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Araştırma Makalesi – Research Article

Determination of Essential Growing Degree Days Amount for Vegetation Period in Some Dry Bean Varieties*

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Abstract

The amount of Growing-Degree-Days (GDD) has been widely used for regional selection of varieties, determination of planting time, all the processing ranking through the growing period of plants as well as biological stage of plants. In this study, it was aimed to determine the GDD amount of some registered dry beans varieties throughout the green remaining period of plants in Konya Region of Turkey.

The varieties of Akman 98, Göksun, Göynük 98, Karacaşehir 90, Noyanbey 98, Önceler 98, Yunus 90, Zülbiye and Weighing were included as research materials. The research was conducted in Bahri Dağdaş International Agricultural Research Institute experimental field according to randomized block design.

According to the results, the period of SPAD values, that measured at particular periods of dry beans varieties, dropped to "0" (length of green remaining period of plants) and the GDD amount of their need for this period was calculated by quadratic regression equation that resulted of regression analysis. Regarding to the regression analysis, the highest SPAD value (1504) was obtained from Yunus 90, while the variety of Weighing came out with lowest SPAD value (1301). The variety of Weighing took a place in front as the earliest one among the varieties.

Keywords: Dry beans, GDD, SPAD, green remaining period

Vejetasyon Dönemi Boyunca, Bazı Kuru Fasülye Çeşitlerine Ait Büyüme-Gün-Derece Değerlerinin Belirlenmesi

Özet

Büyüme-Gün-Derece Değerleri (GDD) Bölge için çeşit seçimi, ekim zamanının belirlenmesi, gelişme dönemi boyunca yapılacak işlemlerin zamanının belirlenmesi gibi konuların yanında sıklıkla biyolojik aşamaların tanımlanmasında kullanılanılır. Yürütülen bu çalışma ile, Türkiye'de tescilli bazı kuru fasülye çeşitlerinin bitki yeşil kalma süreleri boyunca ihtiyaç duydukları Büyüme-derece-gün miktarlarının belirlenmesi amaçlanmıştır.

Araştırmada materyal olarak; Akman 98, Göksun, Göynük 98, Karacaşehir 90, Noyanbey 98, Önceler 98, Yunus 90, Zülbiye ve Weighing, çeşitleri kullanılmıştır. Denemeler Tesadüf Blokları deneme desenine göre 4 tekrarlamalı olarak 2014 yılında, Bahri Dağdaş Uluslararası Tarımsal Araştırma Enstitüsü deneme alanlarında yürütülmüştür.

Yapılan çalışma sonucunda; çeşitlerin belirli dönemlerde ölçülen SPAD değerinin teorik olarak "0" değerine düştüğü durum olan, bitki yeşil kalma süreleri ve bu sürede ihtiyaç duydukları Büyüme Derece Gün (GDD) miktarları regresyon analizi sonucunda elde edilen quadratik regresyon denklemi ile hesaplanmış olup, çeşitler bu bakımından değerlendirildiklerinde; 1504 GDD değeri ile Yunus 90 çeşidi en yüksek, 1301 GDD değeri ile Weighing çeşidi ise en düşük değere sahip olmuşlardır. Weighing çeşidi erkenciliği ile ön planda yer almıştır.

Anahtar Kelimeler: Kuru fasülye, GDD, SPAD, yeşil kalma süresi

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Introduction

The temperature has an important role for vital activities of plants as well as it is determinant factor between different growth periods of plants (Öktem and Ağırtmatlıoğlu, 2006); in addition it is a significant parameter affecting the growth, development and yield of plant. Seasonal temperature changes, fundamentally effects the yield and yield components by changes in growth periods (Serter, 2003). In other words, the growth velocity is a linear function of temperature (Geldiay and Kocataş, 1975).

