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Phenology associated with degree days for bean - cowpea cultivar BR-17 Gurguéia: A literature review

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Abstract: Cowpea (*Vigna unguiculata* (L.) Walp.) is a culture that plays an important role in agricultural production of Brazilian states. While the culture is well researched, when referring to stages of development are little studies about. Therefore, the identification of phenological stages of crops is very important to facilitate the adoption of best management strategies to better yields and profitability. The objective of this review describe the phenological stages of cowpea cv. BR 17 - Gurguéia relating the number of degree-days (GDD) for each stage of development, indicating pests and diseases that can affect the crop. The phenology of plants has the remarkable characteristic the fact that the GDD is independent of the time and the planting site. Research has shown a greater adaptation of the cycle of some crops to GDD than the number of calendar days, and can estimate more easily cycle time, as well as establish the planting season due to the most appropriate time to harvest. The cultivar BR-17 Gurguéia has at least nine vegetative and reproductive stages having the lowest cumulative thermal demand stage V1 and reproductive stages require a greater number of degree-days compared to vegetative.

Keywords: Thermal requirements, growth stages, *Vigna unguiculata* (L.) Walp.

Introduction

Bean Cowpea or cowpea (*Vigna unguiculata* (L.) Walp.) is a legume belonging to the family Fabaceae being grown mainly in warm regions of Ásia, África, America and Europe. This is because of their higher nutritional attributes, adaptability to high temperatures and drought conditions among other stresses (EHLERS, HALL, 1997).

The largest acreage and cowpea production are concentrated in countries Nigeria (45%), Niger (34%) and Brazil (13%), respectively. These have the 5, 6 and 7 higher yields. In contrast, the United States and Unganda are the countries that are at the top productivity ranking (SINGH et al., 2002). In Brazil is grown predominantly in the north to northeast with expansion to the Midwest (FREIRE FILHO et al., 2005; BEZERRA; ALCÂNTARA NETO; MAGGIONI, 2012).

As the United Nations Food and Agriculture Organization (FAO), world production of cowpea in 2014 was approximately 5.6 million tons produced on 12.5 million hectares (FAO, 2015). Therefore, Brazil for not having a significant production does not appear in FAO statistics. The average cultivated area in northeastern Brazil is 1,289,647 ha-1, that is, currently the cultivated area in the state of Maranhão shares with 6.87% of all planted area in the northeastern region.

Data from the Brazilian Agricultural Research Corporation (Embrapa) Rice and Beans (2016), in Brazil cowpea production for crop year 2015 was 452,013 tons harvested in 1,078,040 hectares with a productivity of 419 kg ha^{-1}. The cultivated area in the northeast to the harvest in 2015 was 886 158 hectares with a production of 245,002 tons.

Data from the Brazilian Institute of Geography and Statistics (IBGE), in Maranhão the average annual productivity 2005 cowpea for 2014 found an increase of 12.04% from 457 to 512 $Kg.ha^{-1}$ $kg.ha^{-1}$ while the average productivity of the northeast there was a slight drop of 1% from 441 to 438 kg ha^{-1} kg ha^{-1} (IBGE, 2014).

The lack of a cultivar that is suitable for mechanical cultivation is forcing farmers to use traditional cultivars. Thus, one of the most used is BR 17-Gurguéia (MOURA, 2007). This cultivar combines good quality seeds, productivity and still features virus resistance (FREIRE FILHO et al., 1994). What according to Campos et al. (2000) this can be explained by the great genetic variability for all the characters in particular the size of the plant. Studies on the phenology seek to evaluate the periodic changes in appearance and in the constitution of living beings due to environmental causes (PASCALE; DAMARIO, 2004).

It is estimated that the first work on the detailed phenological characterization with criteria phenological scales for the bean crop were proposed by Mafra (1979) with *Phaseolus vulgaris* L. Given the importance of this culture, this review aims to describe phenological stages of cowpea cv. BR-17 Gurguéia relating the number of degree-days for each stage of development, indicating pests and diseases that can affect the crop.

