



## DEVISING A GUIDE TO THE FLOWERING WINDOW OF COMMON AND INTRODUCTION VARIETIES OF DURUM WHEAT (*TRITICUM DURUM* DESF.) IN IRAQ

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### Abstract

This study was conducted in 2019/2020 agricultural season in a high rainfall area in Fayda sub-district, Dohuk governorate. The study include two factors, the 1st factor was 28 durum wheat varieties grown in Iraq, while the 2nd factor was the sowing date in two levels: early sowing before the fall of first heavy effective rain and late sowing after the fall of the first heavy effective rain. The interaction between sowing dates and studied varieties and its effect on the flowering window was studied by determining three basic growth stages according to the Zadoks scale, which were the end of booting stage (Z-49) when first awns visible, the beginning of anthesis growth stage (Z-61), and anthesis complete growth stage (Z-69). The most important results obtained in the field study on the effect of varieties and sowing dates in the flowering window, it was possible to develop a guide for the ideal sowing dates for durum wheat varieties in Iraq by knowing the extent to which the productivity of these varieties is affected by sowing dates, and through that it was possible to classify them into three groups, the first group of varieties can planted before the 1st effective rain fall, the second after the 1st effective rain fall, and the third is neutral, and these results were according to early and late flowering based on the LSD values of the average varieties for the three growth stages under study.

**Keywords:** Flowering window, Sowing date, Durum Wheat, Zadoks growth scale, Iraqi varieties.

**وضع دليل لنافذة التزهير للأصناف الشائعة والمدخلة والواعد من الحنطة الخشنة****(*Triticum durum* Desf.) في العراق**أري سليمان البرواري\*<sup>1</sup> عبد الستار أسمير الرجبو<sup>2</sup><sup>1</sup>ديوان وزارة الزراعة والموار المائية - مديرية البحوث والارشاد - أربيل<sup>2</sup>كلية الزراعة والغابات - جامعة الموصل

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البريد الالكتروني: [ari84shele@hotmail.com](mailto:ari84shele@hotmail.com)**الخلاصة**

أجريت هذه الدراسة في الموسم الزراعي 2020/2019 في منطقة مضمونة الامطار في ناحية فايدة التابعة لقضاء سميل محافظة دهوك. اشتملت الدراسة على عاملين، العامل الأول كان 28 صنفاً من الحنطة الخشنة المزروعة في العراق، بينما كان العامل الثاني هو موعد البذار على مستويين: البذار المبكر قبل سقوط الامطار (البلة) والبذار المتأخر بعد سقوط (البلة). تمت دراسة بين مواعيد البذار والأصناف المدروسة وتأثيره على نافذة التزهير من خلال تحديد ثلاث مراحل نمو أساسية وفقاً لمقياس Zadoks وهي نهاية مرحلة البطانه (Z-49) عند ظهور السفا، بداية التزهير. مرحلة النمو (Z-61)، ومرحلة النمو عند أكمال التزهير (Z-69). اهم النتائج التي تم الحصول عليها في الدراسة الميدانية حول تأثير الاصناف ومواعيد البذار في نافذة التزهير، كان من الممكن وضع دليل لمواعيد البذار المثالية لأصناف الحنطة الخشنة في العراق من خلال معرفة مدى انتاجية هذه الأصناف تتأثر الأصناف بمواعيد البذار، ومن خلال ذلك أمكن تصنيفها إلى ثلاث مجموعات الأولى تزرع أصنافها قبل البلة والثانية بعد البلة والثالثة محايدة، وذلك حسب التبكير والتأخير في التزهير استناد إلى قيم LSD لمتوسط الأصناف لمرحل النمو الثلاث قيد الدراسة.