The temperature requests of most plants differs, therewithal, dry bean plants needs min 10 ºC to sustain their development, the temperature above 30-35 ºC can cause shrug of flowers (Aytekin and Çalışkan, 2015; Rubatzky and Yamaguchi, 1997; Swiader et al., 1992). In order to get yield from plants, one of the conditions is for net carbon accumulation the plants to be exposed appropriate temperature for certain period of time. For many of plants, changes of the length of growing period occur depending on Growing Degree Days (Slack et al., 1996). GDD is used for physiological maturity stint of plants, and it is calculated with min and max temperature degrees throughout the development and growing period of plants. However, for some plants this simple approach is not modeled since their sensitivity to photo-period. Thus, in order to calculate GDD, several methods such as average temperature method, sinusoidal methods or integration can be used (Snyder, 1985).

GDD is largely used for choice of variety for region, decision for planting time, the correct time of treatment through the growing period, and also it is often used description of biological stages of plants (McMaster and Wilhelm, 1997). For instance, it is an effective pest/disease control method to choose early/late variety and adjusting planting time for maize which is widespread plant in the region. By using this method, the loss can be decreased and crop maturity period can be defined (Serter, 2003). Nield and Smith (1997) indicated that GDD should be considered while choosing an appropriate variety and in the region where the temperature is lower, a variety that needs lower GDD should be preferred. According to their study conducted in Greece, Matzarakis et al. (2007) reported that GDD amount varied between 1100 and 1300 for dry bean, 1360 and 1630 for maize.

All the parts of plant above ground are photosynthetic organs. However, the high chlorophyll content of the leaves as main photosynthetic organs is a desirable point. The amount of solar radiation absorbed by leaves is a function of photosynthetic pigment content; thus, chlorophyll content, photosynthesis potential and can be previously determined (Curran et al., 1990; Filella et al., 1995; Gitelson et al., 2003).

Indirectly chlorophyll content can be calculated by measuring the green color of leaves with SPAD-meter (Taner, 2011), and the strong linear relationship between the chlorophyll content while measuring with SPAD-meter and SPAD values was reported as R^2=0.89 and R^2=0.90 (Coste et al., 2010; Uddling et al., 2007).

Material and Method

This research was conducted in experimental field of Konya Bahri Dağdaş International Research Institute in Turkey, 2014. The average rainfall through the growing season for the year study conducted and long years (1950-2014) was recorded 91.3mm and 135.1 mm and the average temperature was 20.2 ºC and 20.6 ºC respectively.

The first 30 cm of soil of experimental area was clay structured. The soil was medium for organic matter content (2.28%), high for lime content (29.26%) and slightly alkaline (pH 7.82), very rich in phosphorous (4.64 mg kg^{-1} P_2O_5) and potassium (92.31 mg

kg^{-1} K_2O), very poor in zinc (0.262 mg kg^{-1}) content. There was no salinity (272 µS cm^{-1}) problem in the soil of experimental area (Table 1).

Table 1. Some Features of Experimental Field Soil and Its Micro&Macro Nutrient Compositions*

Depth (cm)	Structure				pH	Organic substances (%)	Lime (%)	Salt (µS/cm)	P_2O_5 (mg/kg)	K_2O (mg/kg)	Zn (mg/kg)
	Sand (%)	Clay (%)	Silt (%)	Class							
0-30	30.83	41.62	27.55	Clayey	7.82	2.28	29.26	272	4.64	92.31	0.262

* Analysis were made by Konya Commodity Exchange.

The experiment was carried out according to Randomized Complete Block Design. In the study, 9 varieties (Akman 98, Göksun, Göynük 98, Karacaşehir 90, Noyanbey 98, Önceler 98, Yunus 90, Zülbiye and Weighing) were included as plant materials. The dimensions of parcels were 0.45 m X 5 m X 4 =10 m^2, the hand planting of seeds was made on 17th of May, in depth of 3-4 cm seedbed prepared by marker, and 3 kg N and 7 kg P_2O_5 was applied before planting. Harvesting was made individually for each variety by hand when the plants reached harvest maturity on the dates of 10-15-17-27 September, 2014.

