The effect of plant populations on solar radiation absorption, light transmission and yield components of spring rape seed cultivars

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Abstract

In order to evaluate the influence of plant densities on LAI, solar radiation absorption, light transmission and yield components of three spring rape seed cultivars, this research was conducted on the basis of split plot layout with completely randomized block design with 3 replications. Plant densities in main plots were 40, 80 and 120 plants per m^2, and rapeseed cultivars in secondary plots were Sarigol, RGS003 and Hyola401. This research was conducted at research farm, experimental research station, Shahrekord city, Shahrekord province, Iran. Plant density had significant influence on LAI, solar radiation absorption, light transmission, the number of pods per plant and seed yield. LAI, the number of pods per plant and the number of seed per pod was significantly influenced by cultivar. Plant density and cultivar interaction had significant effect on LAI. The highest LAI, solar radiation absorption, plant height was obtained in 120 plants per m^2; however, 40 plants per m^2 had obtained the maximum number of pods per plant and the number of seed per pod. 80 plants per m^2 had obtained the maximum seed yield. The maximum light interception also obtained by this treatment. RGS 003 had obtained the highest LAI and solar radiation absorption. Although, the maximum number of pods per plant and number of seed per pod was related to Sarigol and Hyola 401, the maximum seed yield was obtained in RGS003. So, it seems that plantation of RGS003 and 80 plants per m^2 was suitable to producing high seed yield.

Keywords: Plant density, LAI, solar radiation absorption, light transmission, rape seed, cultivar.

Introduction

The sustainability of cropping systems can be achieved through the choice of certain field crops which are better able than others to exploit natural resources, like solar radiation- which is no cost resource (Rinaldi and Vonella, 2006). Rapeseed is an important potential source of edible unsaturated oils (Liu et al., 2009). This plant is an annual crop with high seed production ability (Valizadeh and Mirshekari, 2011). Vegetation is regarded as an active surface, which is interacting with solar radiation (Vieira et al., 2009). Absorption, reflection and emission of radiation are consequences of this interaction (Svirezhev and Steinborn, 2001). Awal et al. (2006) reported that the intensity of solar radiation will remain relatively constant and represents a resource that could be used more efficiently for crop production. Soleymani et al. (2011) concluded that the highest solar radiation absorption and light transmission was related to Karaj and

Multicut, respectively. Majd Nasiri and Ahmadi (2005) concluded that radiation absorption ability of safflower cultivars was affected by plant density and this ratio in spring planting was greater than that in summer planting. Assessing solar radiation absorption is an important parameter in agronomic researches (Broumand et al., 2010). Determination of the optimum plant population for crops is essential to optimize yield (Momoh et al., 2004). Karamanos et al. (14) indicated that hybrid canola cultivars overall yielded 23.7% more than open pollinated (OPC) canola cultivars. Momoh et al. (2004) reported the increased of 16.0% and 13.3% in seed yield, respectively, with increasing plant density from 67500 to 97500 plants per ha from 97500 to 127500 plants per ha.

Materials and methods

This research was conducted on the basis of split plot layout with completely randomized block design with 3 replications. Plant densities in main plots were 40, 80 and 120 plants per m^2, and rapeseed cultivars in secondary plots were Sarigol, RGS003 and Hyola401. This research was conducted at research farm, experimental research station, Shahrekord city, Shahrekord province, Iran (latitude $32^o18^/$ N, longitude $50^o56^/$ E). The soil preparation consisted of mouldboard ploughing (20-25 cm) followed by discing and smoothing with a land leveler. On the basis of soil analysis, the field was fertilized with 60 kg N per ha from urea. Top dressed urea was also applied at the rate of 60 kg N per ha at the beginning of the stem elongation stage. Trifloralin (2.5 l per ha) was used as pre-planting herbicide for control weeds. Plots were 7 m long with 6 row spaced 30 cm apart. The distance for main plots in order to fertilize treatment was 2 m. The distance between two plants for 40, 80 and 120 plants per m^2 was 8, 4 and 2 cm. Seed yield was determined after oven drying for 48 h at 75^oC. For determination light transmission (T) and solar radiation absorption (A), equation number 1 and 2 will be used, respectively. I and I0 mean the solar radiation under plant canopy and solar radiation above of plant canopy (Soleymani et al., 2011).

$$T= I/I0 \times 100 \qquad (1)$$

$$A= 100 - T \qquad (2)$$

Analysis of variance (ANOVA) was used to determine the significant differences. The separation of means was done by Duncan 's multiple range test. All statistics was performed with MSTAT-C program (version 2.10).