**كلمات مفتاحية:** نافذة التزهير، موعد البذار، الحنطة الخشنة، مقياس زادوك، الأصناف العراقية.

**Introduction**

The Zadoks scale was invented by the Dutch plant pathologist Jan C. Zadoks in 1974. And is based on ten major growth stages numbered from 0 to 9, each primary growth stage divided into 10 secondary stages, so the scale runs from 00 to 99. Flowering window" defined by (5) as a balance between two limits, the first being the risk of frost damage, disease infection, or poor growth if flowering occurs too early, and the second limit is high temperatures and drought if flowering occurs late. Therefore, the yield of grain in wheat does not depend on the date of sowing, but rather on the date of flowering. Durum wheat varieties of late flowering and maturation give good yields in appropriate conditions, but under stress conditions, their yield decreases

because of the synchronization of the grain filling stage with the period in which the water decreases (6).

The flowering window of cultivars, sowing date can be selected before or after the first heavy rain fall for the cultivars suitable for this sowing date after knowing the flowering window of each cultivar (22). Early ripening cultivars are preferred over late ones in semi-arid environments. (11 and 12) Farmers have already identified early sowing as a useful management strategy to increase yield, but now they need new wheat genotypes with life cycles fit with sowing dates and with the optimum flowering period in order to achieve an increase in yield. (9) Flowering time is very important, as a cultivar that blooms early enough will avoid drought and heat stress, and that early flowering for some cultivars is a strategy. To escape dehydration. (7, 9 and 13). The earliness at the sowing date stimulates the plant to early flowering and to escape from the water deficit in the spring (18). The results of the study by (2). Showed that the best date for sowing of durum wheat varieties is the first date, November 20, as this date was 50% higher in the traits of the number of days until flowering, and the grain yield, compared with the two dates 10 and 30 December. The cultivar selection technique should be wise, i.e. the new cultivar should be better or equal in yield to the old dominant cultivar, disease resistant and environmentally tolerant. It must also be tested over a period of several years and the preferred planting date should be chosen within each environmental spot in order to support the approval and approval of the variety and in accordance with the current market requirements, (20). The results of (10) showed that in low, medium and high rain fall environments, there is a great potential to increase productivity by increasing the proportion of slow-maturing varieties that are planted early. The early sowing system can increase the yield by 0.54 tons.ha<sup>-1</sup>. The number of days needed to flower and ripen was reduced by 10% and 14%, respectively, under drought stress conditions. (15). The optimal flowering period for any wheat variety was defined by (10) as the period during which the grain yield during the same season is not less than 95% of the maximum average yield of the variety.

### Material and Methods

This experiment was conducted during the agricultural season (2019-2020) in the fields of the Department of Seed Testing and Certification in Fayda District in Dohuk Province. This study aims to devise a national guide that determines the ideal dates for sowing local and introduced durum wheat varieties after knowing the flowering window for each of them based on the application of the Zadoks growth scale, and then classifying these varieties into early, medium or late maturity groups based on their growth stages according to the Zadoks scale. The field experiment was designed as a factorial experiment with two factors: varieties and sowing dates and with three replications according to the split-plot design in a randomized complete block design (R.C.B.D) using a GenStat program. The comparison between the averages was done using the LSD test at the level 0.05 to compare the means. Three stages of growth were studied for twenty-eight varieties of durum wheat (*Triticum durum* Desf.), under

rainy conditions with two planting dates, the 1<sup>st</sup> before the first effective rainfall on 11/22/2019, and the 2<sup>nd</sup> after it fell on 26 /12/2019.

Soil Analysis, Precipitation Rates and Temperature: A soil sample was taken from field at a depth of 0-30 cm before sowing for analysis and knowledge of the physical and chemical properties of the soil. The analyzes were conducted in the environmental laboratories in Dohuk. The data of rainfall for Fayda site were obtained from the Directorate of Agriculture of Dohuk Table 1. The maximum Temp was 30 C and minimum Temp was 8 C in the period between 1 April to 11 May at Dohuk, so it was not an effective stress factor on flowering window in this season.