The varieties of Akman 98, Göksun, Göynük 98, Karacaşehir 90, Noyanbey 98, Önceler 98, Yunus 90, Zülbiye and Weighing were included as research materials. Only the variety of Weighing is not national among the varieties included in the study. Akman 98, Göksun, Karacaşehir 90 ve Weighing were in Type 2 form (İndeterminate), the rest of variesties were in Type 1 form (Determinate). In total 6 measurements were taken on dates of 23rd of June, 8th and 22nd of July, 25th of August and 4th of September, by using SPAD 502, MINOLTATM Camera Ltd. Japan that measures leaf chlorophyll content and detects chlorophyll ratios. Twenty measurements were taken from each parcel on 2 farthest leaves of 10 plants, and average leaf content was calculated by arithmetic means of data on exact date of measurements taken of each parcel.

The green period of plant (GDD) was calculated with quadratic regression method (SPAD = a+b (GDD) + c $(GDD)^2$) and the point of chlorophyll decreased to zero on the assumption that of values of chlorophyll content were dependent variable (y), and GDD values on the date of measurements taken were independent variable (x).

In order to calculate GDD values, max and min temperatures (obtained from Weather Station in Bahri Dağdaş International Research Institute) data which was taken from October to harvesting, were given in Table 2 and the following equations were used (Equations 1, 2). The base peak temperature mentioned in equations (T_{base}) assumed as 10 ºC and the average daily temperature of plant growth stopped (TG_{max}), assumed as 32 ºC.

$GDD=\sum\left(\frac{T\max + T\min}{2}\right)$-Tb *[Equations 1]*, $T_b \leq ((T_{max}-T_{min})/2 \leq TG_{max}$ *[Equations 2]* (McMaster and Wilhelm, 1997) In Equations;

GDD :Growing-Degree-Days,

T_{max} :Daily Maximum Temperature,

T_{min} :Daily Minimum Temperature,

T_{base} :The base peak temperature that plant starts growing

$TG_{max=}$:The average daily temperature of plant growth stopped (Kaya, 2010).

Table 2. The Daily GDD Amounts of Months through Experiment Period in 2014

	Months						Months				
Days	May	June.	July	Aug.	Sep.	Days	May	June	July	Aug.	Sep.
1	-	4.40	11.45	12.90	12.15	16	-	10.25	12.45	14.45	-
2	-	5.75	14.75	11.00	12.55	17	8.70	9.10	12.35	11.70	-
3	-	6.85	15.60	13.05	12.50	18	5.90	10.75	15.00	13.75	-
4	-	9.90	13.40	**13.75***	**13.05***	19	6.20	12.35	14.10	13.55	-
5	-	6.90	10.10	12.85	-	20	6.85	9.70	13.30	13.05	-
6	-	6.05	11.00	12.25	-	21	7.20	8.80	12.30	13.45	-
7	-	6.40	11.80	12.20	-	22	7.20	8.90	**13.80***	14.65	-
8	-	6.40	**13.50***	12.10	-	23	6.70	**9.05***	12.40	14.75	-
9	-	7.75	13.75	14.45	-	24	6.10	9.70	13.00	13.85	-
10	-	7.95	12.10	13.95	-	25	7.00	10.20	12.65	**13.30***	-
11	-	7.95	13.25	14.35	-	26	7.25	11.90	13.85	15.40	-
12	-	7.75	13.40	15.30	-	27	8.10	13.10	12.85	13.80	-
13	-	7.70	12.05	14.90	-	28	9.10	12.55	13.40	14.10	-
14	-	9.35	14.25	14.35	-	29	9.85	13.90	13.75	16.45	-
15	-	10.15	13.90	13.25	-	30	9.55	12.50	14.25	15.00	-
						31	8.80	-	14.95	14.20	-

(*) SPAD measurement dates

This study aimed to determine the relationship between climatic data and agricultural practices.

Results and Discussions

The quadratic equation, t value, the coefficient (R^2) and observation numbers (n) of research materials obtained from regression analysis that was done in order to determine the changes in SPAD values from the planting till harvesting, were given in Table 3.

