Agrotechniques in Industrial Crops

Journal Homepage: https://atic.razi.ac.ir

Razi University

The Effect of Delay in Planting Date on the Traits of the Rosette and Phenological Stages of Four Winter Oilseed Rape Cultivars in Hamadan, Iran

Behroz Dolatparast[1], Goudarz Ahmadvand[*1], Behzad Mehrshad[1], Javad Hamzei[1], Mohammad Yazdandoost Hamedani[2]

[1]*Department of Agronomy and Plant Breeding, Faculty of Agriculture, Bu-Ali Sina University, Hamadan, Iran*

[2]*Crop and Horticultural Science Research Department, Hamedan Agricultural and Natural Resources Research and Education Center, Agricultural Research Education and Education Organization (AREEO), Hamedan, Iran*

ARTICLE INFO

Original paper

Article history:
Received: 25 Oct 2021
Accepted: 25 Nov 2021
Published: 29 Nov 2021

Keyword:
Elite
Frost injury
Octans-NK
Okapi
Tassilo

ABSTRACT

This study aimed to investigate the effect of delay in planting date on the traits of the rosette stage and various phenological stages of oilseed rape. For this purpose, an experiment was conducted in split plots based on a randomized complete block design with three replications at the Agricultural and Natural Resources Research Center of Hamedan Province Iran in 2012. The main factor was planting date in four levels, including 10 September, 20 September, 30 September, and 10 October. The second factor was four genotypes (Okapi cultivar, Tassilo, Octans-NK, and Elite hybrids). The results showed that the number of leaves per plant in the rosette stage was only affected by planting date. However, crown diameter, root length, root dry weight, and percentage of frost were affected by planting date, genotype, and their interactions. The studied genotypes in the first and fourth planting dates often did not differ in terms of seedling stage and rosette traits. Still, in the second and third dates, the genotypes' response was often different, and in general, the Octans-NK and Tassilo genotypes showed less susceptibility to planting. With the delay in sowing, the length of the emergence period increased in all genotypes, but the growing degree day required for this stage decreased, so the genotypes entered the rosette stage with weaker vigor. Almost all genotypes, regardless of planting time, emerged from the rosette simultaneously and went through the following stages with a slight difference, which caused a delay in planting time to significantly reduce the cumulative temperature and growth period length in all genotypes.

DOI:10.22126/ATIC.2021.7203.1028

© The Author(s) 2021. Published by Razi University

1. Introduction

Oilseed rape is the most important oilseed crop in temperate and cold regions and the second most important oilseed crop in the world after soybeans (Moradi Telavat and Siadat, 2012). Oilseed rape can be rotated with wheat and barley and reduce the density of diseases, pests, and weeds and increase grain yield in these crops. In a study on oilseed rape-barley rotation, wheat-Oil seed rape rotation, and continuous winter wheat cultivation, the researchers reported that the highest number of fertile stems, highest tiller fertility, and highest wheat plant height were obtained from wheat-Oil seed rape rotation, and the lowest was obtained from continuous winter wheat cultivation (Seibutis *et al*., 2009). Features such as higher oil content than other oilseeds, precious nutritional properties of its oil for humans, distinct economic value among oilseeds, and numerous agricultural benefits make oilseed rape one of the essential oilseeds in the world (Przybylski and Mag., 2002). The growing season of oilseed rape is different from other oil crops such as cotton, soybean, and sunflower, and this plant is harvested when the capacity of lubrication units is empty (Ministry of Jihad Agriculture, 2014) oilseed rape with earlier harvest than wheat provides the necessary ground for the second crop of rice, soybeans, and other

* Corresponding author.
E-mail address: gahmadvand@basu.ac.ir

summer crops. Oilseed rape has a high yield potential, and among oilseeds, it has 40 to 45% of seed oil. Oilseed rape is one of the plants that are very sensitive to planting dates. Therefore, determining the most appropriate date for planting oilseed rape in each region is of great importance for developing this plant in the country (Rudi *et al*., 2003). One of the ecological factors affecting the delayed cultivation of autumn crops is frost. Before the cold comes, plants must have sufficient growth and nutrient storage to be exposed to the gradual decrease in temperature, find good cold resistance, and complete the winter rest period. Late planting not only does not allow plants to grow and resist diseases, but the resulting delay in crop maturity may lead to high temperature or drought at the end of the flowering and seedling stage of the plant (Khajehpour, 2008). In autumn rape cultivation, choosing a suitable planting date is directly related to the area's geographical situation and climatic conditions. As the rainfall in most parts of the country shows a downward trend, the soil moisture is insufficient. The amount of irrigation in autumn is reduced, close to the autumn rainfall, so planting is postponed as much as possible. Therefore, this study investigated the impact of delayed sowing dates on rape rosette stage traits and different phenological stages under Hamadan climatic conditions.

2. Materials and methods

To investigate the effect of delay in planting on rosette stage and phenology of oilseed rape, an experiment was conducted in 2012-2013 in the Agricultural and Natural Resources Research Center of Hamadan province with coordinates of latitude 34 degrees and 52 minutes north, longitude 48 degrees and 32 minutes east, and altitude of 1757 meters above sea level.