Results and discussion

Plant height had significant influence on LAI, solar radiation absorption, light transmission, the number of pods per plant and seed yield (Table 1). LAI, the number of pods per plant and the number of seed per pod was significantly influenced by cultivar. In this experiment cultivar had no significant influence on plant height and seed yield, but Soleymani et al. (2010) reported that cultivar had significant influence on plant height and seed yield. Soleymani et al. (2011) also reported that cultivar had no significant effect on solar radation absorption and light transmission. All experimental characteristics expect of LAI was not significantly affected by interaction between plant density and cultivar (Table 1). Crops grown at high plant densities are often more susceptible to lodging and increase disease incidence without the benefit of any yield increase (Rathke et al., 2006). The highest LAI was related to 120 plants per m^2 which had significant difference with 40 plants per m^2. The maximum and the minimum solar radiation absorption was related to 120 and 40 plants per m^2, respectively. The minimum light transmission was obtained in 120 plants per m^2. A uniform distribution of plants per unit area is a prerequisite for yield stability (Diepenbrock, 2000). Friday and Fownes (2001) reported that light interception on the floor of the alley between the trees and plants affected by rows distance and crops. There were no significant differences in plant height among treatments, but the highest plant height was related to 120 plants per m^2. The highest number of pods per plant and number of seed per pod was obtained in 40 and 80 plants per m^2, respectively. The number of pods per plant was significantly decreased from 40 to 120 plants per m^2. Momoh and Zhou (2001) also reported that in high plant density, number of effective pods per branch decreased. Momoh and Zhou (2001) also reported that, the average number of seeds per pod was significantly lower for high density plants. Cultivation of 80 plants per m^2 had obtained the highest seed yield which had significant differences with other treatments (Table 2). The highest and the lowest LAI was related to RGS 003 and Hyola 401, respectively. Although, RGS 003 had obtained the maximum solar radiation absorption, there was no difference among treatments. The highest light transmission and plant height was related to Sarigol and Hyola 401, respectively. There were no significant differences among these three cultivars. Sarigol had obtained the maximum number of pods per plant. This cultivar had significant differences with other treatments. Hyola 401 had obtained the highest number of seed per pod and the lowest one was related to RGS 003. There were no significant differences in seed yield among cultivars, but the maximum seed yield was related to RGS 003 (Table 2).

Table 1- Analysis of variance for experimental characteristics.

S.O.V.	d.f.	LAI	Solar radiation absorption	Light transmission	Plant height	The number of pods per plant	The number of seed per pod	Seed yield
Replication	2	0.449^{ns}	18.327	18.295	205.442^{ns}	28.593^{ns}	6.417	24597.44
Plant density	2	0.895*	639.212**	639.531**	211.854^{ns}	181.815**	41.890^{ns}	362036.1*
Error (a)	4	0.243	34.155	34.122	54.227	6.315	9.045	24752.55
Cultivar	2	0.354**	2.304	2.317	5.739	65.037*	163.565**	24078.77
Plant density × Cultivar	4	0.904*	3.490	3.523^{ns}	82.774	8.926	8.062	14455.05
Error (b)	12	0.269	3.455	3.447	135.125	9.685	14.721	39896.29

* and ** Significant at P=0.05 and P=0.01 level, respectively in F-test., NS: Not Significant.

Table 2- Mean comparison for LAI, solar radiation absorption (%), light transmission (%), plant height (cm), the number of pods per plant, the number of seed per pod and seed yield (kg/ha).

Treatment	LAI	Solar radiation absorption	Light transmission	Plant height	The number of pods per plant	The number of seed per pod	Seed yield
Plant density (plants per m^2) (D)							

40 (D1)	0.666a	77.37c	22.64a	82.42b	42.89a	20.27b	1901.5b
80 (D2)	1.033b	86.35b	13.64b	83.86b	36.22b	21.19b	2189.4a
120 (D3)	1.294b	94.21a	5.789c	89.45b	34.33b	17.08b	1802.0c
Cultivar (C)							
Sarigol (C1)	0.667b	85.41a	14.59a	85.80a	39.89a	19.16b	1913.5b
Hyola 401 (C2)	0.373b	86.12a	13.88a	86.75a	38.78a	23.94a	1964.2b
RGS 003 (C3)	1.953a	86.39a	13.60a	85.17a	34.78b	15.44b	2016.5b
Plant density × Cultivar (D×C)							
D1C1	0.580ab	76.96c	23.05a	86.54a	46.00a	20.21abcd	1887.3bc
D1C2	0.493ab	78.07c	21.93a	80.32a	43.33ab	22.97ab	1826.5bc
D1C3	0.926ab	77.08c	22.93a	80.40a	39.33abc	17.62bcde	1992.5abc
D2C1	0.413ab	84.75b	15.25b	85.19a	38.67bc	21.54abcd	2073.4ab
D2C2	0.280b	86.29b	13.71b	81.65a	38.33bcd	26.55a	2240.4a
D2C3	2.407ab	88.01b	11.98b	84.74a	31.67d	15.49de	2253.4a
D3C1	1.010ab	94.53a	5.470c	85.68a	35.00cd	15.74cde	1778.5c
D3C2	0.346ab	94.01a	5.990c	98.30a	34.67cd	22.30abc	1825.3bc
D3C3	2.527a	94.09a	5.907c	90.36a	33.33cd	13.20e	1804.3bc

Common letters within each column do not differ significantly.

Conclusion

The highest LAI, solar radiation absorption, plant height was obtained in 120 plants per m^2; however, 40 plants per m^2 had obtained the maximum number of pods per plant and the number of seed per pod. 80 plants per m^2 had obtained the maximum seed yield. The maximum light interception also obtained by this treatment. RGS 003 had obtained the highest LAI and solar radiation absorption. Although, the maximum number of pods per plant and number of seed per pod was related to Sarigol and Hyola 401, the maximum seed yield was obtained in RGS003. So, it seems that plantation of RGS003 and 80 plants per m^2 was suitable to producing high seed yield.

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