Study of the Effects of Planting Date on the Phonological and Morphological Features, the Seed Yield, and the Components of the Yield of Oilseed Rape

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Abstract

In order to study the effects of planting date on the phonological and morphological features, the seed yield, and the components of yield of the spring cultivars of open pollinating oilseed rape, an experiment was conducted in the form of split plots based on the completely randomized complete block design in four replications in the Baiekola Agronomic Research Station in the years 2009-2010. In this study, the five planting dates at: Sep 23, Oct 7, Oct 22, Nov 6, Nov 21 (the first, the fifteenth, and the thirtieth of the first month; and the fifteenth and the thirtieth of the second month of the fall, respectively) were the main factor, and the open pollinating cultivars of RW008911, RAS-3/99, and RGS003 were the subordinate factor. Results of the analysis of the variance on the basis of the split plot design showed that the means of the squares of the planting dates were significant for all the features studied, which indicates the major effect of the planting date on these features. The cultivars were also significantly different for most of the features studied, except for the percentage seed oil content. The interaction effects of the planting date and the cultivar were not significant for most of the features, which shows similar trends of change in these cultivars in response to different planting dates. In all of the cultivars, there was considerable deterioration in most of the features as a result of delays in planting dates. Among the main components of seed yield, the number of pods per plant had a positive and significant correlation with seed yield, which indicates these two features are affected in the same way by different planting dates. In general, the highest seed yield in this study (4003 Kg.h) was observed in the cultivar RW0089 when planted at the earliest planting date.

Keywords: Phonological features, Components of yield, Planting date, Oilseed rape

1. Introduction

Oilseeds have an important role in balancing fats present in human diets and in reducing blood cholesterol levels due to their content of proteins, vitamins, and large amounts of unsaturated fatty acids. The rapeseed is considered to be one of the most important oilseeds in the world; and it acreage has been steadily increasing in our country. Edible oils are one of the important constituents of the daily diets of people; and rapeseed, which has an oil content of 40 to 50 percent, is considered a valuable source for providing the required edible oils. Moreover, in comparison with other oilseeds, the oil in rapeseed contains the least amount of saturated fatty acids (6%) (Anonymous, 2000). According to the latest statistics published by the FAO, rapeseed (*Brassica napus* L.) is the second major source of edible oils in the world after soybean.

Brassica napus, or the common rapeseed, is a natural amphidiploid, long-day plant with a C3-pathway (Hejazi, 2000) which is mainly planted in Europe and Canada; and in Canada it is called the Argentinean rapeseed because it was first imported to Canada from Argentina. Rapeseed, which has spring and fall and intermediate cultivars, has 38 chromosomes; and it is the most important species in the genus *Brassica* (Shiranirad and Dehshiri, 2002). Probably, rapeseed developed naturally through hybridization, and addition of the chromosomes, of oil turnip (*Brassica rapa* L.) and a wild cabbage (*Brassica oleracea* L.). The spring cultivars (Argentinean rapeseed) and the winter cultivars (Swedish rapeseed) are planted as sources of vegetable oil (Anonymous, 2000), but winter cultivars usually yield more (about 30 % more) under favorable conditions, and are harvested simultaneously with winter wheat (Anonymous, 2000). In Europe and China, usually the winter cultivars are planted, but at higher latitudes and at high altitudes and in places where the crop does not stand much chance of surviving the winter, such as in western Canada, only the spring cultivars can be planted. The seeds of the crop are often black, but, normally, there are also crops having yellow seeds. It appears that the yellow color of the seeds is related to lower tannin content of the seeds and the thinness of seed hull; this yellow color also causes an increase in seed protein and oil content and a reduction in the fiber content of the meal (Aliari and Shekari, 2000). Our study was carried out to better identify the qualitative and quantitative features of this oil crop, and to carefully determine its agronomic features.

