁻¹ seeding rate respectively, due to the possible advantage of reduced and raised branching or number of primary branches of plant for these treatment (4 and 12 kg ha⁻¹) respectively (Table 3). Oil percentage tended to decrease from 36.17% to 27.50% when seeding rate decreased from 12 to 8 kg ha⁻¹, while oil yield tended to decrease 22 t ha⁻¹ when seeding rate was increased from 4 to 12 kg ha⁻¹, this result was not in agreement with Chen *et al.*, (2005) which had reported that oil content tended to decrease from 20 to 10 g kg⁻¹ when seeding rate was increased from 11 to 97 seed m⁻².

3- Effect of interaction between sowing methods and seeding rates on some characteristics of rapeseed

The interaction effect of sowing methods with seeding rates on all characteristics studied was also significant. The highest value of total yield was (1344 kg ha⁻¹) for rapeseed sown at drill-row with the low seeding rate (4 kg ha⁻¹) because of number of siliques plant⁻¹ increase (152.67 silique) or increasing of seed weight (0.21 mg) (Table 6). This result is in accord with Clarke *et al.*, (1978) who indicated that drill seeded material yielded more than broadcast material seeded at the same rate, especially at low seeding rates. In both sowing methods, each increase in seeding rate resulted in a significant decrease in yield, and this result was in accord with Khan and Muendel (2002) who concluded that seed yield was the highest at the seeding rate 4 kg ha⁻¹ with straight line seeding. It is obvious that the interaction effect of sowing methods with seeding rates on oil percentage and oil yields were also significant, the highest value of them were (38.33% and 39834 kg ha⁻¹) for seeds sown by drill-row with 12 and 4 kg ha⁻¹ respectively (Table 6), due to increase of total yield which in turn led to increase of oil yield.

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Referring to table (7), the flowering period had a positive correlation with total yield, and with seed formation period at (0.669 and 0.719) respectively. In this study, number of siliques plant⁻¹ and seed weight had significant and positive correlation with total yield. Therefore, any agronomical performance with the aim of increasing of number of siliques plant⁻¹ and seed weight would result in increase in seed yield. The harvest index was negatively correlated with total yield. It is clear from the relationship study (Table 7) that oil yields were positively and highly significant correlated with the total yield (0.966).

Based on results of this study. It could be concluded that sowing methods and sowing rates had significant influence on growth, yield and its components of rapeseed. A drill-row seeding method and 4 kg ha⁻¹ seeding rate produced higher seed and oil yields of rapeseed cv. Pactol in Erbil/Kurdistan Region.

Table 1. Effect of sowing methods on some characteristics of rapeseed

Sowing method	No. of plants m ⁻²	No. of days from sowing to flowering (day)	Flowering period (day)	Seed formation period (day)	Surface area of siliques (mm ²)	Plant height (cm)	No. of primary branches of plant
Drill-Row	211.77	151.87	37	49.5	779.19	129.5	4.8
Broadcasting	107.41	154.27	33	41.3	829.52	115.2	3.6
LSD _{0.05}	62.13	NS	2.8	5.6	NS	12.2	NS

Table 2. Effect of sowing methods on yield, yield components and oil of rapeseed

Sowing method	No. of siliques of plant	No. of seeds of silique	Weight of seed (mg)	Total yield (kg ha ⁻¹)	Harvest Index (%)	Oil percentage (%)	Oil yield (kg ha ⁻¹)
Drill-Row	130.0	21.09	0.17	1091.9	32.1	31.47	34146
Broadcasting	107.1	23.16	0.15	453.3	37.8	30.67	13719
LSD _{0.05}	21.3	NS	0.01	216.9	NS	NS	6586.1

Table 3. Effect of seeding rates on some characteristics of rapeseed

Seeding rates (kg ha ⁻¹)	No of plants m ⁻²	No. of days from sowing to flowering (day)	Flowering period (day)	Seed Formation period (day)	Surface area of siliques (mm ²)	Plant height (cm)	No. of primary branches of plant
4	55.33	153.83	37.3	42.7	816.60	123.2	3.7
6	90.75	155.33	37.3	43.2	742.05	100.0	3.8
8	138.90	152.83	34.7	43.3	791.00	119.3	3.8
10	244.45	154.33	35.3	44.5	928.33	141.0	5.5
12	268.52	149.00	34.2	49.2	743.78	138.2	5.2
LSD _{0.05}	30.96	2.70	2.1	3.2	62.47	8.5	1.3

Table 4. Effect of seeding rates on yield, yield components and oil of rapeseed

Seeding rates (Kg ha ⁻¹)	No. of siliques of plant	No. of seeds of silique	Weight of seed (mg)	Total yield (kg ha ⁻¹)	Harvest Index (%)	Oil percentage (%)	Oil yield (kg ha ⁻¹)
4	140.0	21.37	0.18	1037.3	31.4	30.17	31109
6	129.7	22.87	0.16	797.4	36.1	29.67	23852
8	115.5	22.87	0.16	741.1	34.9	27.50	20268
10	112.3	24.40	0.15	698.5	33.3	31.83	22307
12	95.2	19.13	0.15	588.7	39.1	36.17	22126
LSD _{0.05}	42.2	3.91	0.02	109.8	5.9	1.54	3146.2

