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THE EFFECT OF DIFFERENT SOWING DATES AND PLANT DENSITIES ON PLANT DEVELOPMENT PERIODS IN PEA UNDER RAINFED CONDITIONS IN EARLY SPRING

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ABSTRACT

This study aimed to examine the effect of different sowing dates (5 March and 26 March) in early spring and plant densities (40, 60, 80, 100 seeds/m^2) on plant growth and development under rainfed conditions in semiarid areas over six harvest times on pea. The research was carried out during March-June 2022 in the Dicle University, Faculty of Agriculture, in Diyarbakır, Turkey. Plants were harvested after emergences in every 10 days, and plant height, number of nodes, leaves, stipules and leaflets per plant and leaf area were measured. Absolute growth rate (agr), leaf area ratio (lar), leaf area index (lai), leaf area duration (lad), specific leaf weight (slw), specific leaf area (sla) values were calculated.

Maximum absolute growth rate (AGR) was in 100 seeds per m^2 and in 55 DAE for the first sowing time and in 40 seeds per m^2 and in 35 DAE for the second sowing time. Maximum leaf area index (LAI) was in 100 seeds per m^2 and in 55 DAE for the first sowing time and in 100 seeds per m^2 and in 35 DAE for the second sowing time.

Keywords: pea, sowing date, plant density, growth

INTRODUCTION

Pea is belong to the Leguminosae family, and *Pisum* comprises two species, *Pisum fulvum* and *Pisum sativum* of which *Pisum sativum* L. is cultivated pea (Kumar *et al.*, 2022).

Pea crops favour a cool climate with an average temperature range of 10–18 ºC during its growth period. Seed germination is hampered when the temperature at the time of planting is below 5 °C. Peas can tolerate frost at the early stages of growth (Basdemir *et al.*, 2020). Plant parts such as flowers and pods grow best in those regions where there is a slow transition from cool to warm weather in spring.

The genetic potential of the cultivated variety in plant production, environmental conditions and cultural processes are the factors affecting the amount of crop production. Plant density per unit area is an important condition for crop vegetative and generative development. Plant density may vary depending on the characteristics of the plant, such as its botanic and genetic structure, and environmental conditions such as soil, temperature and humidity. Plant density is an important factor influencing the yield and quality of grain (Dey *et al.*, 2021). Gugała and Zarzecka (2009) reported that a sowing density of 125 pea plants per 1 m^2 was more suited than sowing density of 75 plants per 1 m^2 in pea. Yucel (2013) reported that in winter sowing, the planting density of 40 seeds per 1 m^2 instead of 30 and 50 seeds per 1 m^2 is most appropriate, and an increase in the sowing density was not lead to a significant increase in plant traits. Krizmanić *et al.*

(2020) noted that plant density on pea considerably affected the seed yield, plant height and the number of pods per plant, but the number of seeds per pod nor the 1 000 seed weight was not affected. Prusiński and Borowska (2022) three planting densities were applied (70, 90, and 110 seeds per 1 m^2) to pea varieties, and they reported there was no effect of planting density on pea yield and its components. Guo *et al.* (2019) applied two plant densities (200,000 and 120 000 plants ha^{-1}), and they reported wide plant density was decreased plant height, root length, pod number per plant and seed number per pod, but increased dry weight. For the emergence, growth and development of pea crops, winter sowings are adversely affected by low soil temperature in the cold regions of Turkey, especially in Diyarbakir, where the experiment is carried out, and seedling emergence and plant growth are delayed. Therefore, seed sowing should be planted as early as possible in early spring at the end of February and at being March. Ghodsi *et al.* (2022) showed in Iran both irrigation and rainfed conditions that peas had better growth in the late sowing treatment. Higher yield in pea in the March sowing date treatment compared to February sowing could be related to the lower risk of early frosting or cold weather damages in peas. Silim *et al.* (1985) reported that autumn-sown crops produce similar seed yields to spring sowings, optimum sowing dates were mid-November and early March and mass yield reductions occurred when sowing was delayed until mid-April.

Growth is the increase in plant mass with the increase in dry weight, and the development of the plant's vegetative and generative parts refers to changes. Singh *et al.* (1996) reported that leaf weight and area were affected by the environment, and the CGR ratio was increased as plant density increased in the field peas (Garai *et al.*, 2019). This study aimed to examine the effect of different sowing dates in early spring and plant densities on plant growth and development under rainfed conditions in semiarid areas over six harvest times.