The Zadoks growth scale was applied to all varieties to study three stages of growth, which are the end of booting growth stage Z-49, the beginning of anthesis growth stage Z-61, and the Anthesis complete growth stage Z-69, according to the Zadoks growth scale (21) and by studying the three stages of growth for all studied varieties. The varieties were sequenced in terms of earliness and delay at each stage of growth. The grains of all varieties were planted at a constant sowing rate of 300 grains.m<sup>-2</sup> according to the recommendation of (4), and the field was fertilized with 80 kg.ha<sup>-1</sup> DAP Di Ammonium Phosphate fertilizer with 80 kg.ha<sup>-1</sup> Urea.

**Table 1 Soil analysis and rainfall ppt. in (2019-2020) season.**

Measurement type	Value	Rain Monthly precipitation	mm.
pH	7.07	Oct. 2019	43.3
EC ds.m <sup>-1</sup>	0.26	Nov. 2019	19.3
Available Nitrogen mg.kg <sup>-1</sup>	44.77	Dec. 2019	137.8
Organic Matter %	2.11	Jan. 2020	110.7
Available Phosphorous mg.kg <sup>-1</sup>	15.39	Feb. 2020	101.7
Available Potassium mg.kg <sup>-1</sup>	171.42	Mar. 2020	282.0
Clay %	30.50	Apr. 2020	68.5
Silt%	26.50	May 2020	16.2
Sand %	43.0	Total ppt. mm.	779.5 mm.
Texture	Clay loam		

## Results and Discussion

Study of the end of booting growth stage Z-49 for durum wheat: It is clear from Table 2 that the sowing date has a significant effect on the end-of-booting stage of Z-49 for durum wheat, as the second sowing date achieved an average number of days to reach the end of the booting stage, which amounted to 109.00 days, significantly superior to the first sowing date, which achieved an average of 129.24 days. The genetic factor also had an effective impact on the number of days to reach the stage of the flowering.

The durum wheat varieties under study were divided according to the number of days to reach the end of the booting stage into six groups based on the LSD value of the varieties average, which is 1.30. The first group starting with variety Saribasak 115.83 days and ending with the variety Parasiful 117.67 days, represented the group with the least number of days to reach the end of booting stage, followed ascendingly by the group (Cham3 - Zviko), then the third group involving the two varieties (Atras and Fada 98), and the fourth group containing the variety (Baghdad 2), and the fifth group, which included the two varieties (Karonia and Bakra Joe), while the variety (Ary achieved the highest value of the number of days to reach the end of the booting stage with a value of 134.83 days.

**Table 2 Effect of varieties and sowing dates of durum wheat on end of booting growth stage Z-49 (days after sowing).**

	Varieties	Sowing Dates		Mean
		Sowing 1	Sowing 2	
1	Ary	148.00	121.67	<b>134.83</b>
2	Bakrajo-1	137.00	114.33	<b>125.67</b>
3	Karoneyah	135.00	115.33	<b>125.17</b>
4	Bahgdad-2	130.67	112.67	<b>121.67</b>
5	Fadda-98	133.33	106.67	<b>120.00</b>
6	Atras	129.00	112.00	<b>120.50</b>
7	Zeviko	131.00	108.33	<b>119.67</b>
8	Cham-9	129.00	109.00	<b>119.00</b>
9	LDE357	128.00	109.67	<b>118.83</b>
10	Dora-29	127.67	109.67	<b>118.67</b>
11	Firat-93	127.33	109.00	<b>118.17</b>
12	Cham-5	127.33	109.00	<b>118.17</b>
13	Guayakan	129.00	107.33	<b>118.17</b>
14	Aum Rabee3	129.00	107.00	<b>118.00</b>
15	Cham-3	127.33	108.67	<b>118.00</b>
16	Barsefool	126.67	108.67	<b>117.67</b>
17	Svevo	127.67	107.33	<b>117.50</b>
18	Iraqi-7	126.67	108.00	<b>117.33</b>
19	Smito	126.67	108.00	<b>117.33</b>
20	Wahataliraq	126.00	108.33	<b>117.17</b>
21	Dora-85	126.00	108.00	<b>117.00</b>
22	Kardenenay	127.33	106.33	<b>116.83</b>
23	Secondrous	126.00	107.33	<b>116.67</b>
24	Erbil-3	130.00	103.33	<b>116.67</b>
45	Acsad-65	126.00	107.00	<b>116.50</b>
26	Miki-3	127.33	105.67	<b>116.50</b>
27	Sardar	125.33	107.67	<b>116.50</b>
28	Saribasak	126.67	105.00	<b>115.83</b>
	Dates Mean	129.15	109.00	
L.S.D.(0.05)				
	Sowing Dates	4.042		
	Varieties	1.300		
	Interaction (Dates&Varieties)	7.001		

