Journal of Agriculture and Ecology Research International
11(4): 1-8, 2017; Article no.JAERI.33158
ISSN: 2394-1073

SCIENCEDOMAIN *international*
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Degree Days to 50% Flowering for 12 Cultivars of Spring Canola-Like Mustard

K. M. Hunter[1], D. W. Archer[2], R. W. Gesch[3], M. F. Vigil[4], J. L. Hatfield[5], B. L. Allen[6], J. D. Jabro[6], S. Kim[7], M. N. Meki[1] and J. R. Kiniry[8*]

[1]Texas A&M AgriLife Research, 720 E. Blackland Rd., Temple, TX 76502, USA.
[2]Northern Great Plains Research Laboratory, USDA-ARS, 1701 10th Ave. SW, Mandan, ND 58554, USA.
[3]North Central Soil Conservation Research Laboratory, USDA-ARS, 803 Iowa Ave., Morris, MN 56267, USA.
[4]Central Great Plains Research Station, USDA-ARS, 40335 Co Rd. GG, Akron, CO 80720, USA.
[5]National Laboratory for Agriculture and the Environment, USDA-ARS, 1015 N University Blvd., Ames IA 50011, USA.
[6]North Plains Agricultural Research Laboratory, USDA-ARS, 1500 N Central Ave., Sidney, MT 59270, USA.
[7]Oak Ridge Institute for Science and Education, 1299 Bethel Valley Rd., Oak Ridge, TN 37830, USA.
[8]Grassland, Soil and Water Research Laboratory, USDA-ARS, 808 E. Blackland Road, Temple, TX 76502, USA.

Authors' contributions

This work was carried out in collaboration between all authors. Authors KMH, JRK, DWA, RWG, MFV, JLH, BLA and JDJ designed the study. Authors SK and MNM performed the statistical analysis. Author JRK wrote the protocol and author KMH wrote the first draft of the manuscript. Authors KMH, JRK, DWA, RWG, MFV, JLH, BLA and JDJ collected the plant samples and selected the study sites. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JAERI/2017/33158
Editor(s):
(1) Mirza Hasanuzzaman, Department of Agronomy, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Bangladesh.
Reviewers:
(1) Hakan Sevik, Kastamonu University, Turkey.
(2) Funda Eryilmaz Acikgoz, Vocational College of Technical Sciences, Namik Kemal University, Turkey.
Complete Peer review History: http://www.sciencedomain.org/review-history/18867

Original Research Article

Received 31st March 2017
Accepted 27th April 2017
Published 1st May 2017

**Corresponding author: E-mail: Jim.Kiniry@ars.usda.gov;*
E-mail: laurie.kiniry@gmail.com;

ABSTRACT

Modeling efforts for simulating canola have been based on growth parameters previously established in the Northern Great Plains. However, with advances in canola (*Brassica* sp.) genetics, establishing parameters for newly developed cultivars are essential for the best modeling projections. Accurate simulation of crop phenology, especially flowering dates, is critical for determining the duration of vegetative growth and when seed yield is most sensitive to stress. If measured flowering dates are not available, process-based models can be used to predict the flowering time based on available temperature data. In the present study, the predicted flowering date was compared to actual measured flowering data. The summed degree days (SDDs) to 50% flowering (hereafter referred to simply as "flowering") were collected from twelve different types of cultivars planted across multiple locations. For each location predicted SDDs were computed based on temperature data from planting to the date of flowering. The measured and predicted data showed a similar pattern for SDDs to flowering for all cultivars, except for three. Thus SDDs to flowering were relatively stable across a wide range of latitudes. Furthermore, the SDDs for most cultivars were similar to the potential heat unit sum (450) previously established for *Brassica rapa* (Polish canola).

Keywords: Simulation modeling; oilseed crops; canola; plant parameters.