MATERIALS AND METHODS

The research was carried out in March-June 2022 in the Dicle University, Faculty of Agriculture, in Diyarbakır, Turkey.

The trial soil had in pH value (7.19) neutral, and it had very low organic matter and phosphorus. Climate data for 2022 growing season were given in Fig. 1. The lowest temperature was in March (5.7 ºC), and the highest temperature was in June (27.6 ºC).

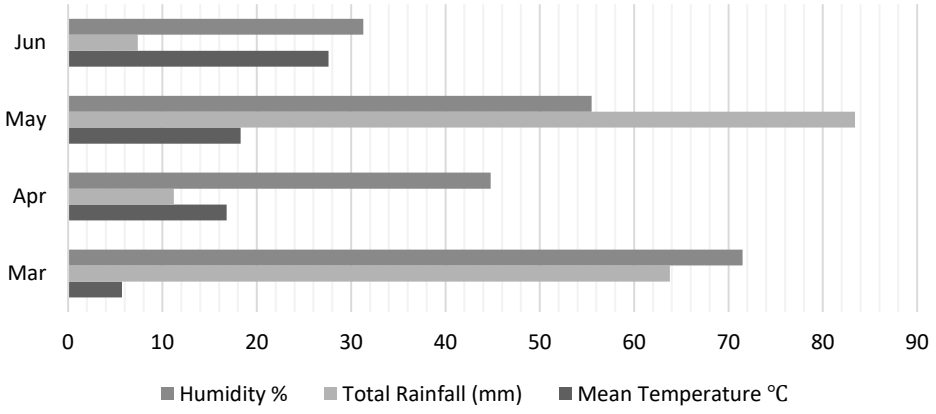
Total precipitation was highest in March (63.8 mm). In general, it was observed that, March was cold but rainy, April was hot and quite dry, but May was rainy, hot and humid.

It used four plant densities (40, 60, 80, 100 seeds/m^2), two sowing dates (5 March and 26 March) and one pea cultivar (Utrillo). The experiment was arranged in the randomized complete blocks design with split plots with three replications. Plots were 4 m in length in 4 rows and had an in-row spacing of 45 cm. Seeds were sown by hand on March 5, 2022, March 26, 2022. For 5 March sowing time, the emergence, 50% flowering and the pod setting dates were 31 March, 3 May and 12 May, respectively. For 26 March sowing time, the emergence, 50% flowering and the pod setting dates were 10 April, 18 May and 21 May, respectively.

Plants were harvested every 10 days, 15 days after sowing on March 5 and 18 days after sowing on March 26 at 0.20 m length. Harvested plants were washed with tap running water, and their moisture was removed by paper. The leaves, stems and roots of the plants were separated, and their fresh weights were weighed. Leaf area was measured by Winfolia 2003 software. The plant samples were dried in an oven at 80 °C for 72 hours and their dry weights were weighed by precision scale. The growth formulas were given below.

$$AGR = \frac{h_2 - h_1}{t_2 - t_1}\ \text{cm day}^{-1}$$ (Benbi, 1994).

$$SLW = \frac{Leaf\ weight}{Leaf\ area}\ \text{g cm}^{-2}$$ (Pearce *et al.*, 1968).



1: *Temperature and rainfall for the growing season*

$SLA = \frac{Leaf\ area}{Leaf\ weight}$ $cm^2\ g^{-1}$ (Kvet *et al.*, 1971).

$LAI = \frac{Total\ leaf\ area\ of\ a\ plant}{Ground\ area\ occupied\ by\ the\ plant}$

(Williams, 1946).

$LAR = \frac{Leaf\ area\ per\ plant}{Plant\ dry\ weight}$ $cm^{-2}\ g^{-1}$ (Radford, 1967).

$LAD = \frac{L_1 + L_2}{2} \times (t_2 - t_1)$ (Power *et al.*, 1967).

h_1 = the plant height at t_1, h_2 = the plant height at t_2, t_1 = first sampling, t_2 = second sampling, L_1 = LAI at the first stage, L_2 = LAI at the second stage. The data were analyzed in the JMP 14 PRO package program. The "Excell" program was used for the growth parameters.

RESULTS AND DISCUSSION

The effects of different sowing dates and plant densities on plant height, number of nodes per plant and number of leaflets per plant in pea were investigated six times during growth and development (Tab. I).