The soil of the experimental site had sand clay texture, 0.34% organic matter, and a pH of 7.75. The experiment farm was in the form of fallow in the previous year. In September 2012, two stages of vertical plowing were performed by a reversible plow to prepare the seedbed. A rotary machine (rotary plow) was used for crushing the lumps. Based on the soil test results, 100 kg/ha of phosphorus fertilizer from a triple superphosphate source and 183 kg/ha of pure nitrogen from the urea source were was used. One-third of urea fertilizer as base fertilizer and total phosphorus fertilizer was mixed with the soil by the rotator. Then, furrows were prepared for planting at a distance of 60 cm by the furrow machine. The remaining two parts of urea fertilizer were applied as top-dressing at the beginning of rapid longitudinal stem growth and early flowering.

The experiment was performed as a split-plot using a randomized complete block design with three replications. The main factor of planting date in 4 levels, including 20 September (d1), 30 September (d2), 9 October (d3), and 19 October (d4), and genotype as a secondary factor in four levels, including Okapi cultivar (g1), Tassilo (g2), Octans-NK (g3), and Elite (g4). Oilseed rape seeds were planted on different dates by hand and wet planting method. Considering their 1000-seed weight and potency, these seeds were planted with an initial density of 1,500,000 plants per hectare at a depth of 2 to 3 cm. Each experimental plot consisted of 4 ridges with a distance of 60 cm, and each ridge also consisted of 2 planting rows with a length of 5 m and a distance of 30 cm.

There was a distance of 60 cm between the experimental plots and 2 m between the blocks. Irrigation was done regularly during the growing season, according to the plant's soil moisture and water requirement during growth. During the growing season, to control aphid pests, Metasystox (oxidimethomethyl) at a rate of 1 liter per hectare was used twice: in the early stages of growth in (October) early pod formation, respectively. In addition, weeding inside the plots was done manually and in the interval between replications by a rotator during the growing season. When the average daily temperature decreases to less than the basal physiological temperature of the plant (5°C) (Alyari *et al*., 2000). By randomly sampling ten plants from each plot, the average number of leaves per plant, crown diameter, root length, and root dry weight, and size were measured. By counting the number of live and healthy plants in an area of one square meter of each plot after the cold and frosty season, the percentage of frost was calculated using the (Eq. 1).

$$\text{Percentage of frostbite} = ((a-b)/a) \times 100 \qquad (1)$$

In this regard, "a" is the number of plants per unit area before the onset of the cold season and "b" is the number of plants per unit area after the end of the cold season. We determined growth stages (phenology) of oilseed rape, including planting to emergence, emergence to the rosette, period of stagnation, budding, flowering, and maturity based on the unit of day and growing degree day (GDD). The unit of cumulative growing degree days (GDD) was calculated using (Eq. 2) (Wien, 1997):

$$GDD = \sum_{j=1}^{n} \left[\frac{T_{max} + T_{min}}{2} \right] - Tb \quad (2)$$

In this equation, GDD is the degree of cumulative growth day, "n" is the number of growing days, Tmax is the maximum daily temperature, Tmin is the minimum daily temperature (degrees Celsius), and Tb is the base temperature for oilseed rape growth (5°C).

Normality tests and analysis of test data were performed using SAS statistical software (version 9.1). Due to the insignificance of the effect of the block on the evaluated traits, analysis of variance was performed in a completely randomized design. The obtained means were compared using the least significant difference test at the level of 1% probability using MSTATC software. Excel (2016) software was also used to draw the graphs.

3. Results and discussion

3.1. Traits related to the rosette stage

3.1.1. Number of leaves per plant

The effect of planting date at the level of 1% probability on the number of leaves per plant was significant. The effect of genotype and the interaction effect of planting date and genotype on the mentioned trait were insignificant (Table 1). The number of leaves per plant is one of the essential traits of oilseed rape in the rosette stage. The mean comparison showed that with delay in planting, the number of leaves per plant decreased significantly. The maximum number of leaves per plant on the first and second planting dates (with 8.33 and 8.16 leaves per plant, respectively) and the minimum number of leaves per plant (4.5 leaves per plant) on the last planting date with a decrease of 46% obtained on the first planting date (Fig. 1). In previous studies, it has been reported that with a delay in planting date from 16 September to 5 October, the number of leaves per plant was reduced (Pasban Eslam, 2013). Also, other studies showed that the number of leaves per plant at the beginning of the rosette stage and in cold-tolerant cultivars is between 6 and 10 leaves (Alyari *et al*., 2000; Gusta and Oconnor, 1987)

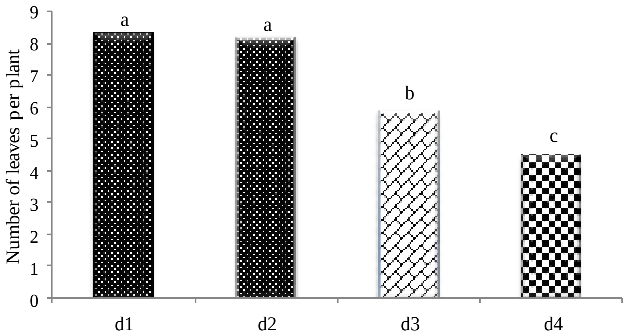

Figure 1. Effect of planting date on the number of leaves per plant before entering the rosette stage (d1: Planting date: 10/09/2012, d2: Planting date: 20/09/2012, d3: Planting date: 30/09/2012, d4: Planting date: 10/10/2012).