1. INTRODUCTION

Crop growth parameters, including leaf area index, light extinction coefficient, radiation use efficiency, and degree days to maturity, for spring *Brassica napus* and *Brassica rapa* have been established for the US Northern Great Plains for model simulations with the Agricultural Land Management Alternative with Numerical Assessment Criteria (ALMANAC) and the Environmental Policy Integrated Climate (EPIC) process-based models [1,2]. More recently crop parameters for spring type *Brassica napus* have been developed for California for the Agricultural Production Systems Simulator (APSIM) model [3]. Flowering dates for various cultivars of canola-like mustards have also been documented for various regions [4,5,6]. In simulation modeling, accurate predictions of flowering date are vital for yield prediction because environmental stresses at this stage can have drastic impacts on seed yield [6]. In addition, new cultivars of spring and winter canola-like mustards have increased yield, and improved resistance to diseases, weeds, drought, and heat [7,8]. Newly-derived plant parameters that include data on flowering time can be incorporated into process-based models such as ALMANAC and EPIC to simulate best management practices that maximize yields while estimating nutrient depletion, soil degradation, and hydrology. This study focused on establishing the summed degree days (SDDs) of 12 cultivars of spring canola-like mustards from planting to 50% flowering (hereafter referred to simply as "flowering"). The twelve cultivars included six different species from the *Brassica* family: *Camelina sativa*, *Sinapis alba, B. napus*, *B. juncea, B. rapa*, and *B. carinata*. The null hypothesis tested was that the SDDs to flowering for these cultivars are relatively stable across large geographical areas of the United States. The alternate hypothesis was that the cultivars differ in their SDDs across geographical areas of the United States.

The study objectives were 1) evaluate the SDD to flowering of canola-like mustard, 2) compare newly-derived parameter values to phenological data reported in previously published literature, and 3) Relate SDDs to flowering to the total degree days from planting to maturity (PHU).

2. MATERIALS AND METHODS

Four randomized plots of each of the 12 different cultivars of spring canola-like mustard were planted at six locations from 2013 to 2015: Mandan, ND, Akron, CO, Morris, MN, Temple, TX, Sidney, MT, and Ames, IA. At the National Laboratory for Agriculture and the Environment in Ames, IA, 4 plots of each of the 12 cultivars were established on the Clarion soil series (fine-loamy, mixed, mesic Typic Hapludolls). In Sidney, MT, at the Northern Plains Agricultural Research Laboratory, 48 randomized plots were established on the Williams soil series (fine-loamy, mixed, superactive, frigid Typic Argiustoll). In Morris, MN, at the Soil Management Research, 48 randomized plots were established on the Barnes soil series (fine-loamy, mixed, superactive, frigid Calcic

Hapludoll).At the Central Great Plains Resource Station in Akron, CO, 48 randomized plots were established on a Rago silt loam (fine, montmorillonitic, mesic, Pachic Argiustolls). In Mandan, ND, at the Northern Great Plains Research Lab, 48 plots were established on a Temvik-Wilton silt loam. The Temvik soil series have mollic epipedons, while the Wilton soil series is a fine-silty loam (mixed, a superactive, with frigid Pachic Haplustolls).In Temple, TX at the Grassland, Soil and Water Research Laboratory 48 randomized plots were established on Houston Black clay (fine, montmorillonitic, thermic Udic Haplusterts).

Phenology data (dates of beginning of flowering and 50% flowering) were recorded once per week. For our analyses, and as mentioned earlier, dates of 50% flowering were taken as “flowering date”. Daily GDD values are calculated as

$$GDD=(Tmax + Tmin)/2 - 5°C \qquad (1)$$

Where Tmax is the daily maximum temperature (°C), Tmin is the daily minimum temperature (°C) and 5°C is the base temperature.

This base temperature has been established for Polish and Argentine (*B. napus*) canola [1]. Daily degree days below zero are set to zero. When the daily Tmax is above the optimum temperature for growth (21°C for Argentine and Polish canola), a heat stress calculation is used [1]. The adjusted Tmax, is 21°C minus the amount Tmax exceeds 21°C.