The effect of sowing dates on plant height was no significant in other observation samples except for after sowing 55 days samples. In 35 DAE, 45 DAE and 55 DAE, the effect of plant densities on plant height was significant. In these observation periods, as the plant density increased, the plant height also increased. Maximum plant height in all observation samples was in 100 seed/m^2 plant density. Low plant density was exhibited the short plant height in all observation periods. The variation in plant height due to the planting density; a classic anti-shade response has been reported in studies where plant height tends to increase at the expense of other growth characteristics such as leaf size, stem diameter, number of leaves, flowering (Selim *et al.*, 1993; Lamido, 1998; Khattak *et al.*, 2015). Krizmanić *et al.* (2020) noted that plant density on pea considerably affeted the seed yield, plant height, also, Guo *et al.* (2019) reported that plant height of pea was decreased by wide plant density.

In observations from 15 DAE to 65 DAE, plant height ranged from 13.41 cm to 48.55 cm. Plant height values on March 26 sowing dates, the second planting time, at all observation samples during growth periods, were low. The highest plant height (48.5 cm) was on March 5 sowing time at 55 DAE. Because early-sown plants have longer vegetative growth periods than late sown plants, plant height was high on the first sowing date. After 55 DAE, the plant went to the physiological maturation period, due to a decrease in plant height was observed (Tab. I). Shaukat *et al.* (2012) reported that in early sowing dates, plant height resulted from long growing period, optimum soil water and favorable temperatures.

In all observations from 15 DAE to 65 DAE, number of nodes per plant was not affected by sowing dates and plant densities. However, at 25 DAE (6,5 and 8,5) and 35 DAE (9,9 and 11,7), the effect of sowing date on number of nodes per plant was significant, and number of nodes per plant values on March 26 sowings at both observation samples were high. The number of nodes per plant was 3,3, which was the smallest value in the first observation samples, and reached up to 14,6 in the latest observation samples, regardless of the planting date and planting density (Tab. I).

The effect of sowing dates on number of leaves per plant was significant at 15 DAE, 25 DAE and 65 DAE. In both observations, at 15 DAE (4,0 and 5,2) and 25 DAE (6,9 and 9,2), the second sowing time was high, but, the first sowing time was high at 65 DAE (11,5 and 3,2) for number of leaves per plant. The number of leaves ranged from 4.0 to 15.3 from DAE 15 to DAE 65 for sowing dates. The effect of plant density on number of leaves per plant was not significant in all observation samples, except for 45 DAE (Tab. I). At 45 DAE, number of leaves per plant ranged from 12,1 in 100 seed/m^2 to 13,6 in 40 seed/m^2. In the samples observed on the 65th day after flowering, the number of leaves per plant was found to be lower (3.2 to 11.5) at the second planting time. A notable decrease was observed in the number of leaves per plant of the samples taken.

The effects of different sowing dates and plant densities on number of leaflets per plant, number of stipules per plant and leaf area were given over six harvest times in Tab. II.

The effect of sowing dates on number of leaflets per plant was significant at 55 DAE and 65 DAE. Maximum number of leaflets per plant (36,8 at DAE 55 and 24,6 at DAE 65) was in the first sowing date. The first sowing time was high in both 55 DAE and 65 DAE, although the other observation samples were not significant, the first sowing time was also high in all observation samples. The effect of plant density on number of leaflets per plant was significant at 45 DAE, 55 and 65 DAE. The number of per plant was affected differently by wide and narrow plant densities. The number of leaflets per plant was 11,1, which was the smallest value in the first observation samples, and reached up to 40,6 in the latest observation samples, regardless of the planting date and planting density (Tab. II).