2. Methods and Materials

This experiment was conducted in the Baiekola Agronomic Research Station in the crop years 2009-2010. The longitude and the latitude of the area are 13˚53 ″ East and 43˚36 North, respectively, and its altitude is 15 meters above sea level. On the basis of the meteorological data and the ambrotic curve, this area is part of the temperate Caspian regions. The average yearly relative humidity of the area, in the year the experiment was carried out, was reported to be 84 percent. The soil at the experiment site was loamy, contained 20 percent clay, and its pH was 7.8. The experiment was conducted in the form of split plots based on completely randomized block design in four replications. Two factors were studied in our study: comparison of the five planting dates and comparison of the cultivars (both factors at three levels, the names of which can be seen in Table 1).

The land was plowed in the first month of summer (July). It was plowed again near the end of the last month of summer, followed by two disking operations in perpendicular to each other, and by two leveling operations. Just before planting, the herbicide Treflan was applied at the rate of 2.5 $L.h^{-1}$ and was immediately incorporated in the soil by one disking operation. Chemical fertilizers were applied based on the soil test performed and on the prevailing conditions in the area. Concentrated superphosphate (50 Kg.h), potassium sulphate (100 Kg.h), and a third of the urea (50 Kg.h) were broadcast in a completely uniform manner on the soil and were disked in. The rest of the urea fertilizer (100 Kg.h) was divided into two equal parts; one part was given to the crop at the start of stem elongation and the other part before flowering.

The seeds were planted (at the five different planting dates) by hand in lines 30 cm apart, which had been made by using a D-hoe (Dutch hoe), and the land was irrigated immediately after planting. The different planting dates constituting five levels, as shown in Table 1, were in the main plot, and the three cultivars consisting of RW 008911, RAS-3/99, and RGS-003 were in the subordinate plot. In this study, each experimental plot consisted of four lines, each 4 meters long. The lines and the plots also, were 30 cm apart, and there was a distance of 4 meters (used as the passageway) between the replications. The features studied included the phonological features (the number of days to the start of flowering, the number of days to the end of flowering, the length of the flowering period, and the length of the maturing period), the morphological features (the height of the plants, the number of lateral shoots), and the yield and its components (the number of pods per plant, the number of seeds per pod, the 1000-seed weight, the seed yield, the harvest index, the percentage oil content, and the oil yield).

Final harvest took place at full maturity and at standard seed moisture content (10-12 %). Harvesting was carried out by hand, the margins were omitted (one row on each side of every plot and a distance of half a meter at the beginning and at the end of each planted line), threshing was performed with a combine used only in experiments, and the harvested seeds were weighed to compare the treatments. The statistical programs Excel and SAS were used to conduct the statistical analysis.

3. Results and Discussion

3.1 The Phenological stages

The effects of the planting dates and the cultivars on the phonological features were significant at the one percent probability level, delays in planting caused a significant reduction in the length of the flowering period, and a positive and significant correlation was observed between the length of the flowering period and the components of seed yield. Results of studies carried out by other researchers indicate that the length of the flowering period has a positive and significant relationship with the number of pods per plant and with the number of seeds per pod (Rahnama and Bakhshandeh, 2005). The figure of the comparison of the means showed that the earlier start of flowering in the earlier planting dates (Figure 2), and also in the cultivar RW008911, caused an increase in the length of the flowering period (which is consistent with results obtained by Faraji, 2003), while at late planting dates, and also in cultivar RGS-003, the length of the flowering period was reduced (Figure 1). Degenhardt and Kondra (1981), and Mendham et al., (1981), reported that delays in planting significantly reduced the growing period of rapeseed. Results of the experiments conducted by Kazerani and Ahmadi (2004) show the effects of planting date on the phonological and morphological stages of different rapeseed cultivars: the flowering period of the early maturing cultivar Maloka planted at the earliest planting date was 71 days, but it was reduced to 23 days at the fourth planting date; the longest growing period (177 days) was that of the first planting date, and the shortest growing period (128 days) was that of the fourth planting date (Kazerani and Ahmadi, 2004). The mutual effects of the planting date and the cultivar on the phonological features were significant at the one percent statistical level, and the treatments of the planting date of the first of Mehr and the cultivar RW008911, the planting date of the thirtieth of Mehr and the cultivar RGS-003 with 95 and 22 days had the longest and the shortest length of flowering period, respectively (Table 2).