Using Statistical Analysis Software version 9.3 (SAS 9.3), mixed-model ANOVA was conducted to test for significant differences of summed GDDs (SDDs) among study locations and the 12 cultivars of spring canola-like mustard at α = 0.05.The year was considered as a random effect, and the cultivars and study locations were considered as fixed effects. We then compared the summed GDD values to those from published research that documented phenological stages of development from planting to flowering of the different canola-like mustard cultivars. In the present study, both the mean initial flowering dates and mean 50% flowering (indicated as “flowering” as described above) dates were recorded for each cultivar. We compared the SDDs to flowering to previously reported values for GDDs from planting to maturity (PHUs) to calculate the fraction of PHUs that would have accumulated by the date of flowering. We tested to assess if any cultivars were significantly different from this mean flowering value using Dunnett’s test at α = 0.1 [9]. The SDDs for each cultivar were calculated from each year’s planting date to flowering and then averaged across all locations.

3. RESULTS AND DISCUSSION

The 12 cultivars had SDD values from planting to flowering differing significantly only by cultivars, and not by locations (Table 1). There was no significant interaction between cultivar and location. The mean SDD for the 12 cultivars at all six locations (Table 2) was 450. This value was used as the standard value for comparing SDD of each cultivar using one-way ANOVAs followed by Dunnett’s test at α=0.1 (Fig. 1).

Table 1. Results of ANOVAs test the effect of location, cultivars, and their interaction on summed degree days (SDD) at α= 0.05

Effect	df	F-value	P-value
Location	5	0.98	0.5217
Cultivars	11	4.53	0.0013
Location*Cultivars	55	0.87	0.6891

The two *B. juncea* cultivars had a mean flowering date of 52 days after planting (DAP) for Pacific Gold and a mean of 58 DAP for Oasis (Fig. 2). Pacific Gold had a mean of 432 SDD at flowering, which was not significantly different from the 450 SDD (P = 0.764) (Fig. 1). The lowest recorded SDD for Pacific Gold was in Morris, MN where it only reached 349 (Table 2). The highest SDD for Pacific Gold was 522 in Temple, TX. Oasis had a mean SDD of 436 at flowering, which also was not significantly different from 450 SDD (P = 0.456).

For both cultivars in the *B. juncea* group, Pacific Gold and Oasis, the mean date for “beginning to flower” was 46 days after planting (data not shown). This mean resembles the days to 10% flowering in Canada reported by Blackshaw [5], which ranged from 45-49 DAP for the cultivars of *B. juncea* canola. For flowering, our mean measured date for *B. juncea* was 55 DAP, the same as the 55 DAP for flowering in an Oregon study with *B. juncea* [10]. Duggan’s [10] plots reached flowering at 399 SDD (Table 3).

The cultivars of *B. napus* studied included Gem, DK3042RR, Invigor L130, and SC. 28. The mean flowering date for SC. 28 was 57 DAP (Fig. 2). At flowering, the mean SDD of SC.28 for all six locations was 427, which was not significantly different from 450 SDD (P = 0.923) (Fig. 1).The mean flowering date for Gem and Invigor L130 occurred 58 DAP. The mean DD for Gem was 452 (P = 0.577) and for Invigor L130 was 455 (P =0.681). DK3042RR had a mean flowering date 59 DAP and mean SDD of 447, which was not significantly different from 450 SDD (P = 0.971).

For Gem, the mean beginning flowering date across all locations was 46 DAP, and its mean flowering date was 58 DAP (Fig. 2).This 58 DAP value was the same as the average flowering day for all of the *B. napus* cultivars. Our mean beginning flower date was similar to the 10% flowering dates in Canada [5], which were 48 and 49 DAP for *B. napus*. Data reported by Aiken, et al. [4] for *B. napus* in Kansas were similar to results from both the present and the Blackshaw et al. [5] studies. Canola plants in Aiken et al. [2] reached flowering by 54 DAP with a 315 SDD value. Duggan [10] reported that Gem grown in Oregon flowered 11 days later than what was found in the present six location study. At flowering, we calculated a 470 SDD value for Duggan's [10] *B. napus* plots in Oregon (Table 3).