The effect of sowing dates on number of stipules per plant was significant at 65 DAE. The highest number of stipules per plant (8,4) was on 5 March sowing date at 65 DAE. The effect of plant densities on number of stipules per plant was significant at 45, 55 and 65 DAE. The highest number of stipules per plant was in 40 seed/m^2 (12,3) and 60 seed/m^2

I: *Plant parameters under different sowing dates and plant densities during all growth periods on pea*

	Plant height (cm)					Number of nodes per plant					Number of leaves per plant				
Sowing Dates	Plant densities														
DAE 15	40	60	80	100	M.	40	60	80	100	M.	40	60	80	100	M.
5 March	15,3	13,6	16,6	15,0	15,2	4,3	4,3	3,6	3,3	3,9	4,3	3,6	4,0	4,0	4,0 b
26 March	14,3	13,6	14,2	11,5	13,4	5,0	4,3	5,0	3,3	4,4	5,6	5,3	5,3	4,0	5,2 a
Mean	14,8	13,6	15,4	13,2		4,6	4,3	4,3	3,3		5,0	4,5	4,6	4,0	
LSD 0,05															0,89*
DAE 25															
5 March	30,5 a	27,6 ab	28,4 ab	26,0 abc	28,1	6,3	7,0	6,6	6,0	6,5 b	6,3	7,0	7,6	6,6	6,9 b
26 March	20,6 d	27,0 ab	22,0 cd	25,0 bcd	23,7	8,7	8,3	8,3	8,6	8,5 a	9,3	9,3	9,0	9,0	9,2 a
Mean	25,6	27,3	25,2	25,5		7,5	7,7	7,5	7,3		7,8	8,2	8,3	7,8	
LSD 0,05	2,22*									0,14*					0,14*
DAE 35															
5 March	30,3	35,8	38,3	40,6	36,3	9,0	9,6	10,0	11,0	9,9 b	10,66	13,3	11,6	12,0	11,9
26 March	35,0	30,3	33,3	41,0	34,9	12,0	11,6	11,6	11,6	11,7 a	12,0	11,3	12,3	11,6	11,8
Mean	32,6 b	33,1 b	35,8 b	40,8 a		10,5	10,6	10,8	11,3		11,3	12,3	12,0	11,8	
LSD 0,05		2,02 *								0,22 *					
DAE 45															
5 March	41,3	43,7	44,0	51,7	45,2	13,3	13,3	13,0	13,0	13,2	12,0 bc	14,3 a	12,0 bc	13,6 ab	13,0
26 March	38,3	37,3	36,0	43,7	38,8	13,7	14,3	12,7	12,3	13,3	13,0 ab	13,0 ab	13,6 ab	10,6 c	12,5
Mean	39,8 b	40,5 b	40,0 b	47,6 a		13,5	13,8	12,8	12,6		12,5 ab	13,6 a	12,8 ab	12,1 b	
LSD 0,05				2,042*							0,94*				
DAE 55															
5 March	41,3 bc	45,0 bc	47,3 b	60,5 a	48,5 a	14,0	14,0	13,6	13,0	13,7	14,3	12,7	14,3	13,7	13,8
26 March	46,3 bc	40,6 bc	39,3 c	47,6 b	43,5 b	15,3	14,0	13,6	15,0	14,5	14,3	22,3	13,3	11,0	15,3
Mean	43,8 a	42,8 a	43,3 a	54,1 b		14,6	14,0	13,6	14,0		14,3	17,5	13,8	12,3	
LSD 0,05	0,73*	2,36*			3,34*										

	Plant height (cm)					Number of nodes per plant					Number of leaves per plant				
Sowing Dates	Plant densities														
DAE 15	40	60	80	100	M.	40	60	80	100	M.	40	60	80	100	M.
						DAE 65									
5 March	38,0 bc	46,0 a	42,0 ab	33,0 c	39,7	14,3	13,6	14,6	13,6	14,2	7,6	11,3 ab	14,3 a	12,6 a	11,5 a
26 March	44,3 bc	37,0 bc	31,6 c	41,3 ab	38,6	14,6	11,6	10,6	13,0	12,5	4,6 cd	2,3 d	3,3 d	2,6 d	3,2 b
Mean	41,2	41,5	36,8	37,2		14,5	13,3	12,6	12,6		6,2	6,8	8,8	7,6	
LSD 0,05	3,62*											1,43*			1,89*

*,**; 0.05 and 0.01 at level significant

II: *Pea plant parameters under different sowing dates and plant densities during all growth periods*

