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Prediction of flowering occurrence in soybean in north of Iran

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Abstract

To predict the date of flowering is very important and determinant in soybean fields. Quantitative information about date of flowering can manage many of agricultural practices. Soybean varieties were planted in seven sowing dates over 2 years. Proper equations were determined between sowing and flowering dates based on 3 variables, day of year, Growth degree day and thermal time. Results indicated the gradient between varieties was significant (p≥ 0.01). Different sowing dates caused changes in day to flowering and this period was decreased in all varieties by delay in sowing dates. The lowest and highest gradient was observed in G3 and Williams, as late and early maturity group respectively. Day to flowering in Williams recorded 39 and 34days in full season and double crop, but in G3 it changed from 66 to 32days. So, the flowering date can predict and some agronomic practices can manage and schedule on time.

Key words: early maturity, flowering time, soybean, sowing date, Temperature

Introduction

The morphological and physiological process of each plant is different in any growth stage of its life cycles. To know the effective factors that impact on the period of different growth stage are very important to get the potential growth and final yield. A number of ecological parameters drive selection on the date of flowering, and plants are under options to get a proper strategy to balance these parameters. The requirements of plant are different in each growth stages and their sensitivity to environmental parameters can also be differing in each variety of any crops (Farre et al. 2002).To predict the time of occurrence of vegetative and reproductive stages is very necessary to schedule the agronomical practices. To have knowledge about the period of growth stage is an essential requirement in agronomical crop modeling (Grimm et al. 1994). The plants are different for response to environmental factors and their function show various reaction. Soybean is known as a sensitive plant to temperature and photoperiod (Allen et al. 2000; Javakumar et al. 2008; Funsak et al. 2009). The suitable temperature for soybean is 20-25°C at flowering, (Liu et al. 2008). Garner and Alard reported for the first time that, higher temperature in soybean causes earlier flowering and there is interaction effect between temperature and photoperiod (Garner & Alard 1930). Then many of researcher reported that higher temperature from germination to flowering causes that flowering stage happened sooner and this period be shorter (Summerfield et al.1993; Upadhyay et al. 1994; Piper et al. 1996; Cooper 2003).In the other hand the growth of soybean from emergence to flowering determine the potential of plant to start reproductive stage and final yield. Although the period of this stage dependent to genotype and environmental factors, but the planting date can effect on number of days from emergence to flowering stage. Delay in planting date affect in period of emergence to flowering and decrease this period, so for having a complete and sufficient period of emergence to flowering, soybean should be planted earlier and on time. Soybean is planted as a full season and double crop system throughout the world (in spring and summer). For a potential production, soybean should be planted in a full season crop system. But many of farmers cannot plant their soybean in full season system due to have more income. So they exert to plant two crops in a year, and soybean has to put in double crop system (normally after wheat). In the area that soybean is planted as a double crop, the growth stage is shortened, so some solutions should be applied to decrease the damage of final yield. In Iran soybean is mostly planted in Northern provinces, that nearly 90% are planted in double crop system, after winter wheat. In some area soybean is planted with more delay and it causes some problem for flowering and filling the pods. These problems finally decrease the potential yield. The effect of delay on yield decrease the period of germination to flowering, that this decreasing is different in soybean varieties. Some research showed that the period between emergence to flowering decreased less in varieties with semi determinate like sahar, than varieties with determinate growth type like G3(Raeisi, 2001). In some area like Iran, planting of soybean in double crop system is unavoidable. This system causes decreasing in period of emergence to flowering. So some solution should be applied like proper varieties with lower risk, or proper density and etc. These solutions can reduce the damages of farmers; so that they can plant two crops in a year and have more income (Khan et al. 1997; Oh et al. 2008).For determine the relation between day to flowering with temperature should be plant each variety in different sowing dates. This is very difficult for all varieties of soybean. But by simulation and modeling can find the phonologic status like day to flowering for each variety. The models for predicting phonologic growth based on mathematical explanation is stand to

environmental factors. Different models proceeded based on temperature, radiance, photoperiod and the other factors that relate with soybean growth stages (Cober et al, 2001, 2014). Also for proceeding different models need too many data in relation to applied parameters. With proper models can predict the time of flowering for different planting dates, but Models become better and more useful if they are simple and apply with less and accessible inputs(Bagheri et al,2014). This study was conducted to predict the time of flowering date for different type of soybean in various sowing dates.