These results are in agreement with what (1) found that there are significant differences between the Pakistani wheat varieties in the number of days until the emergence of 50% of the spikes. It also agrees with what was confirmed by researchers (11) that there are significant differences in the trait of the end date of the booting among the varieties. The general average was 87.8 days, and the earliest

variety was Masoud 7 with 79.3 days, and the late variety was the local variety Macawy with 112 days.

In the interaction between the two factors, the highest average number of days to reach the end of booting stage 148 days was achieved in the interaction of the first sowing date with the variety Ari, while the lowest average number of days to reach the end of booting stage 103.33 days was achieved in the interaction of the variety Erbil 3 with the second sowing date.

Study of the beginning of anthesis growth stage Z-61 for durum wheat: It is clear from Table 3 that the sowing date has a significant effect on the trait of the Z-61 stage for durum wheat, the second sowing date achieved an average number of days to reach the Z-61 stage, which amounted to 119.32 days, significantly superior to the first sowing date, which achieved an average value of 139.06 days. The genetic factor also had an effective impact on the number of days to reach the Z-61 stage, as the durum wheat varieties under study were divided according to the number of days to reach the Z-61 stage into six groups based on the LSD value of the varieties average, which is 3.473, as the first group represented the variety Sardar 122.33 days, which is the lowest variety in the number of days to reach the Z-61 stage, followed by the group (Dur 85 - Fada 98), then the third group (Sivevo - Cardinia), the fourth group (Saribasak - Karonya), and the fifth group, which included only Bakrajo-1 variety with 138.17 days, while the variety (Ari) achieved the highest value of the number of days to reach the Z-61 stage, with a value of 140.5 days. These results agree with what was shown by (14) and it is agree with the early classification of (16) to the durum wheat into groups according to the date of flowering, as the first group represented early flowering varieties (the period between the date of sowing and the date of 50% of flowering was 125 days).

**Table 3 Effect of varieties and sowing dates of durum wheat on the beginning of anthesis growth stage Z-61 (days after sowing).**

	Varieties	Sowing Dates		Mean
		Sowing 1	Sowing 2	
1	Ary	156.00	130.00	<b>143.00</b>
2	Bakrajo-1	151.00	125.33	<b>138.17</b>
3	Karoneyah	147.00	121.00	<b>134.00</b>
4	Guayakan	143.00	123.00	<b>133.00</b>
5	Erbil-3	147.00	118.67	<b>132.83</b>
6	Bahgdad-2	140.67	122.33	<b>131.50</b>
7	Atras	139.67	123.00	<b>131.33</b>
8	Saribasak	144.50	117.67	<b>131.08</b>
9	Kardenenay	138.67	122.33	<b>130.50</b>
10	Barsefool	140.33	119.33	<b>129.83</b>
11	Secondrous	139.00	119.00	<b>129.00</b>
12	Firat-93	138.67	118.00	<b>128.33</b>
13	Wahataliraq	137.00	119.67	<b>128.33</b>
14	Cham-9	136.67	119.67	<b>128.17</b>
15	LDE357	139.00	117.00	<b>128.00</b>
16	Iraq-7	136.67	119.00	<b>127.83</b>
17	Miki-3	135.67	118.67	<b>127.17</b>
18	Dora-29	135.00	119.33	<b>127.17</b>