The only *B. rapa* cultivar studied was Eclipse. This cultivar had a mean flowering day of 58 DAP (Fig. 2). At flowering, Eclipse had a mean SDD of 436, which was not significantly different from the overall 450 SDD. The maximum SDD was in Temple, TX at 618 while the minimum SDD was located in Sidney, MT at 375 (Table 2). In Canada, *B. rapa* began flowering on the main stem at 41 DAP and flowered until 57 DAP [5]. For this 16 day range of flowering, flowering at 49 DAP could be assumed, however the SDD could not be determined from the Canadian study due to unavailable temperature data.

The *B. carinata* cultivars studied included 080814 EM and ACC A110. The mean flowering date for 080814 EM was 61 DAP, while that for ACC A110 was 62 DAP (Fig. 2). These two cultivars, 080814 EM and ACC A110, had significantly higher SDDs than the overall 450 SDD value at α =0.1 (P = 0.073 for 080814 EM and P = 0.047 for ACC A110) (Fig. 1). The mean SDDs for 080814 EM across all locations totaled 482 and that for ACC A110 was 481. The maximum SDD for both cultivars, in Temple, TX, ranged from 599-606. The lowest SDDs for both cultivars were in Akron, CO, ranging from 429-431 (Table 2).This 482 mean SDD value for *B. carinata* was 7% above the 450 SDD.

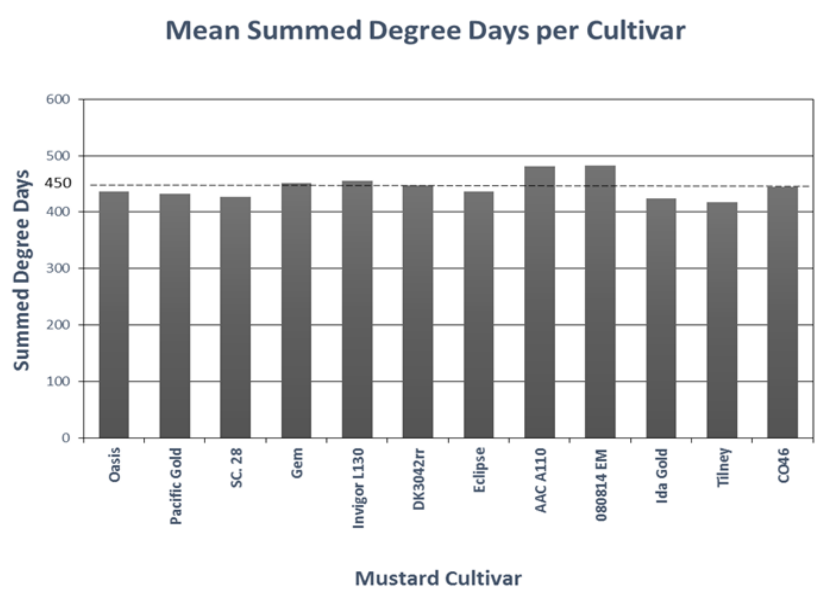

Fig. 1. Mean (+SEM) summed degree days for each of the 12 cultivars. SDDs of three cultivars (Tilney, 080814EM, and AAC A110) differed significantly from the 450 overall average across all cultivars and all six locations as well as previously reported value by Kiniry et al. [1] (one-way ANOVAs followed by Dunnett's test; α = 0.1). * Significantly different from 450 SDD (Dunnett's test)

Table 2. Summed Degree Days (SDD) of canola-like mustard cultivars averaged across years (2013-2015) for all six locations. Values in bold indicate means of SDD across all 6 locations within each cultivar

Species	***B. juncea***			***B. napus***			***B. rapa***	***B. carinata***		***S. alba***		***C. sativa***
Location\Cultivar	**P. Gold**	**Oasis**	**SC. 28**	**DK304 2RR**	**Gem**	**Invigor LI30**	**Eclipse**	**O80814 EM**	**ACC 110**	**I. Gold**	**Tilney**	**CO46**
Akron, CO	420	423	424	444	416	417	394	431	429	407	393	416
Ames, IA	441	396	354	441	416	441	396	465	465	396	363	497
Mandan, ND	410	439	439	439	433	425	423	439	433	418	410	430
Morris, MN	349	408	349	420	346	408	408	462	456	366	370	387
Sidney, MT	449	436	454	381	464	453	375	487	502	430	418	496
Temple, TX	522	515	542	554	636	587	618	606	599	529	549	441
Mean	**432**	**436**	**427**	**447**	**452**	**455**	**435**	**482**	**481**	**424**	**417**	**444**
SDD/450[§]	0.96	0.97	0.95	0.99	1	1.01	0.97	1.07	1.07	0.94	0.93	0.99
Max	522	515	542	554	636	587	618	606	599	529	549	497
Min	349	396	349	381	346	408	375	431	429	366	363	387
Max-min	173	119	193	174	290	179	242	175	170	163	186	111