General characteristics of the cowpea

Cowpea is a dicotyledonous belonging to the order Fabales, Fabaceae, subfamily Faboideae, Phaseoleae tribe, subtribe Phaseolinea, Vigna genus, subgenus Vigna, Catyang section, species *Vigna unguiculata* (L.) Walp and *unguiculata* subspecies (FREIRE FILHO et al., 2005).

In the sixteenth century it was introduced in Latin America by the Spanish and Portuguese settlers, particularly in the Spanish colonies and later in Brazil (FREIRE FILHO, 1988). Cowpea has several traditional names among them: bean-to-Makassar or monkey, bean-to-string, beans of the colony, bean-to-beach, bean-road and bean kid. Since 1983 sought is a name for better identification and ease of product marketing across the country (FREIRE FILHO et al., 2005).

The cowpea is a source of protein (23- 25%) and essential amino acids, carbohydrates (62%), vitamins and minerals having large amounts of dietary fiber, low amounts of fat (2%) and contains no cholesterol (FROTA; SOARES, ÁREAS, 2008).

It is a variety that can be grown in virtually all types of soil, but with prominence for the Oxisol, Oxisol, Red-Yellow Podzolic eutrophic (Argisol Red-Yellow), Alluvial (Fluvisols) and Quartz Sands (Neossolos Quartzipsamments) (OLIVEIRA; CARVALHO, 1987; MELO; ITALIANO; CARDOSO, 1988). It is also noteworthy that the cowpea has tolerance to acid media with soil pH around 5.5. Therefore, the saturation level of aluminum may not exceed 20% of the cation exchange capacity of the soil. Thereafter For the growth and development of the plant is affected mainly by the non-availability of phosphorus (ARAUJO et al., 1984).

As Rachie (1985), the cowpea can be grown in a wide environmental range with 40ºN latitude to latitude 30 degrees at high and low lands in West Africa, Latin America and North America. And, its good development occurs at a temperature between 18-34°C. In this context, the base temperature below which stops the growth varies with the phenological phase oscillations for germination from 8 to 11°C, while for the flowering stage 8 to 10°C. Therefore, elevated temperatures may end up damaging the growth and development of the plant, exerting influence on the abortion of flower, fruit set, the final retention of the pods and the part number of seeds per pod (ELLIS et al., 1994; CRAUFURD et al., 1996).

Still may contribute to the occurrence of phytoenfermities , particularly those associated with high relative humidity occurring when the cultivation is carried out in upland conditions (rainy season) (BENNET; ADAMS; BURG, 1977; JALLOW; FERGUSON, 1985; CARDOSO et al., 2000). Thus, the ideal time for planting varieties with cycle between 70 to 80 days is half of the rainy season in each region. As for the early cycle of 55 to 60 days it is ideal seeding about two months before the end of the rainy season in order to prevent harvesting is carried out in periods with greater probability of rain (CARDOSO et al., 2000).

Productive aspects of cowpea

Cardoso et al. (2000) in a study with cowpea varieties BR 14 and BR Mixed 17-Gurguéia to cities and Parnaíba Teresina, PI under and without irrigation system found that the thermal sums for upland period were lower than the period irrigated at both locations and varieties.

Dutra et al. (2015) to evaluate the cowpea cultivars producing components subjected to different levels of water stress in Paraíba semiarid, found that the productive mass component of pods per plant (MVP) was significantly influenced by the replacement of water slides in cowpea cultivars.

Gurguéia for cities of Teresina and Paranaíba, PI under sequenced and constant irrigated regime as thermal sums for sequencing period less than irrigated period in both sites and varieties.Thus, the occurrence of water deficits at the beginning of crop development may help to stimulate greater root development of plants, although stress near and / or prior to flowering may cause severe shrinkage of vegetative growth, limiting yield (ELLIS et al., 1994).

The components of number of pods per plant and weight of 100 grains are the ones that contribute to differentiate varieties compared to grain yield (HERBERT; BAGGERMAN, 1983).

