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RESEARCH PAPER

Evaluation of growth degree day of different phenological stages of cowpea (*Vigna unguiculata* L.) baghdadi cultivar in Ahvaz climate

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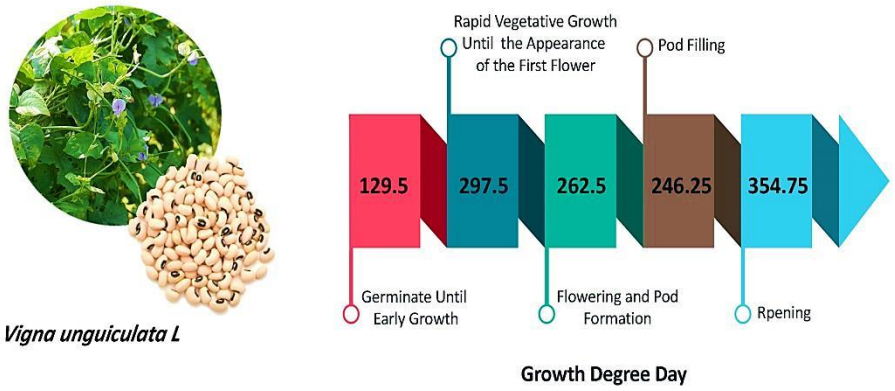
Highlights

- The growing season of crops plays an important role in selection for cultivation in an area.
- Cowpea has certain phenological stages and each of these stages requires a certain growing period.
- Therefore, by determining the necessary conditions for the growth of this crop, the area in which it should be grown can be selected.

Graphical Abstract



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Abstract

Cowpea (*Vigna unguiculata* L) is one of the valuable products whose cultivation is expanding and which has certain phenological stages with a specific need for growing time. Therefore, by determining the necessary conditions for the growth of this plant, the appropriate area for its cultivation can be determined. One of these conditions is the required temperature for each phenological stage, which can be calculated using the Growth Degree Day (GDD) heat unit. The present study was conducted in the field of Baghdadi variety (with a growing period of 90 to 110 days) in open field potted cultivation in Ahvaz city from March 2019 to June 2019. The stages studied include emergence to early growth (number of days from planting to cotyledon emergence, primary leaflet emergence, first three leaflet emergence), rapid vegetative growth to first flower emergence (third three leaflet emergence, flower initiation), flowering pod and pod filling formation (VR123, VR45, R67, R8 and R9 maturation, respectively). To determine the GDD for each of these stages, the degree of growing days from planting to the desired stage was calculated based on the daily temperature statistics and according to the corresponding equation. The result of this study showed that the Cowpea cultivar tested under the climatic conditions of Ahvaz city had an average GDD for the stage of emergence to initial growth (129.5), the stage of rapid vegetative growth to the appearance of the first flower (297,5), flowering and pod formation (262.5), pod filling (246.25), final maturity (354.75), and generally from the time of planting to final maturity (1150.5-1430.5) growth degree days.

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1. Introduction

The growing season of crops plays a key role in selecting them for cultivation in an area. Cowpea, like most crops, has specific phenological stages and each of these stages requires a specific growth period. Therefore, by determining the necessary conditions for the growth of this plant, the area prone to its cultivation can be selected. Each product has its maximum growth and performance in a specific set of environmental conditions. In other words, various factors play a role in choosing the right product for planting in certain environmental conditions. Among climatic factors, heat regime has the greatest effect on plant development and its various stages, and according to the principle of thermal stability, each plant reaches a certain stage of its development when a certain amount of heat is taken from the environment (Zargaran Khouzani, 2021). The growth period of the plant and the selected cultivar should be in the range of specific temperatures to achieve proper yield (Sarker et al., 2020). In general, the use of time factor to reach the basic stages of growth to compare different products, especially in different places due to differences in environmental conditions is not accurate enough (Saffariha et al., 2021). Therefore, Growth Degree Days (GDD) is better than the number of days to examine each stage of growth. According to the above, the purpose of this study is to investigate the GDD of different growth stages in different pinto bean lines and their performance and performance components.

Cowpea (*Vigna unguiculata* L.) is one of the most important legumes that plays a major role in the human diet. Legumes have high nutritional value and good storage capacity and are one of the most important food sources rich in 18 to 32% protein. The importance of legumes in Iran is after wheat and rice, and among them, about half of the area under legume cultivation is beans (Sepahvand et al., 2021). According to available statistics, the area under cereal cultivation in Iran is about 97,300 hectares and its total production is about 208,350 tons of grain. Cowpea is one of the oldest plants in the tropics and subtropics, which grows well in temperate regions and has a great ability to bio-stabilize soil nitrogen, and its branches and leaves are used as animal feed (Mahboub Khomami et al., 2021). Beans are fast-growing plants and it seems necessary to study the effects of moisture stress on plant growth. Therefore, sufficient soil water must be available to ensure its optimal growth and yield (Dixit, 2020).