3.1.2. Diameter of the crown

The simple and interaction effects of culture date and genotype on crown diameter were significant (Table 1). Delay in planting reduced crown diameter in all four genotypes. There was no significant difference between genotypes in the first and last planting dates. However, the maximum crown diameter was assigned to the Elite genotype in the second planting date, which was not significantly different from the Okapi and Tassilo genotypes. On the third date, the highest crown diameter was observed in the Tassilo genotype, which did not show a significant difference with Okapi and Octans-NK genotypes (Fig. 2). According to the statistical grouping of treatments (Fig. 2), it can be seen that the difference between the genotypes was more significant in the second and third planting dates, which is due to the different responses of the genotypes to the decrease in temperature. The trend of decreasing crown diameter in Okapi and Tassilo genotypes with delay in planting was almost similar. Still, in Octans-NK genotype in the second planting date, crown diameter (5.6 mm) decreased sharply by 24% compared to the first planting date (7.36 mm), and Elite genotype (6.76 mm) in the second planting date showed an increase of 6.8% compared to the first planting date (6.33 mm). Also, the same genotype in the third planting date suffered a sharp decrease of 49% compared to the second planting date, which was significant compared to other treatments. It is noteworthy that this genotype had a similar reaction to the planting date on the third and fourth planting dates. It can be concluded that this genotype is probably less sensitive to late planting at this time in terms of crown diameter. The researchers reported a crown diameter of between 2.7 and 3.03 mm at the beginning of the rosette stage in cold-tolerant cultivars (Madani *et al*., 2005), and another researcher reported that oilseed rapes generally have a higher cold tolerance with 1.5 grams of dry weight per plant and about 8 mm of diameter in the crown (Alyari *et al*., 2000).

Table1. Mean squares of some traits related to the oilseed rape rosette period.

S.O.V	DF	Number of leaves	Crown diameter	Root length	Root dry weight	Percentage of frostbite
Planting Date (d)	3	41.638**	40.758**	529.25**	2.36**	1468.940**
"a" Error	6	1.000	0.0452	1.75	0.0152	13.788
Genotype (g)	3	1.638ns	0.802	45.361**	0.2171**	27.346**
g × d	9	1.120ns	0.652**	36.82**	0.009*	21.197**
"b" Error	24	0.666	0.182	2.75	0.04	3.641
CV		12.171	8.236	9.974	12.704	12.307

*, **, and ns were significant at 5% probability level, significant at 1% probability level and non-significant, respectively.

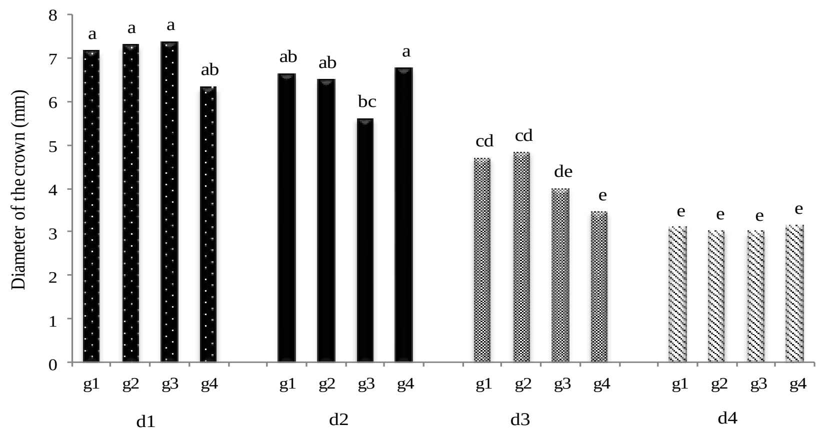

Figure 2. Interaction of planting date and genotype on oilseed rape crown diameter before entering the rosette stage (d1: Planting date: 10/09/2012, d2: Planting date: 20/09/2012, d3: Planting date: 30/09/2012, d4: Planting date: 10/10/2012).

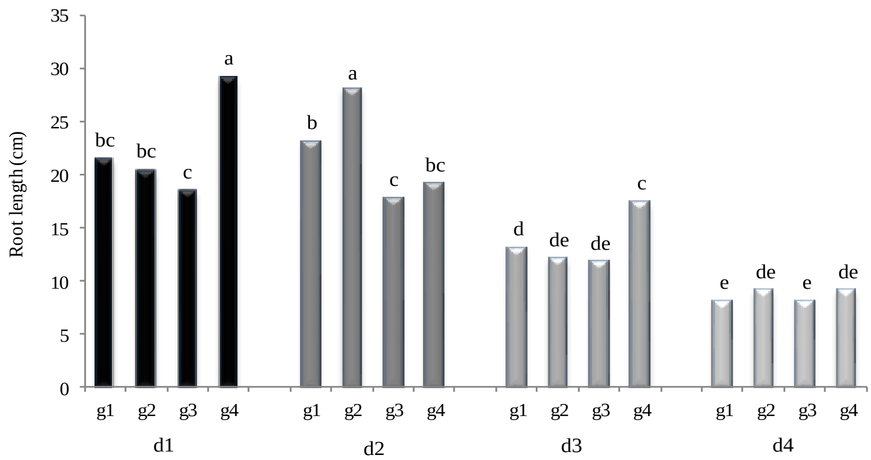

Figure 3. Interaction of planting date and genotype on average root length in oilseed rape plant before entering the (d1: Planting date: 10/09/2012, d2: Planting date: 20/09/2012, d3: Planting date: 30/09/2012, d4: Planting date: 10/10/2012).