	Number of leaflets per plant					Number of stipules per plant					Leaf area (cm^2)				
Sowing Dates	Plant densities														
DAE 15	40	60	80	100	M	40	60	80	100	M	40	60	80	100	M
5 March	12,0 ab	11,6 ab	12,6 a	12,6 a	12,2	3,7	3,3	3,3	4,3	3,7	38,6	36,2	41,2	39,6	38,9
26 March	12,0 ab	11,3 b	11,3 b	10.0 c	11,2	5,7	5,3	4,7	4,7	5,1	45,3	32,1	37,0	23,3	34,5
Mean	12,0	11,5	12,00	11,3		4,7	4,3	4,0	4,5		42,0	34,2	39,1	31,4	
LSD 0,05		0.58*													
						DAE 25									
5 March	16,0	16,0	16,7	14,7	15,8	5,7	7,3	8,3	6,3	6,9	59,6	89,2	80,0	71,4	75,0
26 March	20,0	17,3	16,3	17,3	17,8	9,0	8,3	9,7	8,0	8,8	118,2	102,3	131,3	93,0	111,2
Mean	18,0	16,7	16,5	16,0		7,3	7,8	9,0	7,2		88,9	95,7	105,0	82,2	
						DAE 35									
5 March	21,3	22,0	26,6	24,0	23,5	9,3	9,6	9,0	8,6	9,2	144,3 bc	155,7 abc	195,6 a	158,3 abc	163,0
26 March	23,3	22,6	23,3	24,0	23,3	10,0	10,3	10,3	9,0	9,9	198,1 a	119,2 c	156,6 abc	169,8 ab	160,0
Mean	22,3	22,3	25,0	24,0		9,6	10,0	9,6	8,8		171,2	137,4	176,1	164,1	
LSD 0,05												20,62*			

	Number of leaflets per plant					Number of stipules per plant					Leaf area (cm²)				
Sowing Dates	Plant densities														
DAE 15	40	60	80	100	M	40	60	80	100	M	40	60	80	100	M
							DAE 45								
5 March	29.3	35.3	32.0	29.3	31.5	11,6	12,3	12,0	10,0	11.50	207,4	250,1	210,4	279,1	236.7
26 March	26.0	34.6	26.6	28.6	29.0	12,0	12,3	9,0	9,6	10.75	303,9	221,8	216,0	199,4	235.3
Mean	27.6 b	35.0 a	29.3 b	29.0 b		11.8 a	12.3 a	10.5 b	9.8 b		255,7	235,9	213,2	239,3	
LSD 0,05	1.855*						0.58*								
							DAE 55								
5 March	34.6 ab	34.6 ab	37.3 ab	40.6 a	36.8 a	13.3	10.0	13.3	11.6	12.1	139.5 c	199.5 c	231.9 bc	329.3 ab	225.0
26 March	32.0 b	15.3 c	31.3 b	30.6 b	27.3 b	14.0	9.6	10.6	11.6	11.5	376.5 a	184.5 c	200.9 c	216. bc	244.5
Mean	33.3 a	25.0 b	34.3 a	35.6 a		13.6 a	9.8 c	12.0 b	11.66 b		257.9	192.0	216.4	272.7	
LSD 0,05	1.5 *	2.29*			3.24**		0.72*					56.5*			
							DAE 65								
5 March	25.3 b	24.6 b	14.0 cd	34.3 a	24.6 a	8.0 b	7.6 b	6.6 b	11.3 a	8.4 a	102.6 a	113.3 a	90.1 a	142.3 a	112.1 a
26 March	19.3 bc	6.6 e	10.6 de	7.3 de	11.0 b	4.6 c	2.3 d	3.0 d	2.3 d	3.1 b	117.5 a	23.7 b	23.0 b	25.5 b	47.7 b
Mean	22.3 a	15.6 b	12.3 b	20.8 a		6.3 a	5.0 b	4.8 b	6.8 a		110.1	68.5	57.0	83.90	
LSD 0,05	0.30 *	2.35*			3.33		0.55*	0.52*		0.73*		7.23*			29.65*

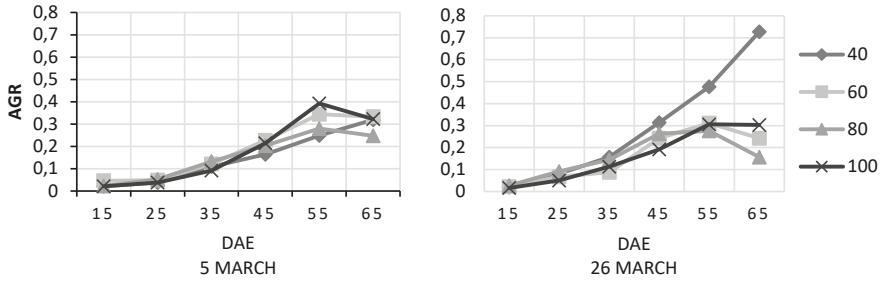
*,**; 0.05 and 0.01 at level significant