Results of the comparison of the means of the effects of the planting dates on the feature of the end of the flowering period indicated that the second and the first planting dates with 194.4 and 185.4 days, respectively, had the largest, and the fifth planting date with 132.8 days had the smallest number of days to the end of the flowering period. Comparison of the means of the effects of the planting dates on the feature of maturity showed that the first planting date (Sep, 23) with 215.1 days ranked first and the treatment of the fourth planting date (Nov, 6) and the fifth planting date (Nov, 21) with 193.4 and 189.8 days ranked last (Figure 2). In Faraji′s experiment also, delays in planting date, besides reducing the length of the flowering period, decreased the maturing period (2003). In the comparison of the means of the cultivars, the cultivars RAS-3/99 and RGS-003 with 202.6 and 201.6 days were in the same statistical level, while the cultivar RW008911 with 195.9 days ranked last (Figure 1).

3.2 Morphological features and yield components

Results of the analysis of the variance of these features showed that the effects of planting date and cultivar on the height of plants, the number of pods per plant, the number of seeds per pod, the 1000-seed weight, the seed yield, and the percentage oil content are significant at the one percent level. The plants in the first planting date had taken advantage of the warm weather in the early part of the month of Oct to grow, and as a result they were taller. Faraji also achieved similar results in 2003. The results of the comparison of the means of the planting dates indicated the first and the second planting dates (that is, Sep, 23 and Oct, 7) produced the tallest plants with 170.9 and 167.2 cm, respectively, while the fourth and the fifth planting dates (Sep, 23 and Oct, 7) resulted in the shortest plants with 122.7 and 115.5 cm, respectively. As can be seen in the table of the comparison of the means, the height of the plants of the cultivar RAS-3/99 was significantly more than those of the other cultivars (Table 3). Results of the experiment conducted by Fanaee et al. (2008) indicated that the effects of the year, the planting date, the cultivar, and the rate of seeds planted, on the height of the plants were significant at the one percent probability level, that the tallest plants were observed at the first planting date with an average height of 152 cm, and that the shortest plants belonged to the fourth planting date with an average height of 122 cm. Fanaee et al. (2008) stated that this difference in height was more due to genetic differences.

Comparison of the means showed that the treatments of the second planting date (Oct, 7) and the first planting date (Sep, 23) with 45.43 and 38.54, respectively, ranked first and second, and that the rest of the treatments were in the next statistical group (Table 3). According to the results of the simple analysis of the variance, the effects of the planting date and the cultivar on the number of pods per plant were significant at the one percent level (Table 2). In the results of the experiments conducted by Faraji (2003) also, the effects of the planting date on the number of pods per plant were significant at the one percent level, but the effects of the cultivar were not. Results of the comparison of the means indicated that the cultivars RW008911 and RGS003 with 135.6 and 129.2 pods per plant, respectively, were in one statistical group, and that the cultivar RAS-3/99 with 116.6 pods per plat ranked last. These results also showed that the treatments of the third and fifth planting dates with 4.767 and 4.647 cm had the longest pods, and that the other treatments were in one statistical group (Table 3). Delays in planting date caused a reduction in the number of siliques per pod, the number of seeds per pod, the 1000-seed weight, the length of the pods, and, ultimately, in the seed yield of rapeseed (Mendham and Salisbury et al.,1985; Fathi et al., 2003). With delays in planting date, the number of seeds per pod increased and then decreased, and these results are consistent with those Faraji (2003) obtained in his experiments. Comparison of the means indicated that the first and the last planting dates with 17.5 and the third planting date with 19.8 seeds per pod ranked last and first, respectively (Table 3). Since components of yield affect each other and an increase or decrease in each influences the other components, it seems that the higher number of pods formed in the first planting date resulted in plants being confronted by problems at the time the first seeds were being formed, and hence the number of seeds per pod decreased; although there is also a relationship between the number of pods per plant and the number of seeds per pod with the height of the plants, the genotype, and the cultivar.