[§] *SDD/450 is the fraction of 450*

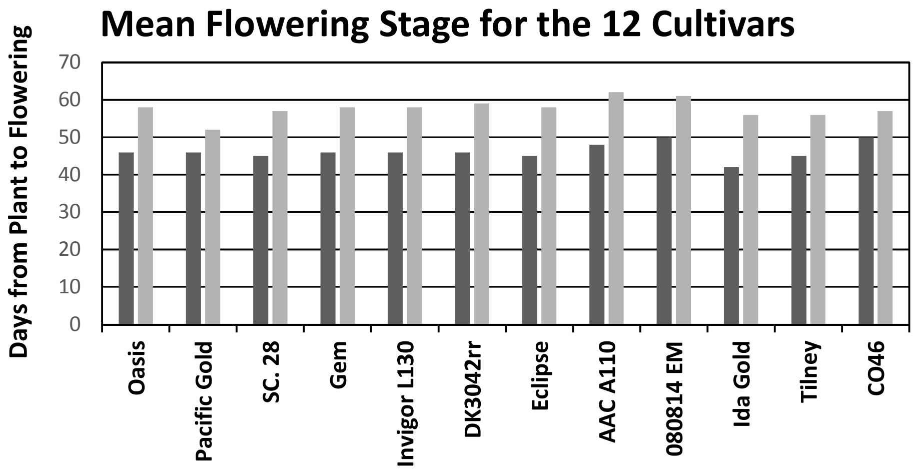

Fig. 2. Days from planting to flowering (black bars) and days from planting to 50% flowering (gray bars) for each cultivar averaged across years (2013-2015) and all six locations

Table 3. Summed degree days (SDD) for validations. SDD values were calculated based on days from planting to 50% flowering obtained from previous studies. The SDD/450 is the fraction of our overall 450 SDD: *B. juncea* [10]; *B. napus* [4]; *B. napus* [1]; *B. rapa* [5]; *B. carinata* [11]; *S. alba* [10]; *C. sativa* [4]. DAP is the days after planting

Species	Literature validation	DAP for 50% flowering	SDD	SDD/450
B. juncea	our mean	55	434	0.96
	Duggan's mean	55	399	0.89
B. napus	our mean	58	445	0.99
	Aiken's mean	54	315	0.70
	Duggan's mean	61	470	1.04
	Kiniry et al.'s (1000 at harvest)	n/a	500	1.11
B. rapa	our mean	58	436	0.97
	Kiniry et al.'s (910 at harvest)	n/a	455	1.01
	Blackshaw's mean	49	n/a	n/a
B. carinata	Our mean	49	482	1.07
	Adeniji and Aloyce's mean	64	n/a	n/a
S. alba	our mean	56	421	0.94
	Duggan's mean	67	462	1.03
C. sativa	Our mean	57	444	0.99
	Aiken's mean	67	422	0.94

n/a, data is not available

In the present study, 080814 EM had a mean beginning flowering date of 50 DAP. Cultivar ACC A110 had a mean beginning flowering time of 48 DAP. Using genetic markers, Adeniji and Aloyce [11] in Tanzania discovered that cool temperatures resulted in some *B. carinata* lines having a median beginning flower date of 64 DAP. The Tanzanian median beginning flower date of 64 DAP occurred 15 days later than the mean beginning flower date (49 DAP) of our present study (Table 3).