3.1.3. Root length

The simple and interaction effects of planting date and genotype on root length were significant at the level of 1% probability (Table 1). The maximum root lengths belonged to Elite (29 cm) and Tassilo (28 cm) genotypes at the first and second planting dates, respectively, and the lowest root length allocated to Okapi (8 cm) and Octans-NK (8 cm) genotypes (Fig. 3). From the second planting date onwards, root length decreased with planting delay. On the fourth planting date, the highest decrease in root length compared to the first was related to the elite genotype with a reduction of 69% (9 cm). The lowest decrease was associated with the Octans-NK genotype (11.66 cm), with a decline of 36.4% compared to the first planting date with a root length of 18.33 cm.

One of the ecological factors affecting cold resistance in the rosette stage is root length. The plant must have sufficient growth and nutrient storage before the onset of cold so that it can be exposed to a gradual decrease in air temperature and find resistance necessary to cold and complete its winter rest. Late planting does not allow the roots to increase dry matter, but delay in planting causes the soil profile to cool further, and therefore, the plant roots will have less longitudinal growth. Researchers reported root lengths for autumn oilseed rape of more than 20 cm (Alyari *et al*., 2000). According to the instructions of the Ministry of Jihad for Agriculture (2012). Oilseed rape with a root length of 15 to 20 cm can resist tolerating a temperature of -18 to -19°C and with a root length of 7 to 9 cm can handle a temperature of -13 to –17°C.

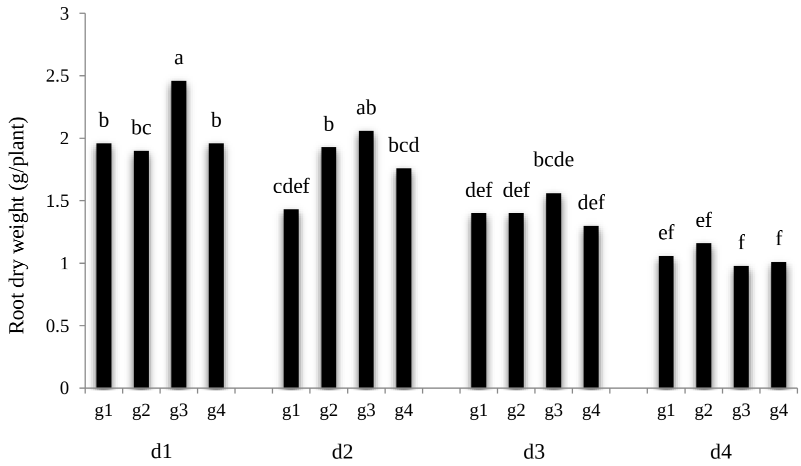

Figure 4. Interaction of planting date and genotype on root dry weight in oilseed rape plant before entering the (d1: Planting date: 10/09/2012, d2: Planting date: 20/09/2012, d3: Planting date: 30/09/2012, d4: Planting date: 10/10/2012).

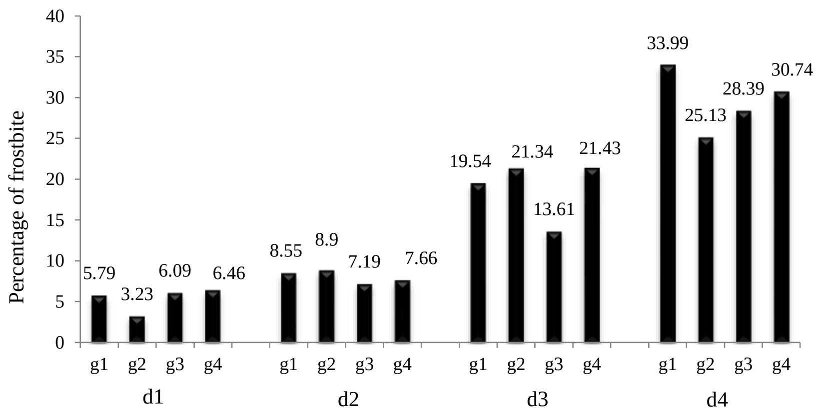

Figure 5. Interaction of sowing date and genotype on oilseed rape frostbite percentage (d1: Planting date: 10/09/2012, d2: Planting date: 20/09/2012, d3: Planting date: 30/09/2012, d4: Planting date: 10/10/2012).

3.1.4. Root dry weight

The simple and interaction effects of planting date and genotype on dry root weight were significant (Table 1). The maximum dry weight was obtained on the first planting date in the Octans-NK genotype (2.46 g/plant). The minimum root dry weight in Octans-NK and Elite genotypes were 0.98 and 1.01 g/plant, respectively. Also, a decrease of 60 and 59% compared to Octans-NK was obtained on the first date (Fig. 4). In all planting dates, except the last planting date, the Octans-NK genotype showed its superiority over other genotypes. The root system acts as a reservoir of nutrients during the fall and winter, and these reserves appear to be used for leaf regrowth in the spring. The later the oilseed rape planting date is delayed, the shorter the period of plant growth until the growth stops at the rosette stage, and the dry weight of the root produced by the plant decreases. The plant must have sufficient growth and nutrient storage before the onset of cold so that it can be exposed to a gradual decrease in air temperature, find resistance necessary to cold and complete its winter rest. In his experiment, Alyari et al. (2000) stated that oilseed rape with a dry weight of 1.5 g/plant tolerates cold. Researchers studied the growth trend of canopy and root dry weight and leaf area index in an autumn oilseed rape genotype on four planting dates. They observed that with a delay in planting date, root dry weight decreases significantly (Mendham and Salisbury, 1995).