(11,8) plant densities at 45 DAE. At 65 DAE, number of stipules per plant ranged from 4,8 (80 seed/m^2) to 6,8 (100 seed/m^2). The ranged from 3.08 to 12.08 for sowing dates between DAE 15 and DAE 65. Number of stipules per plant was affected differently by wide and narrow plant densities. However, the number of stipules per plant in 40 seeds per m^2 was higher than other plant densities (Tab. II).

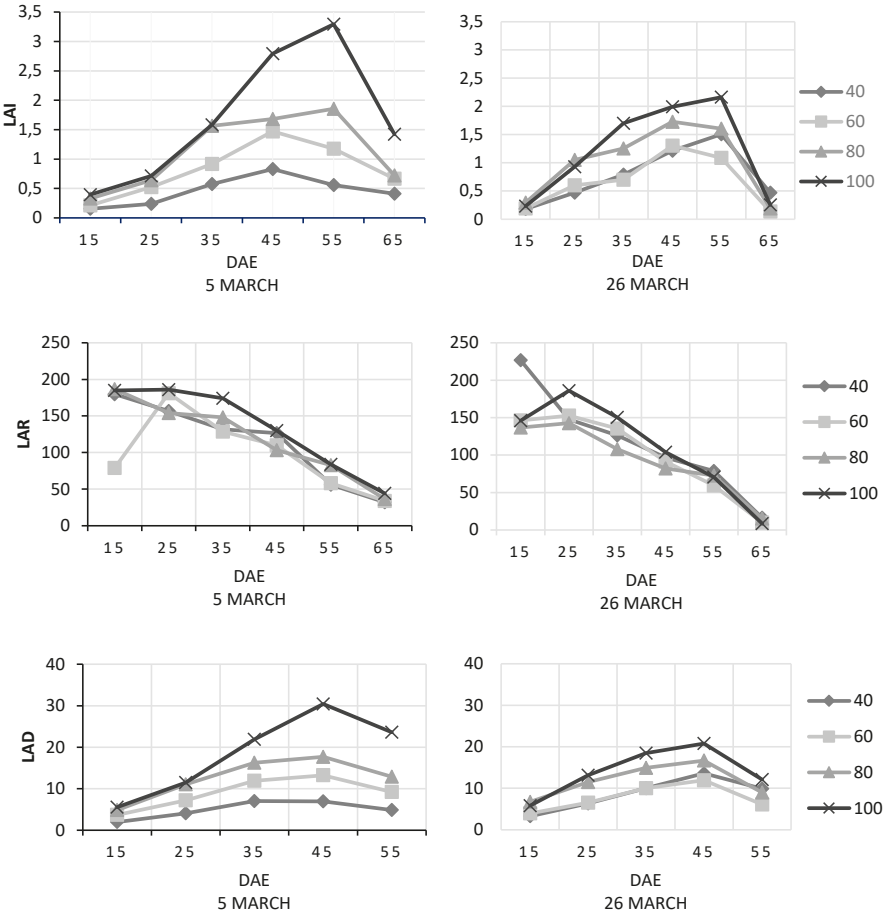
From 15 DAE to 55 DAE, leaf area per plant was not affected by sowing date and plant density, but in 65 DAE, the effect of sowing date and plant density x sowing date interaction was significant. The lowest leaf area per plant was 80 and 100 seeds per m^2 on 26 March. It was affected differently by wide and narrow plant densities, generally, leaf area in wide plant density was higher than other plant densities. The leaf area increased from 34.45 cm^2 to 244.54 cm^2 from 15 DAE to 55 DAE (Tab. II), but it decreased significantly after 55 DAE.

The effect of different sowing times and plant densities on absolute growth rate was investigated (Fig. 2).