Silva; Neves (2011) in experiments with cowpea in the experimental field of the Half-Northern Agricultural Research Center (CPAMN) Embrapa Mid-North, in Teresina, PI found that the component number of grains per pod, the average was 14.26 seeds per pod and the two groups were formed. The first group was stood-MNC99-505C the lines 11 and TE97-304G-4 with an average of 15.80 seeds per pod, matching statistically thirteen other genotypes.

In upland crop farming presents the average yield of 976 kg ha-¹ and ¹-1.606Kg.ha maximum, being superior cultivars Piauí BR-10 315 and CE-18 and 49% (FREIRE FILHO et al., 1994).

Regarding irrigated by sprinkling, the average yield was 1.694Kg.ha-¹ being superior cultivars Piauí BR-10 and CE-315 at 32 and 60%. The spacing between rows for this cultivar ranged from 0.80 to 1.0 m with 8 to 10 plants per meter density (EMBRAPA, 1998).

The practice of mechanical harvesting of feijão-cowpea is becoming more popular and successful it is being held in the states of Piauí, Maranhão and Pará, using mainly the cultivar BR-17 Gurguéia (FREIRE FILHO et al., 2005).

Cultivar BR-17 Gurguéia: History

This cultivar was launched on the market in 1994 by the Brazilian Agricultural Research Meio Norte (EMBRAPA). The BR-17 Gurguéia corresponds to the line TE 86-75-37E.1 being obtained by crossing two cultivars BR-10 Piauí and CE-315 (TVU 2331). The salient features of Gurguéia is the immunity against virus severe mosaic cowpea - CPSMV (*Cowpea severe mosaic virus*), some strains of *Potyvirus* are transmitted by aphids and resistance to the golden mosaic virus cowpea - CGMV (*Cowpea golden mosaic virus*) (FREIRE FILHO et al., 1994).

With the parental CNC 0434 cultivars and "TVU 612 featuring high resistance CGMV (SANTOS; FREIRE FILHO, 1987). The cv. EC 315 (2331 Tvu) originates from India also CGMV resistance (SANTOS; SON Freire, 1987).

To obtain the line TE 86-75- 37E.1 held the cross in 1986 in autogamic Plant Industry College of Agriculture "Luiz de Queiroz", Piracicaba, SP.

For Freire Filho et al. (1994), the trials were assessed for performance and response to virus presenting good standard of behavior.

Phenological cycle

Fields et al. (2000) defined the physiological cycle cowpea in vegetative and reproductive phase.

vegetative phase: V0 - seeding; V1 - emergence of the cotyledons; V2 - unifoliolate opening of leaves; V3 - the first trifoliate leaf meets the separated and fully open leaflets; V4 - the second trifoliate leaf is separated and with the leaflets fully open; V5 - the third trifoliate leaf meets the separated and fully open leaflets; V6 - the beginnings of secondary branch appear in the axils of leaves unifoliolate; V7 - complete opening of the first sheet of the secondary branch; V8 - opening of the second sheet of the secondary branch; V9 and - opening the third sheet of the secondary branch.

reproductive phase: R1 - emergence of the beginnings of the first bud in the main branch; R2 - anthesis of the first flower from the first bud; R 3 - beginning of the first pod maturity; R4 - 50% of mature pods of the plant; and R 5 - 90% of the maturity of the plant pods.

further suggesting a different behavior of cowpea genotypes and without irrigation, in cultivation systems in the vegetative phase (V3, V4, V7, V8 and V9) and reproductive (R2 and R5).

House (1997) reports that the duration between the different stages of plant development may vary according to the cultivar, temperature, climate and sowing time, among other factors.

Silva et al. (2017) found that phases V0, V1 and V2 lasted 4, 2 and 4 days for cowpea Submid culture in the San Francisco Valley.

Pereira (2002) in a study of the soybean Viçosa, MG found gradual increase of photosynthetic rate of the reproductive vegetative stage for reaching maximum values in the grain filling period. A similar effect may occur with feijão- cowpea may explain the acceleration of growth (change stage) of the vegetative stages V1 and V6.