3.1.5. Percentage of frostbite

The simple and interaction effects of planting date and genotype on frost percentage were significant at the level of 1% probability (Table 1). A delay in planting increased the rate of frost on the plants. Among the studied genotypes, Tacillo genotype at the first planting date (3.23%) and Elite genotype at the fourth planting date (33.99%) had the lowest and highest percentage of frost, respectively (Fig. 5). One of the influential ecological factors in the delayed planting of autumn crops is the issue of cold stress, which is affected by many traits such as the number of leaves, root length, crown diameter, and root dry weight. Researchers' studies have reported the effect of planting dates on resistance to freezing in the UK, with earlier planting dates having the highest correlation with winter survival (Robertson *et al*., 2004). The researchers stated that these changes are due to environmental messages and light and low temperatures (Mendham and Salisbury, 1995). Ahmadi (2000) also stated that physiological processes affecting the development of cold resistance such as cell sap concentration, enzymatic and protein changes occur at the cellular surface and especially plant cell membranes. Others have shown that, in late autumn crops, green speed and the establishment of oilseed rape seedlings are reduced by reducing the activity of enzymes involved in dissolution and the movement of seed stores toward meristematic points. The reason is that the necessary temperatures are not provided for the optimal activity of the relevant enzymes, which leads to an increase in frostbite (Nykiforuk and Johnson-Flanagan, 1994). Other researchers have reported that a gradual decrease in temperature during the cold season increases the plant's cold tolerance by inducing defense mechanisms in plants (Gusta and Flower, 1997; Mendham *et al*., 1984).

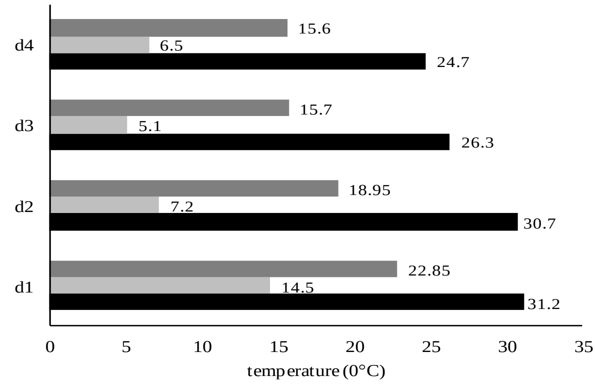

Figure 6. Maximum, minimum and average daily ambient temperature at different planting dates (d1: Planting date: 10/09/2012, d2: Planting date: 20/09/2012, d3: Planting date: 30/09/2012, d4: Planting date: 10/10/2012).

3.2. Phenology (developmental stages)

3.2.1. From planting to emergence (emergence of seedlings)

The number of days from planting to emergence increased with delay in planting. The lowest number of days was related to Tasillo genotype for ten days on the first planting date, and the highest number of days was associated with Octans-NK genotype for 18 days on the fourth planting date (Table 2). This increase in the number of days from planting to emergence is related to the decrease in temperature to obtain the growing degree day (GDD) required at this stage of plant phenology. This result is consistent with previous researchers who reported that cold slows down the germination of seedlings and thus prolongs the emergence and establishment of plants (Auld *et al*., 1985; Acharya *et al*., 1983). The maximum degree of recorded days from sowing to emergence was related to the elite genotype with 175.97 GDD on the first planting date. The minimum was related to the Okapi genotype with 134.05 GDD on the fourth planting date (Table 3). According to Fig. 6, the minimum mean temperature at planting time was related to the fourth planting date with 15.6, and the maximum temperature was associated with the first planting date with 22.85°C. Zade Hassan (2000) showed that temperatures of 18 to 20°C are suitable for germination and growth of oilseed rape seedlings. Thus, it can be said that in the conditions of Hamedan, the first and second planting dates provide the optimal temperature for the proper establishment of the plant (from 11 to 13 days). The speed of germination and establishment of seedlings in the third and fourth planting dates are from 16 to 18 days.

3.2.2. From planting to rosette formation

Among the various stages of vital activity of the plant, the rosette stage is crucial for providing a solid rosette to present a reasonable daily growth rate. At the first planting date, genotypes with a mean degree of the cumulative day of 633.17 GDD (65 days) were able to enter the recession stage with a strong rosette containing 8 to 10 leaves and minimal frost (Table 3). In proportion to the delay in planting, the amount of daily growth from planting to rosette was reduced in the studied cultivars, and the plants could not produce the required number of leaves for a strong rosette. As shown in Table 3, the genotypes achieved only 250.1 GDD on the fourth planting date in 35 days. As the Canada oilseed rape Association in 2006 recorded, the growth stage of autumn oilseed rape, based on a base temperature of 5°C, was at about 400 to 600 GDD. Therefore, in Hamedan, the first and second planting dates with a daily growth rate of 483 to 633 can provide the optimal temperature for this stage of oilseed rape phenology. The highest percentage of frosts was related to the fourth planting date with an average of 29.56%, and the lowest rate of frosts was associated with the first planting date with a mean of 39.5%, respectively (Fig. 5).