19	Svevo	138.67	115.33	<b>127.00</b>
20	Fadda-98	136.00	117.67	<b>126.83</b>
21	Zeviko	137.00	116.00	<b>126.50</b>
22	Cham-3	135.67	117.00	<b>126.33</b>
23	Aum Rabee3	133.67	118.67	<b>126.17</b>
24	Smito	135.00	117.00	<b>126.00</b>
25	Cham-5	133.67	118.00	<b>125.83</b>
26	Acsad-65	132.00	119.00	<b>125.50</b>
27	Dora-85	133.00	116.33	<b>124.67</b>
28	Sardar	131.67	113.00	<b>122.33</b>
	Dates Mean	139.06	119.32	
L.S.D.(0.05)				
	Sowing Dates	0.912		
	Varieties	3.473		
	Interaction(Dates&Varieties)	4.911		

And the second group they are varieties with the medium flowering date (the period between sowing date and the date of 50% of flowering was less than 136 days, as for the third group, it was late flowering varieties (the period between the date of planting and the date of 50% of flowering was less than 161 days).

In the interaction between the two factors, the highest average number of days to reach the Z-61 stage 156 days was achieved in the interaction of the first sowing date with the (Ari) variety, while the lowest average number of days to reach the Z-61 stage was 113 days in the interaction of (Sardar) variety with the second sowing date. These results agree with the results of researchers (17) in their study that wheat varieties vary among themselves in flowering date and duration, as the differences between the early variety in flowering and maturity and the late variety reach up to 42 days in the case of early sowing, and up to 20 days in the case of Late sowing.

Study of the Anthesis complete growth stage Z-69 for durum wheat: It is clear from Table 4 that the sowing date has a significant effect on the trait of Z-69 stage for durum wheat. The second sowing date achieved an average number of days to reach the Z-69 stage, which amounted to 122.79 days, significantly superior to the first sowing date, which achieved an average value of 143.13 days. Whereas the genetic factor was also effective on the number of days to reach the Z-69 stage, as the durum wheat varieties under study were divided according to the number of days to reach the Z-69 stage into five groups based on the LSD value of the varieties average, whose value is 3.517, the first group represented one variety (Sardar with the least number of days until flowering completed 125.33 days, with a significant difference from the second group that follows it in ascending order, which is the group (Semito - Zvico), then the third group (LDE 357 - Cardinia), and the fourth group (Atras - Erbil 3), while the two varieties, (Bakra Jo 1 and Ari), achieved the highest value for the number of days to reach the Z-69 stage, with a value of 143.17 and 146.67 days, respectively.

The reason for the difference in these varieties in the length of the growth stage may be due to the difference in their genetic structures, as well as the difference in their interaction with the environmental conditions in which they are cultivated. This

characteristic is important in distinguishing varieties that are earlier in flowering and maturity.

In the interaction between the two factors, the highest average number of days to reach the stage of Z-69 161.00 days was achieved in the interaction of the first sowing date with the (Ari) var., while the lowest average number of days to reach the stage of Z-69 117.00 days was in the interaction of the second seed date with (Sardar) var., these results agree with what was indicated by (3) in their study of three sowing dates (November 10, November 25, December 10) and five genotypes with a local variety (Sivevo) to outperform the early sowing date of November 10, in terms of the number of days for flowering. This phenomenon gives evidence that the genetic factor is different in its response to environmental conditions, which generated this variation in the response of varieties to environmental stress, as environmental stress accelerates the stages of plant growth, but at the expense of productive and sometimes qualitative traits. And our conclusion is based on the results of the current study as well as the results of other studies that stated that exposing wheat plants to drought stress as a result of stop or reducing irrigation reduces the number of days from sowing to ear emergence, flowering, and maturity, and this depends on the time of exposure to stress and the stage of growth in which the stress occurred.