For the March 5 sowing date, absolute growth rate ranged from 0,0214 cm day^{-1} to 0,3233 cm day^{-1} at all observation samples. Maximum absolute growth rate (AGR) was obtained in 100 seeds per m^2



2: *Absolute Growth Rate (AGR) of pea under different sowing times and plant densities*

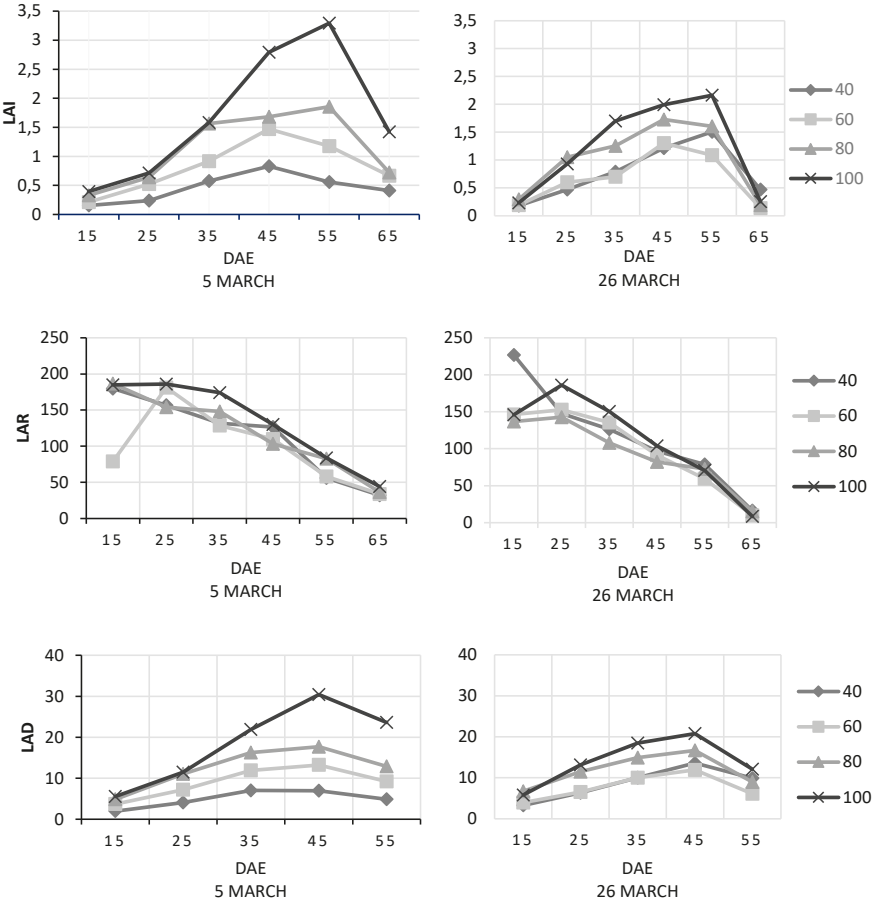


3: *Leaf area index (LAI), leaf area ratio (LAR) and leaf area duration (LAD) of pea under different sowing times and plant densities*

(0,3925 cm day^{-1}) and in 55 DAE for the March 5 sowing date and in 40 seeds per m^2 and in 35 DAE for the March 26 sowing time. Gul *et al.* (2013) obtained the highest AGR value from early sowing, and this is the result of a long vegetative period.

The effect of different sowing times and plant densities on leaf area index was investigated (Fig. 3). For the 5 March sowing date, leaf area index ranged from 0,213 m^{-2} m^{-2} in 60 seeds per m^2 at 15 DAE to 3,2926 m^{-2} m^{-2} in 100 seeds per m^2 at 55 DAE. For the March 26 sowing date, leaf area index ranged from 0,233 m^{-2} m^{-2} in 60 seeds per m^2 at 15 DAE to 2,162 m^{-2} m^{-2} in 100 seeds per m^2 at 55 DAE. In almost all observation samples, plant densities of 40 and 60 were low leaf index values. At 65 DAE was a rapid decrease in LAI values for both sowing dates. Because the plant approached the harvest period and the leaf area decreased and the rate of photosynthesis slowed down. LAI was recorded more during the linear growth stage and during the flowering stage. During the grain filling stage, there was a decrease in leaf area and consequently in LAI. Leaf area index is the photosynthetic area of a plant over a given time interval on leaf number, leaf production rate and leaf development. Gezahegn *et al.* (2016) emphasized that the widest distance produced a lower leaf area index (LAI). Tuttobene and Vagliasindi, (1995) reported that the maximum leaf area index can always be reached at high plant densities, but Loss *et al.* (1998) reported that the highest values were recorded in the most favorable environments, regardless of plant density. They state that the maximum LAI is obtained during flowering and until the beginning of pod filling and that it is the index that best explains the differences compared to other crop growth indices (Coelho and Pinto, 1989).