Table 3. The Regression Equations and Significance Levels of SPAD Value Reduction Belongs to Each Varieties Included in the Study

	VARIETY	REGRESSION EQUATIONS	t	R^2	CV%	N
1	AKMAN 98	$17.80+0.0858GDD-0.0000658GDD^2$	-5.10**	0.73	15.79	24
2	GÖKSUN	$21.52+0.0862GDD-0.0000696GDD^2$	-6.66**	0.79	15.44	24
3	GÖYNÜK 98	$18.18+0.0904GDD-0.0000711GDD^2$	-8.35**	0.87	11.60	24
4	KARACAŞEHİR 90	$18.98+0.0886GDD-0.0000696GDD^2$	-6.55**	0.80	14.34	24
5	NOYANBEY 98	$14.11+0.0910GDD-0.0000689GDD^2$	-7.14**	0.85	11.76	24
6	ÖNCELER 98	$14.43+0.1019GDD-0.0000775GDD^2$	-5.26**	0.75	17.08	24
7	YUNUS 90	$19.73+0.0931GDD-0.0000706GDD^2$	-4.72**	0.71	15.50	24
8	ZÜLBİYE	$15.62+0.0949GDD-0.0000751GDD^2$	-9.46**	0.89	11.70	24
9	WEIGHING	$19.55+0.1116GDD-0.0000973GDD^2$	-14.73**	0.94	13.13	24

**; The difference between groups was found at significance level of 1%.

GDD values at max SPAD value and theoretical time that SPAD values equal to zero and the max SPAD measurement that were calculated with quadratic equation each of varieties included in experiment, can be seen in Table 4.

Table 4. The Maximum SPAD Values of Each Varieties and GDD Amounts regarding to Plant Green Period

	VARIETY	$SPAD_{max}$	GDD ($SPAD_{max}$)	GDD ($SPAD_0$)
1	AKMAN 98	45.77	639	1486
2	GÖKSUN	48.21	609	1451
3	GÖYNÜK 98	46.91	635	1448
4	KARACAŞEHİR 90	47.18	635	1468
5	NOYANBEY 98	44.16	650	1464
6	ÖNCELER 98	47.93	650	1444
7	YUNUS 90	50.42	652	1504
8	ZÜLBİYE	45.60	633	1411
9	WEIGHING	51.55	571	1301

When it was assessed the SPAD value falls to zero in terms of period of plant green period, Yunus 90 variety showed the highest value the with 1504 GDD value and the lowest value was obtained from th variety of Weighing among the varieties included in this study. Akdağ ve Düzdemir (2001) reported that the vegetation period of bean changed between 108.5-146.0 days depending on nature of growth. However, one of the important priorities on dry bean breeding is earliness, so that, the variety of Weighing the earliest one among the varieties.

The regression curve of the green period of variety of Akman 98 was stated in Figure 1, and coefficient of quadratic regression equation (R^2=0.73**) was at high level and statically significant at P<0.01 (Table 3). The GDD (green period) of Akman 98 was in total 1486, max SPAD value that can be obtained from the variety was 45.77 SPAD unit and at the max SPAD value, GDD was calculated as 639 with quadratic regression model, variation coefficient was determined as 15.79% (Table 3).

For the variety of Göksun that is half-cling and plump-white seed typed, the vegetation period was registered as 80-90 days, the regression curve of variety that determine the plant green period, was given in Figure 2. Regression coefficient (R^2= 0.79**) was statistically found highly significant at P<0.01 (Table 3). Total GDD requirement of the variety was determined as 1451 and max SPAD value that can be obtained from the variety, was 48.21 SPAD unit and at this point total GDD was calculated as 609 by regression model (Table 4), variation coefficient is determined as 15.44% (Table 3).

Total GDD amount required by Göynük variety that is dwarf, has Horoz seed type and the 110-120 days of vegetation period determined as 1448 (Figure 3) and max SPAD value that can be obtained from the variety, was 46.91 SPAD-unit and at this level of SPAD, GDD amount was calculated as 635 (Table 4), Regression coefficient (R^2= 0.87**) was statistically found very highly significant at P<0.01 and variation coefficient is determined as 11.60% in calculation (Table 3).