In investigating the comparison of the means, the greater length of the pods in the cultivar RWoo8911, as compared to the cultivar RGS-003 (Table 3), was effective in making this component of the yield (the number of seeds per pod) significant; and, therefore, the number of seeds per pod in the cultivar RW008911 was the highest (19.43) and in the cultivar RGS-003 the lowest (17.1). Rao et al. (1991) reported that the number of seeds per pod is one of the effective and determining factors in the seed yield of rapeseed, and that any factor increasing the number of seeds per pod will raise the seed yield as well. Of course, increase in the number of seeds per pod has limitations, because the productive capacity of this component of yield is more influenced by genetic factors.

Results of the interaction effects indicated that the number of seeds per pod was influenced by the mutual effects of the planting date and the cultivar at the one percent probability level (Table 2). Comparison of the means of the number of seeds per pod in the table of interaction effects shows that the highest number of seeds per pod was achieved in the treatment of the planting date of Oct, 22 and the cultivar RAS-3/99, and the lowest in the treatment of the planting date of Sep, 23 and the cultivar RAS-3/99 (Table 3). Shiranirad and Ahmadi (1996), in their study of the effects of the planting date and the density of the plants, reported that delays in planting date caused a significant decrease in plant height, the total dry matter of the plants, the rate of growth of the crop, and in the seed yield, that the densities of 40 and 120 plants per hectare had the highest and the lowest seed yield, and that among the cultivars studied the cultivar Serez had a higher seed yield than the cultivar Blinda; and attributed this to the number of seeds per pod and to the fact that the growing period of the cultivar Serez is longer than that of the cultivar Blinda. On the basis of the results of the analysis of the variance, the effects of the planting date and the cultivar were significant at the one percent level (Table 2).

Comparison of the means indicated that the first planting date with 3.6 g had the largest and the fifth planting with 3.19 g the smallest 1000-seed weight. The reason for the reduction of the weight of seeds in late planting dares was that the stage of the filling of the seeds coincided with a sharp increase in the temperature of the experimental site. In this regard, it is believed that at these high temperatures the rate of respiration is increased and the metabolite reserve is reduced; and also, the great heat influences the mechanism of the translocation of photosynthetates to the seeds, thus causing the seeds to be partially filled (Ghobadi et al., 2006). Moreover, in the comparison of the means of the cultivars, the 1000-seed weight of the cultivar RW008911 with 3.51 g was more than those of the other cultivars (Table 3). These results are consistent with those of the experiment carried out by Faraji (2003).

Results of the interaction effects showed that the 1000-seed weight was influenced by the mutual effects of the planting date and the cultivar, and that the differences were significant at the one percent probability level, so that the largest 1000-seed weight (3.965 g) belonged to the treatment of the first planting date and the cultivar RW008911, and the smallest (3.142) to the treatment of the planting date of Nov, 21 and the cultivar RAS-3/99.

Results of the analysis of the variance indicated that the effects of the planting date and the cultivar on the seed yield were significant at the one percent level. As a whole, with a delay in the planting date, the seed yield significantly decreased (Table 2). The first planting date enjoyed the favorable conditions of the warmth present at the early stages of the growth of the plants, the fast and suitable vegetative growth before flowering, and the sufficient growing period; and hence it was able to produce the largest number of pods per plant and, in the end, the highest seed yield. The lowest seed yield was observed in the last planting date. There were no statistically significant differences in the seed yields of the second, the third, and the fourth planting dates.