Table 2. Duration (day) of each phenological stage of oilseed rape genotypes in the four planting dates.

Genotype	Planting date	Emergence period	Rosette period	Budding period	Flowering period	Maturity period	From planting to maturity
Okapi	d1	11	54	35	36	39	175
	d2	13	42	33	36	37	161
	d3	16	29	32	29	35	141
	d4	17	18	31	27	35	128
Tassilo	d1	10	55	35	36	38	174
	d2	11	44	32	35	37	159
	d3	17	28	34	30	34	143
	d4	17	18	35	28	33	131
Octans-NK	d1	11	54	35	38	37	175
	d2	13	42	33	36	37	161
	d3	16	29	33	27	33	138
	d4	18	17	33	27	35	130
Elite	d1	12	53	31	36	38	170
	d2	13	42	33	35	38	161
	d3	17	28	33	27	33	138
	d4	17	18	34	27	35	131

Table 3. Cumulative growing degree days (GDD) for each of the phenological stages of oilseed rape genotypes at four planting dates.

Genotype	Planting date	From planting to emergence	From planting to rosette	From planting to beginning of flowering	From planting to end of flowering	From planting to maturity
Okapi	d1	162.17	633.17	793.57	1066.87	1684.27
	d2	157.70	484.50	625.95	893.70	1463.05
	d3	166.80	358.05	492.30	700.65	1127.55
	d4	134.05	250.10	377.40	558.90	948.55
Tassilo	d1	148.67	633.17	793.57	1066.87	1665.37
	d2	137.10	484.50	618.75	875.65	1425.25
	d3	175.15	358.05	508.10	724.80	1194.35
	d4	134.05	250.10	372.35	560.50	966.40
Octans-NK	d1	162.17	633.17	793.57	1090.97	1687.67
	d2	157.70	484.50	625.95	893.70	1463.05
	d3	166.80	358.05	499.50	691.45	1110.00
	d4	142.55	250.10	391.55	583.50	1040.95
Elite	d1	175.97	633.17	760.47	1022.42	1589.72
	d2	157.70	484.50	625.95	882.45	1458.35
	d3	175.15	358.05	499.50	691.45	1090.10
	d4	134.05	250.10	391.55	585.75	1048.50

3.2.3. From planting to budding

The length of the oilseed rape activity stage, regardless of planting date, is recorded from 31 to 35 days and from 122 to 161 GDD (Tables 2, 3 and 4). The highest number of cumulative days from planting to the beginning of budding was related to the first planting date (with a maximum of 220 days). The lowest was related to the fourth planting date (with a minimum of 186 days). Some researchers reported that 136.2 GDD and 28.7 days are needed to complete the budding stage in Shahrekord, probably due to the higher altitude of Shahrekord (2070 meters vs. 1748 meters above sea level Hamedan (Khoshhal Dastjerdi and Baratian, 2010). Also, the highest cumulative GDD in the first planting date with a maximum of 797.57 GDD and the lowest in the fourth planting date with 377.4 GDD showed an enormous difference. Most of this difference is related to planting to the rosette. Therefore, if the plant has a strong rosette before budding, it will reach faster to more branches and more suitable canopies (Johnson *et al*., 1995; Mandal *et al*., 1994). According to the results of the Faraji experiment (2010) which stated that the length of the period from emergence to the beginning of flowering was affected by temperature and photoperiod, it was concluded that the reason for the small difference in genotypes at each planting date could be due to photoperiod change. The results of the first planting date of this study are consistent with the results of others who reported a cumulative daily growth rate for Okapi and SLM-046 cultivars from planting to the beginning of flowering, equivalent to a 714.3 daily growth rate (Khoshhal Dastjerdi and Baratian, 2010).

Table 4. Active growing degree days in phenological stages of oilseed rape genotypes on four planting dates.

Genotype	Planting date	Emergence period	Rosette period	Budding period	Flowering period	Maturity period
Okapi	d1	162.17	471.00	160.4	273.30	617.40
	d2	157.70	326.80	141.45	267.75	569.35
	d3	166.80	191.25	134.25	208.35	426.90
	d4	134.05	116.05	127.30	181.50	389.65
Tassilo	d1	148.67	484.50	160.40	273.30	598.50
	d2	137.10	347.40	134.25	256.90	549.60
	d3	175.15	182.90	150.05	216.70	469.55
	d4	134.05	116.05	122.25	188.15	405.90
Octans-NK	d1	162.17	471.00	160.40	297.40	596.70
	d2	157.70	326.80	141.45	267.75	569.35
	d3	166.80	191.25	141.45	191.95	418.55
	d4	142.55	107.55	141.45	191.95	457.45
Elite	d1	175.97	457.20	127.30	261.95	567.30
	d2	157.70	326.80	141.45	256.50	575.90
	d3	175.15	182.90	141.45	191.95	398.65
	d4	134.05	116.05	141.45	194.20	462.75