This explanation agrees with what (10) found in low rainfall environmental sites, where the optimal flowering period was short 19-35 days, while in heavy rain sites the optimal flowering period was relatively long 30-52 days. As well as with what (19) found in their study to evaluate the effect and dates of sowing on the traits of durum wheat, as the study included four dates 10/11, 25/11, 10/12 and 25/12, and it became clear that the most number of days until flowering is 107 days, which was at the early sowing date of 10/11, and what we have concluded is also supported by what (15) explained that the number of days required for flowering and ripening decreased by 10% and 14%, respectively, under drought stress conditions.

It is clear from Figure 1 and Figure 2 that the response of durum wheat varieties to sowing dates did not differ relatively in terms of earliness or delay in growth stages, starting from the end of the booting stage Z-49 and ending with the anthesis complete growth stage Z-69, as we note the stability of the variety (Sardar) in the forefront of the early varieties and for the two dates of sowing, while the two varieties (Ari and Bakra Jo1) settled at the bottom of the varieties sequence of the late-flowering and then ripening, for the two sowing dates as well, while the response of the rest of the varieties was relatively different.

**Table 4 Effect of varieties and sowing dates of durum wheat on anthesis complete growth stage Z-69 (days after sowing).**

	Varieties	Sowing Dates		Mean
		Sowing 1	Sowing 2	
1	Ary	161.00	132.33	<b>146.67</b>
2	Bakrajo-1	157.33	129.00	<b>143.17</b>
3	Erbil-3	152.33	123.00	<b>137.67</b>
4	Saribasak	153.00	121.67	<b>137.33</b>
5	Karoneyah	150.00	124.33	<b>137.17</b>
6	Guayakan	147.00	125.00	<b>136.0</b>



7	Bahgdad-2	143.67	126.67	<b>135.17</b>
8	Atras	143.67	126.33	<b>135.0</b>
9	Kardenenay	142.00	125.33	<b>133.67</b>
10	Barsefool	143.33	123.33	<b>133.33</b>
11	Secondrous	142.33	123.33	<b>132.83</b>
12	Miki-3	140.00	123.67	<b>131.83</b>
13	Cham-9	140.00	123.67	<b>131.83</b>
14	Firat-93	142.33	121.00	<b>131.67</b>
15	Wahataliraq	140.67	122.33	<b>131.5</b>
16	Iraq-7	140.00	122.33	<b>131.17</b>
17	Svevo	143.67	118.67	<b>131.17</b>
18	Dora-29	139.00	123.00	<b>131.0</b>
19	LDE357	141.67	120.33	<b>131.0</b>
20	Zeviko	139.00	121.33	<b>130.16</b>
21	Cham-3	140.33	119.67	<b>130.0</b>
22	Cham-5	139.33	120.33	<b>129.83</b>
23	Aum Rabee3	138.00	121.67	<b>129.83</b>
24	Fadda-98	138.00	121.67	<b>129.83</b>
25	Acsad-65	138.00	121.00	<b>129.5</b>
26	Dora-85	138.67	120.33	<b>129.5</b>
27	Smito	138.67	119.67	<b>129.17</b>
28	Sardar	133.67	117.00	<b>125.33</b>
Dates Mean		143.13	122.79	
L.S.D.(0.05)				
Sowing Dates				0.924
Varieties				3.517
Interaction(Dates&Varieties)				4.974