The study of plant development concerning climatic conditions is called Phenology. Understanding plant Phenology makes understanding developmental processes, yield capacity, and plant Phenology predictable (Hammer et al., 1982). Given that a large number of physiological and morphological processes change with the plant Phenology stage, accurate quantification of the Phenology developmental stages is essential for any of the growth replication models. Today, the use of modeling and simulation methods of developmental stages is recognized as an effective tool in the optimal management of crops around the world (Bouman et al., 1996). Based on the type of plant, important and Phenology-based stages including emergence, beginning of flowering, time of maximum leaf area index, end of flowering, beginning of seed filling and maturity can be predicted. The physiology of the various stages of growth and development of the Cowpea plant is based on both heat time and calendar time. Temperature is the most important stimulus for Phenology development. Cowpea core temperatures, including basal temperature (Tmin or Tb), the optimum temperature for growth (TO), and maximum or ceiling temperature (Tmax or TC), are 10, 24, and 30.1 degrees Celsius, respectively (Ferreira, et al., 1997). The heat index used is GDD, which is used to predict different developmental stages over a limited range of planting dates and latitudes. The GDD calculation was performed as (equation 1**)**.

$$GDD = \sum[(Tmax + Tmin)/2 - Tb] \quad (1)$$

Where T, TB, and TO are the average air temperature, base temperature and optimum temperature in degrees Celsius, respectively. Fig. 1 shows the equation above. GDD was cumulatively expressed for different stages of development. Therefore, from the beginning of each developmental stage to the end of that stage, it was calculated daily and then added together and finally presented cumulatively. In this study, to predict the duration from planting to different stages of development, using equation 1, from data related to Cowpea

(*Vigna unguiculata* L.) in Ahvaz city in the date of planting from March to mid-June, which it is has been used on the Baghdadi cultivar. The GDDs for the developmental stages predicted were emergence to early growth, rapid vegetative growth to the emergence of the first flower, flowering, pod formation, pod filling, and ripening, respectively, in degrees Celsius per day.

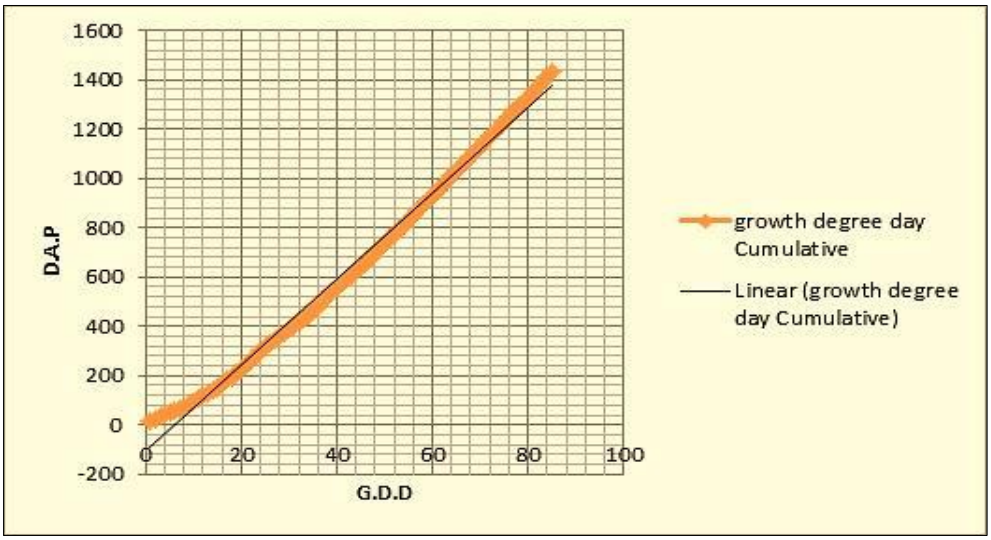

Figure 1. The cumulative trend of Growth Degree Day based on days after planting.

2. Materials and Methods

In this study, the local cultivar Cowpea (Baghdadi) was measured for different phenological stages in terms of GDD on the planting date of March to the end of the growth period in mid-June (Fig. 2). The cultivars were planted in open pots. Field operations including fertilizing, irrigation, weeding, spraying against pests, diseases and weeds, etc. were carried out on time. Different stages of cultivar growth were recorded as date (time), which included the number of days until the emergence of cotyledons, day to the emergence of the first leaves, day to emergence of the first three leaflets, day to the emergence of the third three leaflets, day to flowering, day to flowering was, the day until pod formation, the day until pod filling and the day until maturity. To calculate the degree of growth days of each of these stages, meteorological statistics during the growing season were measured by standard minimum and maximum thermometers and then, using equation 1, the heating unit was determined for each of them. The base temperature in this study was 10 °C and temperatures above 30 and below 10 °C were considered as 30 and 10, respectively.