3.2.4. From planting to the end of flowering

The highest duration of the flowering period (from the beginning of budding to the end of flowering) increased in Octans-NK genotype at 297.4 GDD in the first planting date and it lasted for 38 days. The lowest belonged to Okapi genotype in the fourth planting date increased to 181.5 GDD. A duration of 27 days was allocated (Tables 2 and 3), which was consistent with the results of previous researchers (Khayat and Gohari, 2009). Also, the maximum cumulative GDD from planting to flowering, on the first planting date with a maximum of 1097.97 GDD and 220 days for Octans-NK genotype and the lowest for Okapi genotype on the fourth date with a minimum of 558.9 GDD and 186 days were recorded. The results of this study in reducing the number of days of the flowering period in delayed cultivation were consistent with the results of experiments of other researchers (Aynehband, 1993; Abolhasani, 1995). Researchers have shown that low temperatures during the flowering period by sterilizing pollen grains are the leading cause of crop reduction (Toriyama and Hinata, 1984). Another researcher declared the flowering period as the most critical stage in oilseed rape growth that affects the yield of this plant

(Diepenbrock, 2000). The final number of pods and seeds in this four-week period, which is highly dependent on the milk supply, is determined. The relationship between the source and the reservoir during this period depends on the available sap. The researchers also stated that delay in planting reduced plant development and reduced the number of days from planting to flowering, which is consistent with the results of this study (Adamsen and Coffelt, 2005).

3.2.5. From planting to maturity

The maximum GDD for maturity was related to Octans-NK genotype with 617.4 GDD and 37 days at the first planting date. The minimum (405 GDD and duration of 33 days) was related to the Tassilo genotype. Also, the highest GDD (1687.67 GDD) and the number of active days equal to 175 cumulative days from planting to maturity were related to Octans-NK genotype at the first planting date. The lowest was 966.4 cumulative GDD and 131 days and belonged to the Tassilo genotype in the fourth planting date (Tables 2 and 3). With a delay in planting, the plant's vegetative growth stops earlier due to the long day, and the plant enters the reproductive stage. Also, the presence of heat and drought stress at the end of the growing season and the tendency of the plant to end its life cycle in order not to deal with adverse environmental factors is one of the main reasons for shortening the plant maturity period) (Madani *et al*., 2005). Researchers have reported the required heat from flowering stage to full maturity based on a base temperature of 5°C, 581 GDD, which is about the same amount of heat recorded for this stage of oilseed rape phenology in the first and second planting dates (549-617 GDD) in Hamedan (Morrison *et al*., 1989). The researchers showed the cumulative number of days for winter Acacia oilseed rape and SLM 046 in Shahrekord with an average of 162 days, which is close to the numbers of the first and second planting dates in Hamedan (159 to 175 days) (Khoshhal Dastjerdi and Baratian, 2010). Therefore, it can be said that the date of the second planting in Hamedan corresponded to the optimal planting date in Shahrekord. If the number of days with a temperature below 35°C is more, it will cause the crop to ripen early, reduce the seed weight in the pod, and reduce the yield because it reduces the length of the ripening stage (Malcolm and Stewart, 2002).

4. Conclusion

Delayed planting reduced the number of leaves per plant, crown diameter, length, and dry weight of roots in all genotypes by delaying the emergence and establishment of seedlings and reducing the time between emergences and entering the rosette stage. Therefore, the entry of weak seedlings into the rosette stage with less material storage in leaves, roots, and crown increased seedlings' frost during the rosette period. In seedling vigor for entering the rosette stage and passing the mentioned period, Okapi and Elite genotypes showed more susceptibility to delay planting. All genotypes, regardless of planting time, with a slight time difference, were out of rosette (the length of the rosette period was the same in all treatments) and passed the later stages of growth. Therefore, the main difference between the treatments in terms of time and cumulative temperature of the whole period (from planting to maturity) goes back to the vegetative stage, especially before entering the rosette stage. Generally, it can be concluded that if oilseed rape planting in the Hamedan region is delayed, it is better to use Octans-NK or Tassilo genotypes. Because these genotypes have less sensitivity and minor deficiency in seedling characteristics for passing the rosette period.

Acknowledgement

We appreciate farmers and nature. We thank all the dear farmers who produce food and ensure the food security of the country.

References

Aynehband A. 1993. Determining the growth curve and investigating the effect of planting date on the yield of rapeseed cultivars. Master Thesis Tarbiat Modares University.

Alyari H., Shkari F., Shkari F. 2000. Oilseed crop (Agronomy and Physiology). Tabriz, Amidi, 182 PP.

Abolhasani A. 1995. Study of planting density and arrangement on agronomic and qualitative characteristics of winter rapeseed in Khorasan region. Tarbiat Modares University.

Ahmadi R. 2000. Time and method of canola harvest. Extension Journal of Agricultural Research and Education Organization, Deputy of Extension.

Acharya S.N., DuecK S.N., Downey R.K. 1983. Selection and heritability studies on canola/ rapeseed for low temperature germination. Canadian Journal of Plant Science 63:377-384. https://doi.org/10.4141/cjps83-043

Adamsen F.J., Coffelt T.A. 2005. Planting date effects on flowering, seed yield and oil content of rape and crambe cultivars. Ind. Crops Prod. 21: 293-307. https://doi.org/10.1016/j.indcrop.2004.04.012

Auld D.L., Bettis B.L., Dial M.G. 1985. Planting date and cultivar effect on winter rape production.AgronomyJournal6:197-200. https://doi.org/10.2134/agronj1984.00021962007600020007x

Diepenbrock W. 2000. Yield analysis of winter oilseed rape (*Brassica napus* L.): A Review Field Crop Research. 67:35-49. https://doi.org/10.1016/S0378-4290(00)00082-4