Materials and Methods

Three commercial varieties of soybean were planted in 7 sowing dates from interval 13 days over two years. The varieties included Williams, Sahar and G3, early and indeterminate, medium and semi determinate, late and, determinate maturity groups and growth types respectively. The sowing dates are the range of time that farmers involve to plant soybean in the north of Iran. (Included planting in full season, double crop and planting with delay).The place of experiment was agricultural research station named Araghi mahaleh in agricultural and natural resource research center of Golestan in Gorgan, the north of Iran. The region classify as semiarid Mediterranean climate. This station is located, with elevation 5 meter above sea level, 36˚ 55´ N, 54˚ 20´E. The soil was a fine clay-loam and average temperature is 17˚ C and the mean of rainfall is 450 mm in year. The experiment was conducted in a factorial based on randomized complete block design in three replication. In each sowing date, the seeds were planted in the plots that already had a good condition in terms of moisture in the soil. All agronomical practices were done from planting until maturity such as, irrigation and control of weeds and pests. The phonology of each treatment was recorded based on Feher and Caviness form (Feher &Caviness1977) from the beginning of emergence to end of maturity. So the dates of flowering were used as the data in applied model in this study. The preparing and changing of data were done using Microsoft Excel 2010, and StatGraphic software (Stat Point) transcription 11/1/16 was used for analysis of data using as an statistical methods of linear regression.

Results and discussion

The variance of gradient in models for the date of flowering time was fully significant (P< 0.01) based on three variables, day of year, growth degree day and thermal time between varieties in two years (tables 1-3). This result revealed a good relationship between sowing date and flowering time based on related equations .Based on day of year, R- Square was higher than 93%, and it reveals high validity of this model for its predictions (table 1). The variety of Williams showed the highest slope (0.870) and the lowest slope was belonged to G3 variety (0.563). These high coefficients indicated, there is a high relationship between sowing and flowering date based on, day of year. This results show this model can explain considerable relation between different variables.

Table 1. Correlation coefficient and linear regression statistic between sowing and flowering date based on day of year in varieties of soybean in two years

Year	variety	P-Value	Correlation	R-squared	adjusted	MSE	Intercept	Slope
1	1	0.0000	0.969	93.921	93.564	29.144	47.474	0.841
1	2	0.0000	0.996	99.168	99.119	2.934	66.935	0.741
1	3	0.0000	0.993	98.578	98.494	4.106	78.080	0.668
2	1	0.0000	0.998	99.685	99.668	1.854	41.112	0.886
2	2	0.0000	0.997	99.492	99.465	1.719	72.207	0.671
2	3	0.0000	0.979	95.908	95.693	9.624	88.692	0.549
mean	1	0.0000	0.985	96.989	96.910	15.570	43.583	0.870
mean	2	0.0000	0.996	99.290	99.259	2.368	71.467	0.683
mean	3	0.0000	0.980	96.002	95.828	9.382	87.809	0.563

Varieties
1:Williams
2: Sahar
3:G3

Delay in sowing dates from spring to summer caused the period of emergence to flowering decreased in three varieties(figure 1). But the distinction was different in varieties. This differences were evaluated in two years indivitually. In first year, the period of emergence to flowering showed significant differences. Tthe highest period from emergence to flowering was observed in G3 in first planting time(11May). This period was 61 days in first planting time (11May) that changed to 34 days in last planting date (28july). The period of this stage also has changed in two other varieties. This period in Sahar as a semi determinate and medium maturity, changed from 55 days in first planting time to 33 days in last planting time. In Williams as an indeterminate and early maturity group, it was from 41 days in first sowing date to 27 days in last sowing date. In second year, the period of emergence to flowering also showed significant differences. The period of this stage was higher in G3

variety in the first sowing date (11May). The length of this period also was higher in this variety in different planting times, so that it was 71 days in the first planting time, but about 31 days in last planting time. But this variation was lower in Williams as an early variety of soybean. Totally, the most variation between emergences to flowering in two years observed for G3 variety. For Williams as an early maturity group the lowest variation of this period recorded**.** The results of two years revealed two important facts. At first the delay in sowing date causes decreasing the period of emergence to flowering. The other researcher also reported that later sowing date causes lower days from emergence to flowering and all reproductive stage in soybean (Kumar, 2008). The second result showed, there is variation for this period between soybean varieties. The period of this stage in Williams was very low, so that it differed from 39 days in spring sowing date to 34 days in summer planting dates. But this stage for G3 was 66 and 39 days in spring and summer sowing dates, respectively. Williams as an early variety tend to be less sensitive to planting date. Nafziger also indicated, when varieties planted in full season and late sowing date, their sensitivity was different. He reported, earlier varieties that were planted in early May tend to be less sensitive to planting date, as long as they are planted by late May(Nafziger 2009). In another research that reported from extension office, days to flowering for soybean in full season, double crop and late date, recorded 65, 55 and 45 days respectively (Holshouser 2010*).*