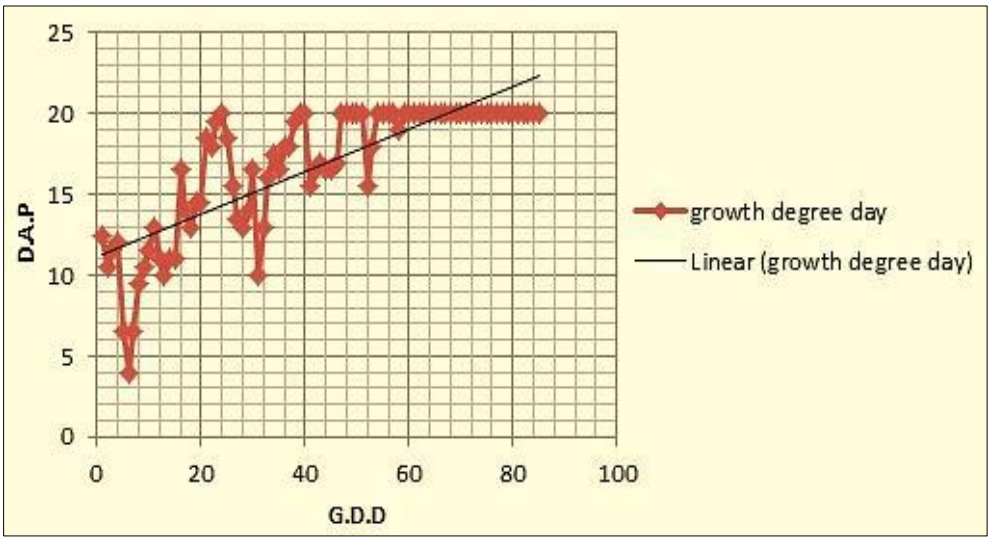

Figure 2. Daily GDD trend based on days after planting.

3. Results and Discussion

GDD is a parameter that is used in most growth analysis studies and can be used to assess how the plant responds to environmental conditions (Russell et al., 1984). The results of this experiment showed that Cowpea cultivar tested in climatic conditions of Ahvaz city during the middle and late March planting dates on average for the stage of emergence to early growth (129.5), the stage of rapid vegetative growth until the appearance of the first flower (297.5), cumulative (427), flowering and pod formation (262.5), cumulative (689.5), pod filling (246.25), cumulative (935.75), final ripening (354.75), cumulative (1290.5), and generally requires Growth Degree Day from planting to final ripening (1150-1430.5) (Fig. 3). In the other study, reported that the major effect of future climate change will be on temperature. Due to the increase in ambient temperature due to climate change, the required degree of growth day for each stage of developmental stages is received in a shorter time (Pal et al., 1996; Qayyum et al., 2020). Due to the shorter developmental stages, components of performance that are stabilized at this stage are affected due to the faster receipt of the growth day. Also, in the other research, stated that the cumulative growth day degree as an indicator to explain the relationship between yield and temperature may be misleading and should be used the other indicators (Sikder, 2009).

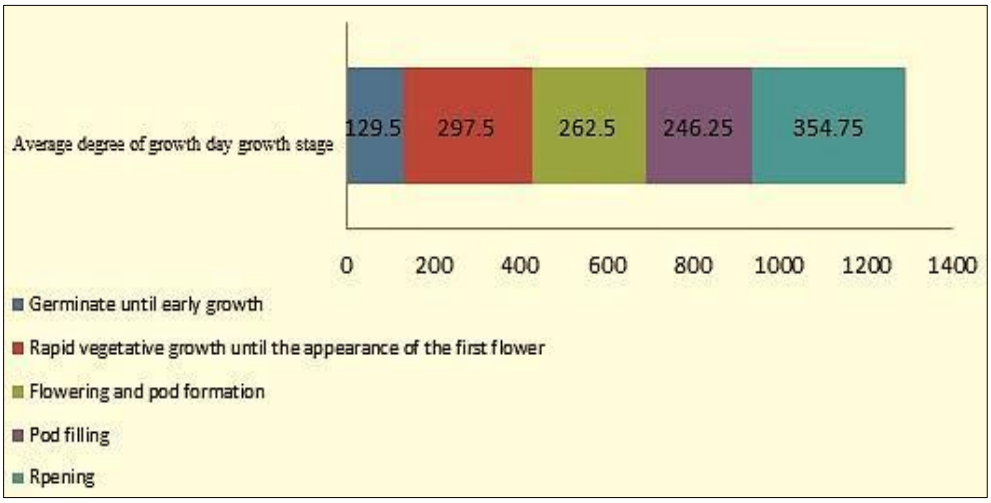

Figure 3. Growth Degree Day Cumulative for the intended phases of developmental stages.

4. Conclusion

Climatic parameters, especially temperature, have a significant effect on increasing plant yield. Having accurate information from the time the crop reached different stages of phenology was a great help to the stage and ultimately production in agriculture. This study was performed to determine the time of occurrence of different phenological stages of cowpea. The degree of suitable growth day of different stages of cowpea phenology was extracted from different sources. Using the parameter of maximum temperature and minimum temperature and also considering the base temperature for cowpea, the degree of cumulative growth day (GDD) for each growth stage of this plant in the climatic conditions of Ahvaz was calculated. The results showed that using the degree of cumulative growth, the start and end dates of different growth stages of the kidney bean plant can be obtained. Using this method, according to the total degree of growth days of phenological stages of Cowpea in different parts of Khuzestan province and other parts of the country can be predicted and the best planting date and the best possible time to take action can be selected. Appeared in different places.

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