Karacaşehir 90 is half-cling growth formed and plump-small seed typed variety. The green period of variety at "0" SPAD unit point was calculated as 1468 GDD value (Figure 4), max SPAD value was determined as 47.18 and at this level of SPAD, GDD amount was calculated as 635 (Table 4). In calculation, determination coefficient of regression equation (R^2=0.80**) was high and significant P<0.01 level and variation coefficient was found as 14.34% (Table 3).

Noyanbey 98, is a dwarf-steep growth natured variety. GDD amount as an expression of plant green period, at "0" unit of SPAD level, was calculated as 1464 (Figure 5), and max SPAD value was determined as 44.16 and at this level of SPAD, GDD amount was calculated as 650 (Table 4). In calculation, the coefficient of II. degree of equations

was high (R^2=0.85**), statistically significance was at P<0.01, variation coefficient was determined as 11.76% (Tabel 3). Total GDD amount was determined as 1444 for the variety of Önceler 98 (Figure 6), which is red bean seed typed and dwarf, developed by Transitional Zone Agricultural Research Station, max SPAD value was 47.93 for this variety and total GDD value was determined as 650 at this SPAD value level (Table 4). The quadratic regression equation determination coefficient (R^2=0.75**) was high, was found statistically significant at P<0.01 level and variation coefficient was determined as 17.08% (Table 3).