The effect of different sowing times and plant densities on leaf area ratio was investigated (Fig. 3). Leaf area ratio (LAR) ranged from 78,91 cm^{-2} g^{-1} in 60 seeds per m^2 at 15 DAE to 44,15 cm^{-2} g^{-1} in 100 seeds per m^2 at 65 DAE. The maximum value (186,056 cm^{-2} g^{-1}) was obtained from 100 seeds/m^2 at 25 DAE. LAR values were decreased from 15 DAE to 65 DAE on 5 March sowing date. LAR values showed a regular decreasing trend from the beginning to the end of growth and development at the first sowing date. For the second sowing date, LAR values ranged from 226,65 91 cm^{-2} g^{-1} in 40 seed/m^2 to 8,429 cm^{-2} g^{-1} in 100 seed/m^2. The fastest decrease was in late sowing date. As the temperatures increase and the plant approaches the harvest period, the LAR value was decrease (Prasad *et al.*, 2012).



4: *Specific leaf area (SLA) and specific leaf weight (SLW) of pea under different sowing times and plant densities*

The Leaf area duration (LAD) is the plant's ability to both the ability of the plant to maintain that leaf area and the leaf area (Boyd *et al.*, 2002). In the 5 March sowing date, the leaf area duration (LAR) ranged from 1,969 cm^{-2} g^{-1} in 40 seed/m^2 to 23,577 cm^{-2} g^{-1} in 100 seed/m^2 during 15 DAE and 55 DAE. For 26 March sowing date, the leaf area duration ranged from 3,956 cm^{-2} g^{-1} in 40 seed/m^2 to 20,787 cm^{-2} g^{-1} in 100 seed/m^2 during 15 DAE and 55 DAE. The highest values were in 100 seeds per m^2 plant density for the 5 March sowing date. The LAD value increased as the plant density increased (Fig. 3). Li *et al.* (2022) reported that the LAD value increased as the plant density increased in the maize crops. Increased LAD is improve leaf photosynthetic potential and is increase photosynthetic production capacity, providing a high percentage of above-ground biomass (Abeledo *et al.*, 2020; Li *et al.*, 2021).

The effect of different sowing dates and plant densities on specific leaf area was investigated (Fig. 4). Specific leaf area (SLA), which expresses the leaf-stem ratio, continued with a non-linear increase until 35 DAE in 5 March sowing time, while it decreased between 35 DAE and 65 DAE. In the 26 March sowing time, it continued with a non-linear increase up to 25 DAE, while it decreased between 25 DAE and 35 DAE. Increased air temperature and low rain were decreased the leaf-stem ratio per plant. According to plant density, the highest fluctuation in both sowing dates was at 60 plant density.

The effect of different sowing times and plant densities on specific leaf wide was investigated (Fig. 4). Specific leaf wide is positively correlated with temperature. With low temperatures, increasing light intensity increases the leaf area, and with high temperatures and decreasing light intensity, the leaf area decreases. An increase in the number of leaves with the effect of temperature is reported in some studies (Hunter *et al.*, 1974), but in some studies, the number of leaves is inversely proportional to the temperature (Bonaparte, 1975).

CONCLUSION

The effect of different sowing dates and plant densities in early spring on plant growth and development during six harvest times in rainfed conditions on pea was investigated. According to different harvest times, all traits were differently affected by plant density and sowing time. Although the effect of plant densities on plant characteristics differed according to plant development times, plant densities were not significantly affect the whole plant growth and development period. Early sowing time caused delays in seed germination and emergence. The effect of soil temperature on emergence and germination was significant in early spring planting of peas. Cold damage was detected in some seedlings that first emerged, but this negative effect disappeared with temperature rising. Germination and emergence were early in late March sowing. Although May was not rainy in the region in long term, rainy May in the trial year was rainy thus positive effect on the late sowing plants. Otherwise, plant growth could be adversely affected from mid-May. Early sowing should be preferred for a long vegetation period for the plant and to avoid drought at the beginning of pod and seed formation. However, cold-tolerant pea varieties should be preferred under rainfed conditions. These finding indicate that the pea crop has the ability to alter plant size and canopy structure in response to changes in plant density.

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