Faraji A. 2010. Determination of Phenological Response of Spring Canola (*Brassica napus* L.) Genotypes to Sowing Date, Temperature and Photoperiod. Seed and Plant Production Journal 26(1): 25-41.10.22092/SPPJ.2017.110392

Gusta L.V., Flower D B. 1997. Factors affecting the cold survival of winter cereals. Canadian Journal of Plant Science 57: 213-219. https://doi.org/10.4141/cjps77-029

Gusta L.V., Oconnor B.J. 1987. Frost tolerance of wheat ،oat ، barley ،canola and mustard. Canadian Journal of Plant Science 67: 1155-1165. https://doi.org/10.4141/cjps87-155

Johnson B.L., Mckay K., Schneiter A.A., Hanson B.k., Schatz B.G. 1995. Influence of planting date on canola and crambe production. Journal of Production Agriculture 8: 594-599 https://doi.org/10.2134/jpa1995.0594

Khajehpour M R. 2008. Principles and foundations of agriculture. University Jihad Publications, Isfahan University of Technology, 384 PP.

Khoshhal Dastjerdi J., Baratian A. 2010. Thermal requirements estimation of the phenological stages of autumn Colza SLM046, Okapi in Iranian cold climatic conditions (ShahreKord Case Study). Physical Geography Research Quarterly 41(70).

Khayat M., Gohari M. 2009. Planting date effect on yield, seed yield, growth index and phonologic traits canola (*Brassica napus* L.) Genotypes in Ahvaz condition. New Finding in Agriculture, 3(No. 3 (Spring 2009)), 233-248.

Madani H., Nourmohammadi G., Majidi H. E., Shiranirad A. H., Naderi, M. R. 2005. Comparing winter rapeseed cultivars (*Brassica napus* L.) according to yield and yield components in cold regions of Iran.) 7 (1): 25.

Ministry of Jihad Agriculture. 2014. The situation of rapeseed in Iran and the world. (Statistics).

Ministry of Jihad-e-Agriculture. 2012. Iran's agriculture sector statistical report.

Mandal S.M.A., Mishra B.K., Patra A.K. 1994. Yield loss in rapeseed and mustard due to aphid infestation in respect of different varieties and dates of sowing. Orissa Journal of Agriculture.

Malcolm J.M., Stewart D.W. 2002. heat stress during flowering in summer Brassica. Crop Science. 42:797-80. https://doi.org/10.2135/cropsci2002.0797

Mendham N.j., Russel j., Buzza G.C .1984. The contribution of seed survival to yield in new Australian cultivars of oilseed rape (*B. napus*) Journal of Agricultural Science. Cambridge. 103: 303-316. https://doi.org/10.1017/S0021859600047250

Mendham N.J., Salisbury P.A. 1995. Physiology: Crop development, growth and yield. In: Kimber D & McGregor DI (eds.) Brassica oilseed. CAB International. pp. 11-64.

Morrison M.J., Mcvetty P.B.E., Shaykewich C.F. 1989. The determination and verification of a baseline temperature for the growth of westtar summer rape. Canadian Journal of Plant Science 69: 455-464. https://doi.org/10.4141/cjps89-057

Moradi Telavat M R., Siadat S A. 2012. Introduction and production of oilseed crops. Agricultural Education and Extension Publications. 349 PP

Nykiforuk C.L., Johnson-Flanagan A.M. 1994. Germination and early seedling development under low temperature in canola. Crop Science 34: 1047- 1054. https://doi.org/10.2135/cropsci1994.0011183X003400040039x

Pasban Eslam B. 2013. Effects of planting dates on yield and yield components of fall rape oilseed cultivars. Iranian Journal of Field Crop Science 44(1): 1-8. 10.22059/IJFCS.2013.30479

Przybylski R., Mag T. 2002. Canola/rapeseed oil in vegetable oils in food technology. composition, properties, and Uses, Gunstone, F. D. (ed), Blackwell Publishing, Osney Mead, Oxford (UK), Pp: 98-101.

Robertson M.J., Holland J.F., Bambach R. 2004. Response of canola and Indian mustard to sowing date in the grain belt of north-eastern Australia. Australian Expertion Journal of Agriculture 44: 43-52. https://doi.org/10.1071/EA02214

Rudi D., Rahmanpour S., Javidfar F. 2003. Rapeseed field. Publications of Tehran Promotional Media Planning Office. 53 PP.

Seibutis W., Deveikytė I., Feiza V. 2009. Effects of short crop rotation and soil tillage on winter wheat development in central Lithuania. Agronomy Research 7:471-476.

Toriyama K., Hinata K. 1984. Anther respiratory activity and chilling resistance in rice. Plant cell Physiol. 25: 1215.

Wien H.C. 1997. The Physiology of Vegetable Crops. Oxford. Newyork: CAB International: 662 p.

Zade Hasan A. 2000. Study of cold resistance and its relationship with protein markers in rapeseed genotypes. The University of Tabriz. Master Thesis.

HOW TO CITE THIS ARTICLE

Dolatparast B., Ahmadvand G., Mehrshad B., Hamzei J., Yazdandoost Hamedani M. 2021. The Effect of Delay in Planting Date on the Traits of the Rosette and Phenological Stages of Four Winter Oilseed Rape Cultivars in Hamadan, Iran. *Agrotechniques in Industrial Crops* 1(3): 129-138. 10.22126/ATIC.2021.7203.1028