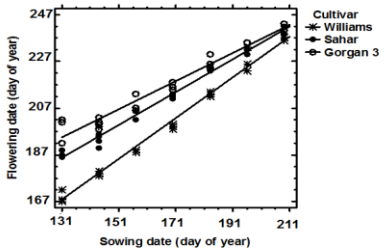

Figure1: Regression relationship between sowing and flowering date based on

Day of year

Similar results also observed for flowering time based on Growth degree day for varieties in two years (table 2). R square also was very high (more than 96%) and the slop of equations was higher for Williams variety (about 16).

Table 2. Correlation coefficient and linear regression statistic between sowing and flowering date based on Growth degree day in varieties of soybean in two years

Year	Variety	P-Value	Correlation	R-squared	adjusted	MSE	Intercept	Slope
1	1	0	0.968869	93.8707	93.5101	12314.8	228.861	17.2031
1	2	0	0.995967	99.195	99.1477	1218.12	606	15.3474
1	3	0	0.992894	98.5839	98.5006	1765.7	834.147	13.8883
2	1	0	0.997276	99.4559	99.4273	1359.41	396.322	18.2368
2	2	0	0.99731	99.4628	99.4345	813.703	563.131	14.1998
2	3	0	0.978985	95.8412	95.6224	4301.18	921.709	11.5181
mean	1	0	0.968802	93.8578	93.6961	14170.4	569.766	18.0706
mean	2	0	0.977344	95.52	95.4022	6940.14	566.879	14.9384
mean	3	0	0.964332	92.9936	92.8092	7618.39	903.694	12.3486

Varieties
1:Williams
2: Sahar
3:G3

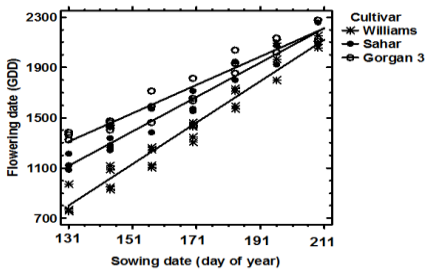

Figure2: Regression relationship between sowing and flowering date based on Growth degree day

Destination between growth degree days for three varieties was different in seven sowing dates. Accumulated growth degree day was more in Williams from earliest to latest sowing date, but it was less in later varieties(Sahar and G3) (Figure 2). Also the results showed, when sowing date delayed, higher growth degree day would be happened sooner due to the plant involve with higher temperature and the requested heat accumulate sooner. So flowering date would be happened earlier, due to the plant accumulate more heat and it achieve to requested degree day, so enter to flowering stage sooner. Khage pour reported higher temperature causes shorter growth stage in plants, due to the requested heat will supply in shorter time (Khage pour, 1988). The minimum GDD in the first sowing date for earliest variety was 700, but it recorded about 2000 for last sowing date, but GDD for this destination was lower for two later varieties (Figure 2).In relation to Thermal time the results was very similar with GDD due to, Thermal time in fact derived from the common data with GDD. R-square determined more than 93% for all varieties. The highest slope also belonged to Williams more than 17(table3). A similar relationship also observed between sowing date and flowering time based on thermal time (figure 3). The flowering time occurred sooner in later sowing date, due to thermal time for each variety happened sooner. Later sowing date caused the stage of emergence to flowering face to higher temperature, so more heat accumulate by plant and flowering stage occur sooner. Khage pour reported in higher temperature, the growth stage decreased due to accumulate demanded heat in shorter time (Khage pour, 1998). The varieties also showed similar results like growth degree day. The late variety (G3) showed higher sensitivity to thermal time and with lowers thermal time achieved to flowering time whereas this sensitivity was less in Williams as an early variety (Figure3)

Table 3. Correlation coefficient and linear regression statistic between sowing and flowering date based on thermal time in varieties of soybean in two years Varieties

Year	Variety	P-Value	Correlation	R-squared	adjusted	MSE	Intercept	Slope
1	1	0	0.968869	93.8707	93.5101	12314.8	228.861	17.2031
1	2	0	0.995967	99.195	99.1477	1218.12	606	15.3474
1	3	0	0.992894	98.5839	98.5006	1765.7	834.147	13.8883
2	1	0	0.997276	99.4559	99.4273	1359.41	-39.6322	18.2368
2	2	0	0.99731	99.4628	99.4345	813.703	563.131	14.1998
2	3	0	0.978985	95.8412	95.6224	4301.18	921.709	11.5181
Mean	1	0	0.968802	93.8578	93.6961	14170.4	56.9766	18.0706
Mean	2	0	0.977344	95.52	95.4022	6940.14	566.879	14.9384
mean	3	0	0.964332	92.9936	92.8092	7618.39	903.694	12.3486