Results also showed that for every 60-day delay in the planting date from Sep, 23 to Nov, 21, the seed yield decreased by 1008 Kg.h (which is a reduction of 16.8 Kg.h for every day the planting date was delayed).The cultivar Rw008911 with 3301 Kg.h had a greater seed yield than the other two cultivars (Table 2). Degenhardt and Kondra (1981) reported that delays in planting significantly reduced the yield of rapeseed. Our results are consistent with those obtained by Robertson et al. (2004), Johnson et al. (1995), who had concluded that delays in planting caused a significant reduction in seed yield. Johnson et al. (1995), and Ozer (2003), considered the reduction in the number of pods per plant, which happened in the late planting dates, to be the main reason for the reduction in seed yield. Rao et al. (1991) also reported that the number of seeds per pod was one of the influential and determining factors in the seed yield of rapeseed, and that any factor increasing the number of seeds per pod will also raise the seed yield. Their report is consistent with the results we observed in our study.

Results of the simple analysis of the variance indicated that the effects of the planting date on percentage oil content were significant at the one percent probability level (Table 2). On the basis of the comparison of the means, the highest percentage oil content was that of the first planting date with 42.23%, and the lowest belonged to the fifth planting date with an average of 40.13% (Table 3). Based on the results obtained, it is clear that, among the meteorological factors, temperature has the greatest effect on the percentage oil content of rapeseed. In the late planting dates, the percentage oil content decreased due to the coincidence of the stages of increase in seed oil with high temperatures in the environment; while the highest seed oil content was achieved at intermediate temperatures and suitable relative humidity. Hocking and Stapper (2001), Robertson et al. (2004), and Walton et al. (1999) obtained similar results and reported a 1.7% reduction in percentage oil content for every one degree centigrade increase in temperature at flowering and seed filling stages.

4. Conclusions

The fact that the effects of the planting date are significant for all the features studied suggests that the planting date has a pronounced effect on all the features studied, so that delays in planting often result in a decrease in plant height and plant stamina, a reduction in the components of yield, and a decrease in seed yield. The interaction effects of the planting date and the cultivar were not significant for most of the features. This shows that there is a similar trend in changes in the features of the cultivars studied resulting from differences in planting dates, so that most features which influence seed yield deteriorated as a result of a delay in planting date (and this declining trend was observed in all of the three cultivars studied). In our study, the highest seed yield (4003 Kg.h) was that of the cultivar RW008911 planted at the first planting date, and the lowest seed yield (2022 Kg.h) was that of the cultivar RAS-3/99 planted at the last planting date.

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Table 1. The main and the subordinate factors of the study

A- The main factor	B- The subordinate factor
A1 = planting date at Sep 23, 2009	B1 = cultivar RW008911
A2 = planting date at Oct 7, 2009	B2 = cultivar RAS-3/99
A3 = planting date at Oct 22, 2009	B3 = cultivar RGS-003
A4 = planting date at Nov 6, 2009	
A5 = planting date at Nov 21, 2009	

Table 2. Comparison of the means of the interaction effects of planting date and cultivar on the phenological features using Duncan's method

Item number	Treatment Planting date x cultivar	Start of Flowering (days)	End of Flowering (days)	Length of Flowering (days)	Number Of days To maturity
1	Sep 23 x RW008911	100 gh	203.5 ab	95.5 a	211.8 ab
2	Sep 23 x Ras-3/99	108 g	183B cd	64.5 d	217.5 a
3	Sep 23 x RGS-003	118.5 e	169.8 cde	47.25 f	216 a
4	Oct 7 x RW008911	122.5 d	210.3 a	78.25 b	203 bcd
5	Oct 7 x Ras-3/99	132 bc	203.3 ab	68.5 c	209.3 ab
6	Oct 7 x RGS-003	135.3 ab	169.3 cde	47 f	205 bc
7	Oct 22 x RW008911	122.3 d	193.8 ab	59.5 e	192 ef
8	Oct 22 x Ras-3/99	134.3 ab	186.5 bc	50.5 f	198.5 cde
9	Oct 22 x RGS-003	136 a	157.8 ef	43.25 g	196.5 cde
10	Nov 6 x RW008911	114.5 f	162 def	37 h	189.3 ef
11	Nov 6 x Ras-3/99	125 d	163 def	34.25 hi	197 cde
12	Nov 6 x RGS-033	129.3 c	144.8 f	32.75 ij	194 de
13	Nov 21 x Rw008911	112 f	152.5 ef	30.5 j	183.3 f
14	Nov 21 x RAS-3/99	122 d	149.3 ef	26 k	190.8 ef
15	Nov 21 x RGS-033	123.3 d	96.75 g	22 l	195.5 cde