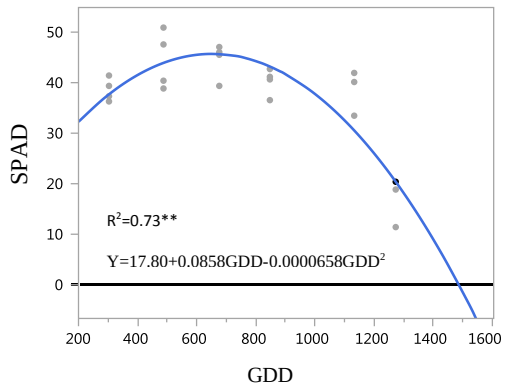

Figure 1. SPAD and GDD relationship regarding to the variety of Akman 98

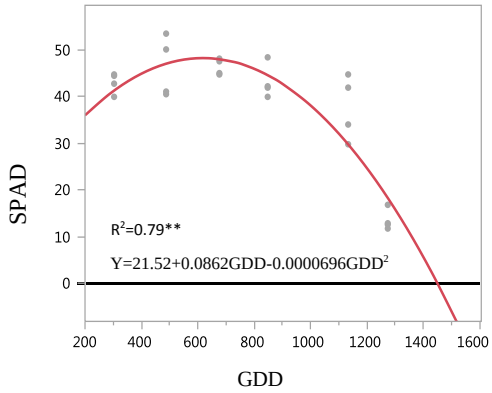

Figure 2. SPAD and GDD relationship regarding to the variety of Göksun

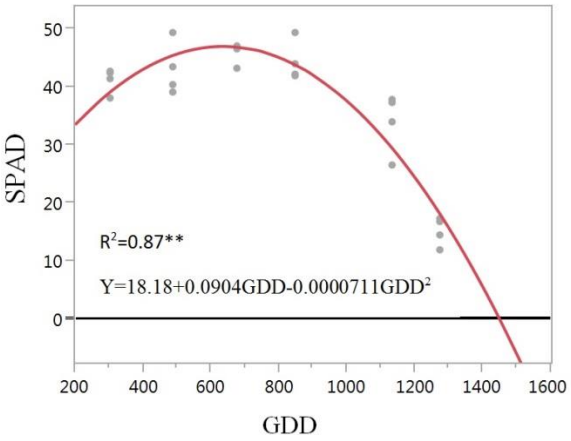

Figure 3. SPAD and GDD relationship regarding to the variety of Göynük 98

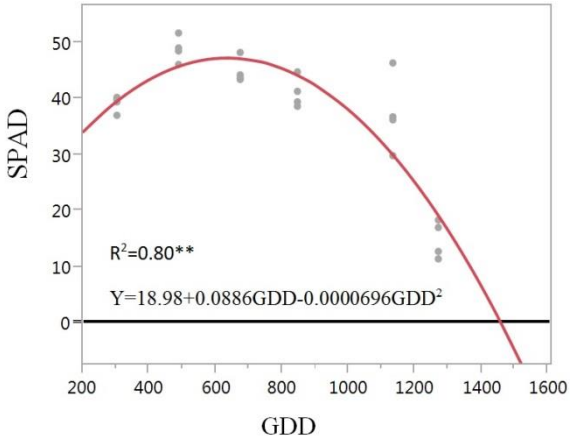

Figure 4. SPAD and GDD relationship regarding to the variety of Karacaşehir 90

For the variety of Yunus 90 which has dwarf growth nature and 115-120 days of vegetation period, the determination coefficient (R^2= 0.71**) of regression equation which was calculated with theoretical point assumed as the chlorophyll content was "0" and the end of living activity, was high, and was found statistically significant at P<0.01 level (Table 3). According to regression model, total GDD value was determined as 1504 (Figure 7) when SPAD value was theoretically at "0" point, the max SPAD value was recorded as 50.42 and at this point max GDD amount was determined as 652 (Table 4). Thus, all of the values of this variety were the highest among the varieties included in this study. This can be explained by latish feature of Yunus 90 variety (Karadavut et al., 2005). The variation coefficient of regression model was 15.50% (Table 3).