Table 5. Effect of sowing methods and seeding rates interaction on some characteristics

Sowing method	Seeding rates (kg ha ⁻¹)	No. of plants m ⁻²	No of days from sowing to flowering (day)	Flowering period (day)	Seed formation period (day)	Surface area of siliques (mm ²)	Plant height (cm)	No. of primary branches of plant
Drill-Row	4	69.9	150.7	39.67	48.00	720	148.3	4.0
	6	107.4	155.0	40.67	52.67	851	104.0	4.3
	8	181.5	151.3	38.00	49.33	771	122.0	4.3
	10	337.0	156.7	34.00	44.67	822	154.0	5.0

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	12	363.0	145.7	36.67	52.67	731	119.0	6.3
Broadcasting	4	40.7	157.0	34.33	37.33	913	98.0	3.3
	6	74.1	155.7	34.00	41.67	633	96.0	3.3
	8	96.3	154.3	31.33	37.33	811	116.7	3.3
	10	151.9	152.0	34.67	44.33	1035	128.0	4.0
	12	174.1	152.3	33.67	45.67	756	137.3	4.0
LSD _{0.05}		27.3	2.1	1.69	2.40	50.2	15.8	2.4

Table 6. Effect of sowing methods and seeding rates interaction on yield, yield components and oil of rapeseed

Sowing method	Seeding rates (kg ha ⁻¹)	No. of siliques plant	No of seeds/silique	Seed weight (mg)	Total yield (kg ha ⁻¹)	Harvest Index (%)	Oil percentage	Oil yield (kg ha ⁻¹)
Drill-Row	4	152.67	18.47	0.21	1344	35.63	29.67	39834
	6	138.00	24.00	0.16	1102	33.23	30.33	33441
	8	131.00	20.73	0.17	1047	30.77	27.00	28272
	10	120.67	26.33	0.15	991	31.07	32.00	31769
	12	107.67	15.93	0.14	975	29.67	38.33	37411
Broadcasting	4	127.33	24.27	0.15	731	27.23	30.67	22383
	6	121.33	21.73	0.16	493	38.93	29.00	14264
	8	100.00	25.00	0.15	435	39.07	28.00	12265
	10	104.00	22.47	0.15	406	35.50	31.67	12844
	12	82.67	22.33	0.15	202	48.43	34.00	6841
LSD _{0.05}		62.44	4.01	0.01	116.2	7.07	10.03	29993

Table 7. Correlation coefficient analysis among the traits of rapeseed

	Total yield (kg ha ⁻¹)	No. of plants m ⁻²	No of days from seeding to flowering (day)	Flowering period (day)	Seed formation period (day)	Surface area of siliques (mm ²)	Plant height (cm)	No. of primary branches of plant	No. of siliques /plant	No of seeds/silique	Seed weight (mg)	Harvest Index (%)	Oil percentage (%)	Oil yield (kg ha ⁻¹)
No. of plants m ⁻²	0.163*	1.00												
No of Days from Seeding To flowering	-0.165*	-0.339*	1.00											
Flowering period	0.669**	-0.023	0.271*	1.00										
Seed Formation period	0.445**	0.337**	-0.495**	0.719**	1.00									
Surface Area of siliques	-0.146*	-0.080	0.240*	-0.124	-0.199*	1.00								
Plant height	0.203*	0.438**	-0.252*	0.057	0.215*	-0.051	1.00							
No. of Primary Branches of plant	0.265*	0.475**	-0.409**	0.241*	0.514**	-0.009	0.223*	1.00						
No. of Siliques/ plant	0.528**	-0.203*	0.018*	0.562**	0.148*	-0.049	0.029	0.036	1.00					
No. of Seeds/silique	-0.181*	-0.170*	0.639**	0.341**	0.473**	0.339**	-0.099	-0.324*	-0.064	1.00				
Seed weight	0.476**	-0.293*	-0.039	0.436**	0.130*	-0.209*	0.292*	-0.044	0.149*	-0.282*	1.00			
Harvest Index	-0.572**	-0.227*	-0.077	-0.232*	0.001	-0.236*	0.122	-0.207*	0.205*	0.057	-0.048	1.00		
Oil percentage	-0.058	0.641**	-0.391*	-0.072	0.251	0.027	0.156	0.319*	-0.299	-0.299	-0.274	-0.096	1.00	
Oil yield	0.966**	0.327*	-0.245	0.610**	0.479*	-0.141	0.205	0.341*	0.326*	-0.246	-0.376*	0.603*	0.186	1.00

*Significant at 0.05 level

** Significant at 0.01 level

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