The *S. alba* cultivars used in this study were Ida Gold and Tilney. Both cultivars had a mean flowering date of 56 DAP (Fig. 2). The SDD of Ida gold at flowering was 424, which was not significant different from 450 at α =0.1 (P = 0.134). The highest SDD for Ida Gold occurred in Temple, TX at 529 and the lowest SDD occurred in Morris, MN at 366 (Table 1). The cultivar Tilney's SDD at flowering reached 417, which was significant lower than 450 at α =0.1 (P = 0.076). Ida Gold began flowering 42 DAP while Tilney began flowering 45 DAP

(Fig. 2). In Oregon, Ida Gold began flowering 55 DAP [10], which is 10 -13 days later than the flowering date in this study. We calculated 462 SDD for Duggan's *S. alba* plots at flowering (Table 3).

Only one cultivar of *C. sativa,* CO46, was used in the study. This cultivar had a mean beginning flowering of 50 DAP (Fig. 2). CO46 reached flowering an average of 57 DAP. At flowering, the mean SDD value was 444, which was not significantly different from 450 SDD (P = 0.547) (Fig. 1). In our study, flowering occurred 10 days sooner than the varieties of *C. sativa* used in the Aiken et al. [4] study in Kansas. We calculated a 422 SDD value for Aiken et al'. [4] *C. sativa* plots (Table 3), which was 95% of our derived mean *C. sativa* SDD value of 444.

In general, the SDD values for flowering were 40 to 43% of the mean published PHU values of 1100 for planting to maturity of Argentine canola [8].The mean SDD for all 12 varieties at all six locations (Table 2) was 450, 41% of the PHU reported by Kiniry et al. [1]. For Gem, Duggan's [10] 470 SDD value and our mean *B. napus* 445 SDD value were 43% and 40% of the 1100 PHU value. For Eclipse in the present study, the mean of 436 SDD to flowering was 40% of the 1100 value. For Dungan's Ida Gold data [10], 462 SDD value was 42% of the 1100 value.

There are many factors such as climate, elevation, method of planting, fertilizer application, plant growth regulators, plant stress factors, photoperiod that can affect the phenological stages of plant development [12-22]. While temperature and photoperiod [22] are two of the most important environmental factors affecting phenological development, this study focused only on one factor, temperature, with impacts calculated in degree days. The study managed to quantify the flowering SDD for the12 cultivars of spring canola-like mustard in response to variations in temperature. Based on our findings at 6 six locations, the SDDs to flowering for these cultivars are relatively stable across large geographical areas of the United States. Future work could investigate errors in this simple simulation approach, looking at such factors as those listed above.

4. CONCLUSION

As pointed out earlier, flowering data is vitally important for describing the stage when seed number is most sensitive to stress [7], which occurs just prior to the start of grain filling. Thus, accurate yield simulation modeling relies on accurate predictions of flowering date. In this study, our results for flowering SDD values can be used as a starting point to build other parameters for several different cultivars of canola-like mustard for a wide range of latitudes. Except for Tilney, 080814 EM, and ACC A110, each cultivar's SDD from planting to flowering across the 6 locations were all within 7% of 450 SDD. One of *S. alba* cultivars, Tilney, had a mean SDD at flowering that was 7.5% lower than 450 across the 6 locations. The *B. carinata* cultivars (080814 EM and ACC A110) had a mean SDD values that were 7.2% -8.1% greater than the mean of 450.The three cultivars' SDD differences are supported by values reported in the literature. We can therefore conclude that the SDD values for cultivars of canola-like mustard are similar to the potential heat units already established for *B. rapa* (Polish canola) by Kiniry et al. [8]. Although many factors such as climate, elevation, method of planting and fertilizer application can affect the phenological stages of development, the null hypothesis appeared to be valid based on our findings at 6 locations.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Kiniry J, Major D, Izaurralde R, Williams J, Gassman P, Morrision M, Bergentine R, Zentner R. EPIC model parameters for cereal, oilseed, and forage crops in the northern Great Plains region. Can J Plant Sci. 1995;75:3.
2. Williams J, Jones D, Kiniry J, Spaniel D. The EPIC crop growth model. Trans ASAE. 1989;32:494-511.
3. George N, Kaffka S. Canola as a new crop for California: A simulation study. Agron J. 2017;109:496-509.
4. Aiken R, Wolf R, Dible L, Oien A. Spring oilseed planting method. Field Res Rep Progr SRP. 2010;1030:69-71.
5. Blackshaw EN, Johnson RE, Gan YT, May WE, McAndrew DW, Barthet V, McDonald T, Wispinski D. Alternative oilseed crops for biodiesel feedstock on the Canadian prairies. Can J Plant Sci. 2011;91:889-896.
6. Gan Y, Angadi S, Cutforth H, Potts D, Angadi V, McDonald C. Canola and