Varieties
1:Williams
2: Sahar
3:G3

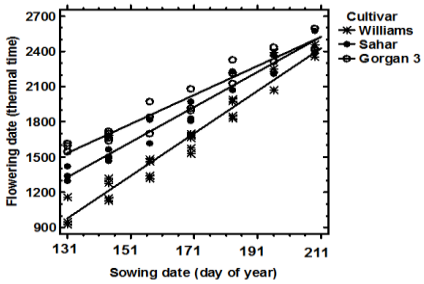

Figure3: Regression relationship between sowing and flowering date based on Thermal time

The equations were proceeded Based on the data that recorded in two years for 3 varieties and 7 sowing dates and the meteorological data. These equations were resulted from regression relation between sowing date and flowering time based on day to flowering, Growth degree day and thermal time (table4).

Table 4. Equations of final models of regression relationship between sowing dates and flowering time for varieties

variables	variety	Equations
DFD = 43.583+ (0.870) SD	Williams	Day of year
DFD = 71.467+ (0.683) SD	Sahar	
DFD = 87.809+ (0.563) SD	G3	
GFD = 569.766+ (18.0706) GSD	Williams	Growth degree day
GFD = 566.879+ (14.9384) GSD	Sahar	
GFD = 903.694+ (12.3486) GSD	G3	
TFD = 569.766+ (18.0706) TSD	Williams	Thermal time
TFD = 566.879+ (14.9384) TSD	Sahar	
TFD = 903.694+ (12.3486) TSD	G3	

SD: sowing date
FD: flowering date
DFD: flowering date based on day of year
GFD: flowering date based on Growth degree day
TFD: flowering date based on thermal time

These equations obviously revealed a high relationship between sowing dates and flowering time especially based on Growth degree day. Ramesh and. Gopalaswamy also indicated, a linear relationship between sowing date and development of phonological phases, their results showed a better prediction for initial flowering time based on Growth degree day (Ramesh and. Gopalaswamy, 2008).

Conclusion

The period of emergence to flowering is very important in soybean and the variations of its can be determine the potential of plant for entry to reproductive growth stage. In fact the reaction of varieties depends to their maturity group, but their growth type can modify their behavior in stress condition. Results of this study confirmed, the date of flowering can predict in different varieties of soybean in different sowing dates. This prediction is very important for soybean farming, due to the sowing dates for soybean is very changeable and can be from full season to very late planting dates. So with prediction of flowering date can manage many decisions about agronomical practices like, irrigation, pest control and the others. Especially in recent years, climate change causes some problems for soybean in some area, as well as Iran. Warmer days and night in flowering process causes abortion of flowers and to generate some abnormalities in pod setting and finally maturity. So with predicting the flowering time and forecasting the weather condition can attend the farmers to manage more their farms and schedule some practices like irrigation to avoid less damage to flowering in soybean in stress condition. This results also confirm the variety of soybean with early maturity and indeterminate growth type like Williams has less sensitivity to sowing dates and can keep the stage of vegetative period(from emergence to flowering), so they are more proper in condition with stress. The old researches also reported this funding about soybean (Hodge and French. 1984).Based on the results of this study, the late maturity variety like G3 did not know as a proper variety with stable seed

yield for condition with probable stress. So for in the area like the north of Iran, climate change causes some stress (high temperature and drought) in recent years, varieties like G3 should not be plant. Pervious study also had reported about sensitivity of this variety (Raeisi et al.2012).

References

1 - Allen, LH and Boote, KJ. 2000. Crop ecosystem responses to climate change: Soybean. In: Reddy, KR and Hodges, HF (Eds.). Climate Change and Global Crop Productivity

2 - Bagheri, S, Sepaskhaha, A, Razzaghia, F and Zand-Parsaa, S. 2014. Developing a dynamic yield and growth model for maize under various water and nitrogen regimes. Archives of Agronomy and Soil Science Volume 60, Issue 9, 2014

3 - Cober, ER, Daniel, F, Curtis, D, Stewart, W and Morrison, M J. 2014. Quantifying the Effects of Photoperiod, Temperature and Daily Irradiance on Flowering Time of Soybean Isolines. Plants, 3, 476-497; doi: 10.3390.