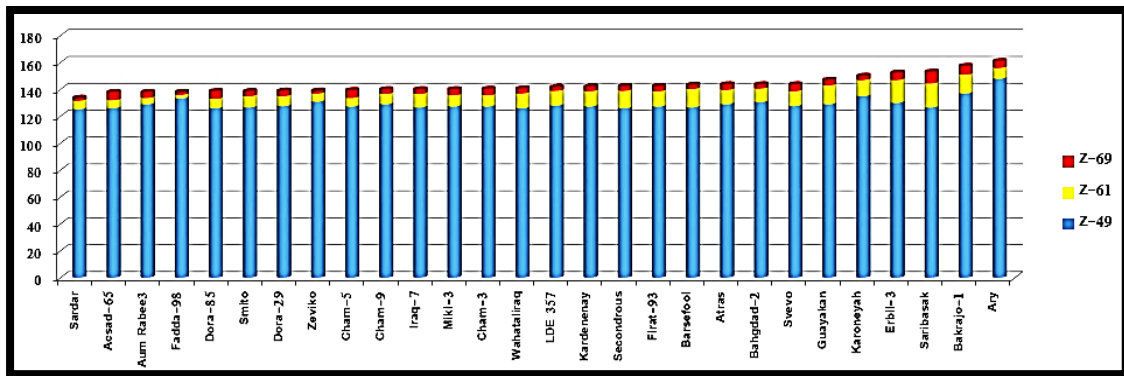


Figure 1 the number of days of the three growth stages of durum wheat varieties at the 1st sowing date.

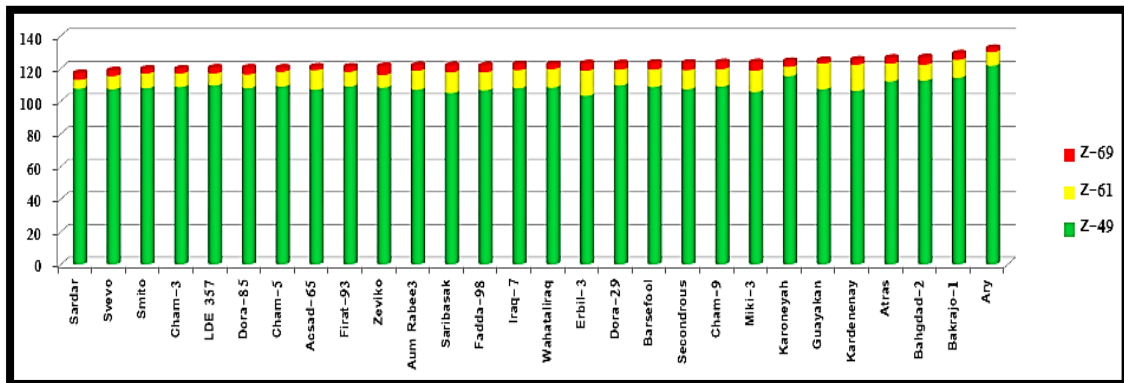


Figure 2 the number of days of the three growth stages of durum wheat varieties at the 2nd sowing date.

Conclusion: According to the foregoing results, we conclude that it is possible to divide the durum wheat varieties into three groups, which are an inferred guide for the dates of sowing durum wheat varieties in Iraq (Ary and Alrijabo guide 2022) according to Appendix 1.

#### Appendix 1 Ary and Alrijabo guide (2022) for the ideal dates for Cultivation of durum wheat varieties in Northern Iraq.

A group of varieties that are planted late after the first effective rain falls	The group of neutral varieties grown on both dates without affecting the yield	A group of varieties that are planted early before the first effective rain falls	
<b>Secondrous</b>	Karoneyah	Acsad-65	Fadda-98
Guayakan	Zeviko	Ary	Firat-93
Dora-85	Erbil-3	Atras	Iraq-7
	Smito	Aum Rabee3	Kardenenay
		Bahgdad-2	LDE357
		Bakrajo-1	Miki-3
		Barsefool	Sardar
		Cham-3	Saribasak
		Cham-5	Svevo
		Cham-9	Wahataliraq
		Dora-29	

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