mustard response to short periods of temperature and water stress at different developmental stages. Can J Plant Sci. 2004;84:697-704.
7. Aliakbari M, Razi H, Kazemeini SA. Evaluation of drought tolerance in rapeseed (*Brassica napus* L.) cultivars using drought tolerance indices. IJABBR. 2014;2:696-705.
8. Beckie HJ, Johnson EN, Blackshaw RE, Gan Y. Weed suppression by canola and mustard cultivars. Weed Technol. 2008; 22:182-185.
9. Steel RGD, Torrie JH. Principles and procedures of statistics. Second Edition. McGraw-Hill, New York; 1980.
10. Duggan B. Spring canola and mustard variety trial. Central Oregon Agricultural Research Center 2007: Annual Report #1084; 2007.
11. Adeniji O, Aloyce A. Floral and seed variability patterns among Ethiopian mustard (*B. carinata* A. Braun) of East Africa. Tropicultura. 2012;30:133-140.
12. Sevik H, Cetin M. Effects of water stress on seed germination for select landscape plants. Pol J Environ Stud. 2015;24(2): 689-693.
13. Topacoglu O, Sevik H, Akkuzu E. Effects of water stress on germination of *Pinus nigra* arnold. Seeds. Pak J Bot. 2016;48(2):447-453.
14. Yigit N, Sevik H, Cetin M, Kaya N. Determination of the effect of drought stress on the seed germination in some plant species, water stress in plants. Rahman M, editor, InTech, Chapter. 2016; 3:43-62.
DOI: 10.5772/63197
15. Guney K, Cetin M, Sevik H, Guney KB. Effects of some hormone applications on germination and morphological characters of endangered plant species *Lilium artvinense* L. seeds, new challenges in seed biology. Rahman M, editor In Tech. 2016;Chapter4:97-112.
ISBN: 978-953-51-2659-1
16. Guney K, Cetin M, Sevik H, Guney KB. Influence of germination percentage and morphological properties of some hormones practice on *Lilium martagon* L. Seeds. Oxid Commun. 2016;39(1-II):466-474.
17. Sevik H, Cetin M. Effects of some hormone applications on germination and morphological characters of endangered plant species *Lilium artvinense* L. Onion Scales. Bulg Chem Commun. 2016;48(2): 256-260.
18. Topacoglu O, Sevik H, Guney K, Unal C, Akkuzu E, Sivacioglu A. Effect of rooting hormones on the rooting capability of *Ficus benjamina* L. Cuttings. Šumarski list. 2016;1–2:39–44.
19. Sevik H, Cetin M, Belkayali N. Determination of characteristics factors of grafted natural varieties in landscaping: A case study of black pine (*Pinus nigra*) clone. Oxid Commun. 2016;39(3A):2820-2831.
20. Sevik H, Guney K. Effects of IAA, IBA, NAA, and GA3 on rooting and morphological features of *Melissa officinalis* L. Stem Cuttings, The Scientific World Journal; 2013. Article ID 909507.
21. Sevik H, Guney K, Topacoglu O, Unal C. The influences of rooting media and hormone applications on rooting percentage and some root characters in *Schefflera arboricola.* Int J Pharmaceutical Sci Invent. 2015;4(2):25-29.
22. Major DR, Kiniry JR. Predicting day length effects on phenological processes. In: Hodges, T. (Ed.), Predicting Crop Phenology. CRC Press, Boca Raton, FL. 1991;15-28.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/18867