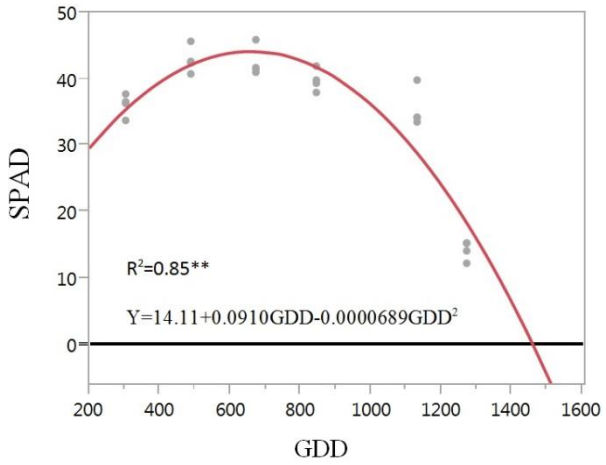

Figure 5. SPAD and GDD relationship regarding to the variety of Noyanbey 98

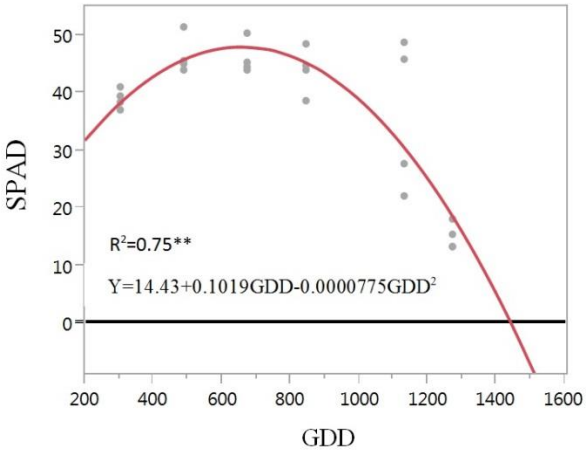

Figure 6. SPAD and GDD relationship regarding to the variety of Önceler 98

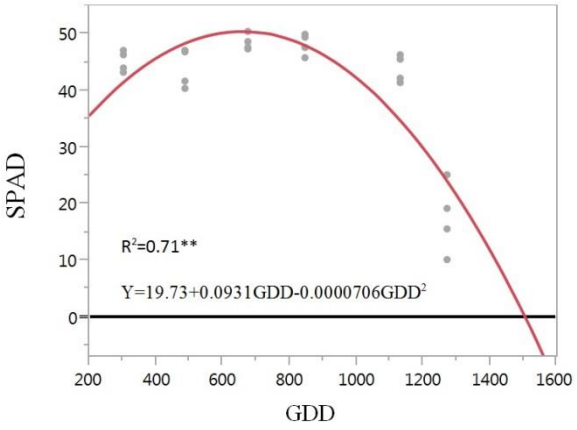

Figure 7. SPAD and GDD relationship regarding to the variety of Yunus 90

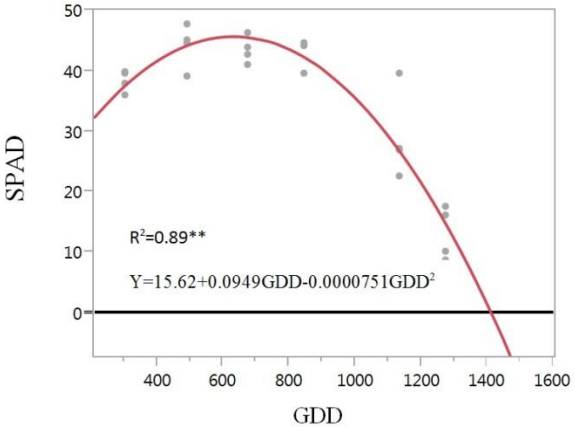

Figure 8. SPAD and GDD relationship regarding to the variety of Zülbiye

For the Zülbiye variety which is dwarf and white seeded, GDD amount was determined as 1411 (Figure 8), the max SPAD value 45.60 and at this point of value, total GDD amount was calculated as 633 (Table 4). In calculation, the determination coefficient of quadratic regression equation (R^2=0.89**) was too high, and statistically found as significant as P<0.01 level (Table 3). The variation coefficient of this regression model was determined as 11.70% (Table 3).

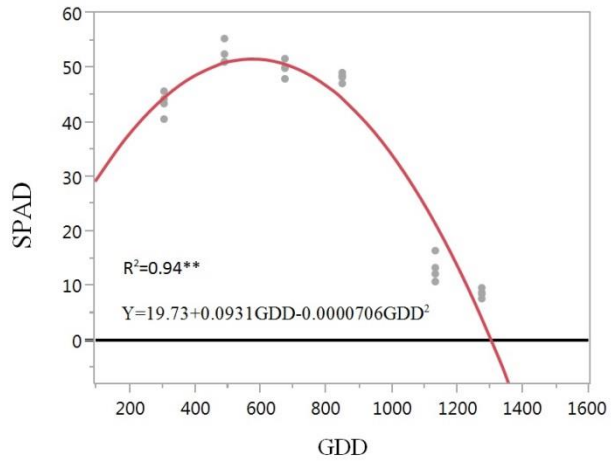

Figure 9. SPAD and GDD relationship regarding to the variety of Weighing

The variety of Weighing that was registered for 80-90 days of vegetation period is an exterior variety and the regression curve of its green period can be seen in Figure 9. Regression determination coefficient (R^2= 0.94**) was high and statistically found significant at P<0.01 (Table 3). The total GDD requirement of the variety was 1301; max SPAD value was obtained as 51.55, and at this point of SPAD value, GDD amount was calculated as 571 (Table 4), variation coefficient was determined as 13.13% (Table 3).

Consequently, it was indicated by this study that the total temperature needs differs among the plant kinds as well as varieties of the same plant. Using this temperature for a total value it would be more advisable to take proper decision about both choosing variety and planting time for the region in that will be growing.

In Konya-Karaman basin and alike regions, growers prefer ealier varieties in the features of dermason grain type, dwarf, semi-surrounded form (Küsmenoğlu et al., 2009). In this context; Weighing variety is in the dermason grain type, semi-surrounded form, quite earlier. Thus; the lowest GDD (1301 GDD) amount for maturation, therewithal Wood et al. (1993) reported that the variety in which a linear relationship was determined between yield SPAD value (R^2=0.88**). Additionally, they added that the variey showed the highest value SPAD value (51.55 SPAD) among the varieties. The Weighing variety can be considered as parent line with the features of earliness and high yielding capacity as well as suitability for basin and alike regions for breeding studies.

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