Numbers having common letters in each column are not significantly different at the probability level of 5 percent.

Table 3. Analysis of variance of morphological features and seed yield components as affected by the treatments of the planting date and the cultivars of rapeseed on the basis of Duncan′s split plot design

Sources of change	Degree of freedom	Plant height	No. of pods per plant	No. of seeds per pod	1000-seed weight	Seed yield	Percentage oil content
Replications	3	79.22	1021.55	135.54	0.062	274041.79	0.65
Planting date	4	7808.01**	26181.86**	12.72**	0.35**	1621876.52	9.04**
Error a	12	207.12	267.37	1.28	0.041	117081.25	0.98
Cultivar	2	6595.23**	1856.33**	28.29**	0.30**	3326803.73**	1.49
Planting date x cultivar	8	154.13	263.78	9,14**	0.22**	135826.04	1.91
Error b	30	74.17	178.20	1.99	0.03	135728.23	1.23
Coefficient of Variation	-	5.9	10.50	7.68	4.98	12.81	2.67

Significance at five and one percent probability level is shown by * and **, respectively.

Table 4. Comparison of the means of the mutual effects of the planting date and the cultivar on plant height and components of seed yield using Duncan's method

Item no.	Treatment Planting date x cultivar	Plant height (cm)	No. of pods per plant	No. of seeds per pod	1000 seed weight (g)	Seed yield (Kg.h)	Percentage oil content
1	Sep 23 x RW008911	148.3d	170.8ab	18.33cdef	3.965a	4003a	43.47A
2	Sep 23 x Ras-3/99	185.4a	156.3bcd	16.32f	3.64bc	2663cdef	41.9ab
3	Sep 23 x RGS-003	179.1ab	170.1ab	17.85	3.145f	3224bcd	41.32Bcd
4	Oct 7 x RW008911	139.7de	178.6a	21.33ab	3.805ab	3131bcd	41.87ab
5	Oct 7 x Ras-3/99	183.9ab	146cd	19.26bcd	3.495cde	2431efg	42.12ab
6	Oct 7 x RGS-003	178ab	172ab	16.82ef	3.18f	3036bcde	41.9ab
7	Oct 22 x RW008911	126.9ef	154.7bcd	20.03bc	3.325def	3472ab	42.39ab
8	Oct 22 x Ras-3/99	171.2bc	136.4d	22.58a	3.64bc	2700cdef	41.59Abc
9	Oct 22 x RGS-003	162.8c	161.4abc	16.77f	3.553bcd	2750cde	42.42ab
10	Nov 6 x RW008911	110gh	90.53e	19.13Cde	3.305def	3264bc	42.48ab
11	Nov 6 x Ras-3/99	132.6ef	85e	17.82cdef	3.240ef	2625def	41.87ab
12	Nov 6 x RGS-033	125.4f	79.97ef	17.31def	3.240ef	2878bcde	41.1Bcd
13	Nov 21 x Rw008911	102.2h	83.29e	18.33cdef	3.17f	2385def	39.64d
14	Nov 21 x RAS-3/99	125.6f	59.63f	17.36Def	3.142f	2022g	39.98cd
15	Nov 21 x RGS-033	118.8fg	62.48f	16.75f	3.255ef	2208fg	40.77Bcd

Means with at least one common letter are not significantly different from the statistical point of view.