4 - Cober, ER, Stewart, DW, Voldeng, HD. 2001. Photoperiod and Temperature Responses in Early-Maturing, Near-Isogenic Soybean Lines. Crop Sci. 41(3):721-727

5 - Cooper, RL. 2003. Delayed flowering barrier to higher soybean yields. Field Crops Research. 82:27–35.

6- Farre, I, Robertson, M J, Walton, G H. and Asseng, S. 2002: Simulating phonology and yield response of canola to sowing date in Western Australia. Australian Journal of Agricultural Research 53, 1155-1164.

7- Feher, WR and Caviness, C E. 1977. Stage of soybean development. Special report 80 Iowa State. Univ.of Arkansas.

8 - Garner, WW and Allard, HA. 1930. Photoperiodic response of soybeans in relation to temperature and other environmental factors. J. Agric. Res. 41, 719–735.

9- Grimm, SS, Jones, JW, Boote, KJ and Herzog, DC. 1994. Modeling the occurrence of reproductive stages after flowering for four soybean cultivars, Agron. J. 86, 31–38.

10 - Holshouser, L. 2010. Days to Soybean Physiological Maturity. Virginia Cooperative Extension. www.ext.vt.edu.

11 - Jayakumar K, Vijayarengan, P, Chang-Xing, Z and Jaleel, CA. 2008. Soil applied cobalt alters the nodulation, leg-haemoglobin content and antioxidant status of *Glycine max* (L.) Merr. Colloids and Surfaces B: Biointerfaces. 67 (2) : 272-275.

12 - Khan, MV, Steele, CC and Grabau, LJ. 1997. Early maturing soybean cropping system: I. Yield response to planting date. Agron. Journal 89: 454 – 458.

13 - Khaje Pour, M.1998. Effect of temperature and photoperiod in selection of crop planting date. 5th Iranian congress of crop production and plant breeding. Aug31. – sep4. Karaj – Iran.

14 - Kumar, A, Pandey, V, Shekh, AM. and Kumar, M. 2008. Growth and Yield Response of Soybean (Glycine max L.) In Relation to Temperature, Photoperiod and Sunshine Duration at at Anand, Gujarat, India. Am-Euras. J. Agron., 1 (2): 45-50,

15 - Liu, B, Kanazawa, A, Matsumura, H, Takahashi, R and Harada, K. 2008. Genetic redundancy in soybean photoresponses associated with duplication of the phytochrome a gene. Genetics 180: 995–1007

16 - Nafziger, E. 2009. Illinois Agronomy Handbook, 24th edition. University of Illinois Extension C1394. Available for download at http://extension.cropsci.illinois.edu\handbook

17 - Oh, YJ, Kim, Kh, Cho, SK, Kim, TS, Kim, jG, Wood, Aj and Cheo, Y. 2009.Selectable traits for yield improvement in double crop soybeans at high plant density with late plant density with late planting. World journal of agriculture science 5(3): 301- 307.

18 - Piper, E, Boote, KJ, Jones, JW and Grimm, S. 1996. Comparison of Two Phenology Models for Predicting Flowering and Maturity Date of Soybean. Crop Science. Vol. 36 No. 6, p. 1606-1614

19- Raeisi, S. 2001. Evaluation of the effect of different planting date on yield components developed and yield of two soybean cultivars with different growth types. M. Sc. Thesis. Agriculture and Natural Resources Univ. of Gorgan. Gorgan, Iran, 89 pages (In Persian, with English Abstract).

20 - Raesi, S, Shahbazi, M and Hezar-jaribi,E. 2012. Effects of Planting Dates on Flower and Pod Shedding and Podding Disorder in Different Soybean Growth Types. Iranian journal of oil plants.1; 1-17. Issn:2251-8258

21 – Ramesh, P and Gopalaswamy, N. 2008. Heat Unit Requirement and Prediction of Developmental Stages in Soybean.Journal of agronomy and crop science. 167(4):236 - 240.

22 - Summerfield, RJ, Lawn, RJ, Qi, A, Ellis, RH, Roberts, EH, Chay, PM, Brouwer, JB, Rose, JL, Shanmugasundaram, S, Yeates, SJ and Sandover, S. 1993. Towards the reliable prediction of time to flowering in six annual crops. II. Soyabean {Glycine max). Experimental Agriculture 29: 253-289.

23 - Upadhyay, AP., Summerfield, RJ, Ellis, R H, Roberts, EH and Qi, A. 1994. Variations in the durations of the photoperiod-sensitive and photoperiod-insensitive phases of development to flowering among eight maturity isolines of soyabean [Glycine max (L.) Merrill]. Annals of Botany 74: 97-101.

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