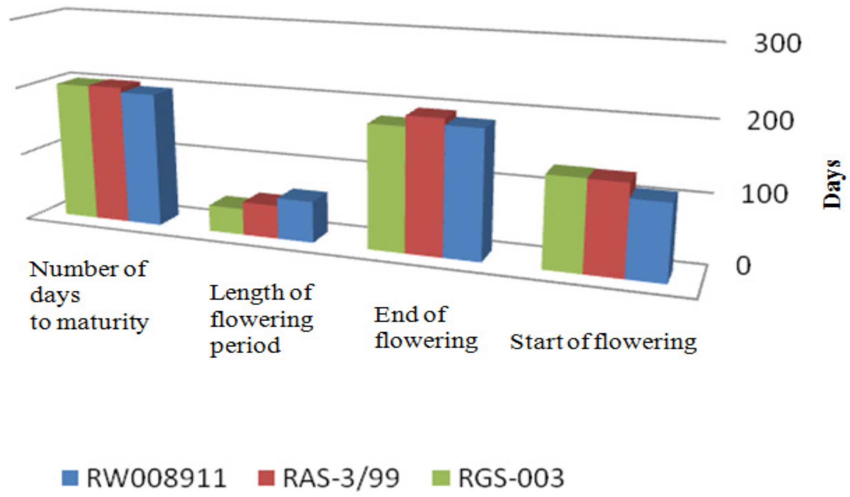

Figure 1. Comparison of the means of the phonological features as affected by the cultivars

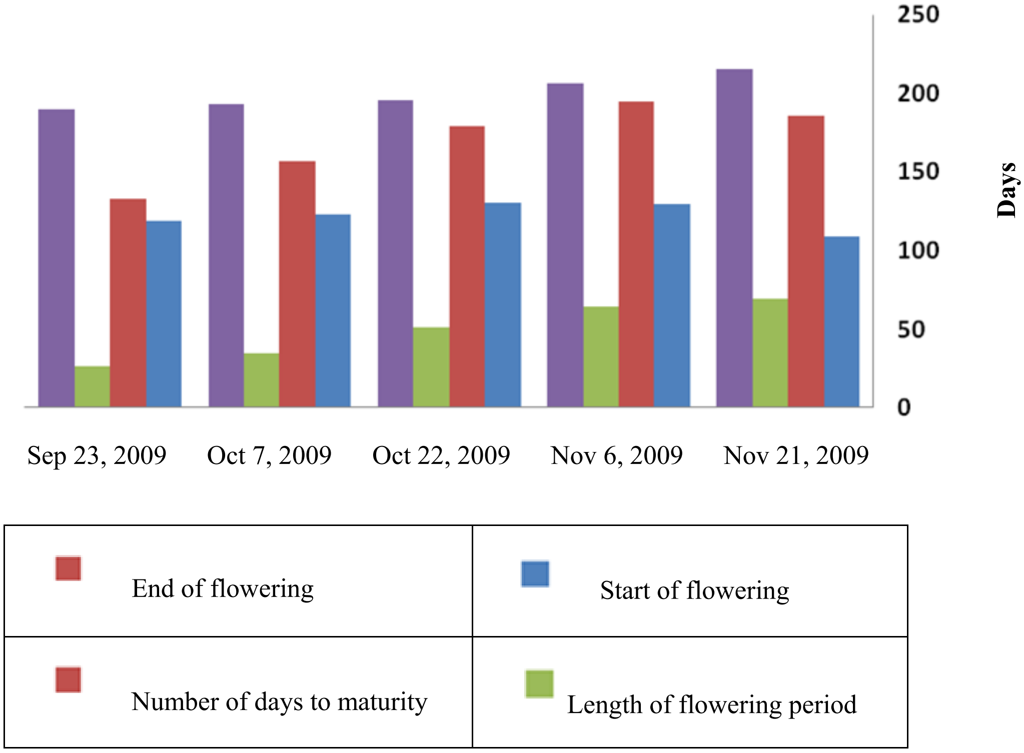

Figure 2.Comparison of the means of the phonological features as affected by the planting date