For Freire Filho et al. (2005) one of the factors that affect the onset of flowering are the high temperatures, especially at night, as they may influence the onset of flowering and duration of the reproductive period, which may cause even abortion of flowers.

Moura et al. (2012) in a study with the cv. BR-17 Gurguéia at conditions of Teresina, PI 18.85 degrees obtained for the same-day phenophase.

The determination of the thermal accumulation at the early stages of emergency to the first sheet is valuable significance. This is due to the cowpea is a thermosensitive culture and any variation in temperature, soil or air is be able to markedly influence the phenology (SOUZA et al., 2007).

Andrade et al. (2010) working with cowpea in the experimental field of Embrapa Mid-North, Teresina, PI obtained for the production of green beans average between 36 and 40 days after emergence with values 38.25 and 39.5 days for the beginning of flowering for MNC05-lines 847B-123 and MNC99-541F-15.

Miranda et al. (2017) in an experiment conducted in the city of Ipameri, GO obtained for the bean pod average number of days for the early flowering (R1) between 39 to 45 days and the beginning of the harvest in edible step (R6) required in average of 55 to 65 days.

Mendonca et al. (2015) in cowpea experiment performed in Fortaleza, CE found that the strain BRS - Tumucumaque showed a 36 days to reach the flowering stage (R2) and 694 day degrees.

Moura (2012) noted that the cowpea cv. BR-17 Gurguéia at conditions of Teresina, PI required 818.2 degree days from sowing to the beginning of the reproductive stage, which required 60 days for ripening the grains.

Degree-day (DRM)

According to Cardoso et al. (2001), the concept of thermal units (degree days) was developed to overcome the inadequacies of the daily calendar and predict the stages of growth and development of culture, and also useful in identifying best sowing dates, the production scheduling and to predict phenological phases in breeding and production culture prediction programs.

The use of DRM is the accumulation of daily temperatures and more accurately characterizes the duration of phenology of crop plants. For this purpose, each plant species is an upper and lower base temperature above or below which its development is compromised (PEZZOPANE et al., 2008).

In this context, it is possible to "quantify" the phenological phases of plants, with the hallmark of the fact that the GDD is independent of the time and the planting site. Research has shown a greater adaptation of the cycle of some crops to GDD than the number of calendar days, and can estimate more easily cycle time, as well as establish the planting season due to the most appropriate time to harvest.

The temperature is a factor that influences the behavior of plants, requiring the search for a model that allows the simulation of temperature (Yan; Hunt, 1999) so that part of the physiology of production and tools that are important to decision support systems, aiding in better understanding the operations of a real system as well as the interactions of the components (LARSEN; PERSSON, 1999; GOLDEN-NETO et al., 1998). Thus, growth and development of plants are associated to more than the thermal time clock time (SEVERINO; AULD, 2014).

For Souza (1990), or the thermal time is one of the DRM methods used to correlate the temperature with the development and / or growth of plants. It is also used to enable a better planning of times when cultivation will be made, the application of fertilizers and programming harvest in both the agricultural aspect as administrative and financial (Ometto, 1981) and is based on the assumptions that growth ceases below the base temperature (BT) (YANG, LOGAN; COFFEY, 1995).

Degree days (GD) necessary for the development of each phenological stage of culture can be calculated by Equation 1 proposed by Arnold (1959):

$$GDD = \sum_{i=1}^{n} \left[\frac{T\max - T\min}{2} \right] - Tbase$$

On what:
GDD - degree-day development;
Tmax - maximum daily temperature (°C);
Tmin - minimum daily temperatures (°C); and
TBase - base lower temperature (°C).

Pests and diseases

Kitties

The most common species are *Diabrotica speciosa* and *Cerotoma arcuata* (Coleoptera: *Chrysomelidade*) (Figure 1). The adults of *Diabrotica speciosa* have green and yellow color and the black and yellow *C. arcuata*. Thus, the occurrence of the attack the larvae of these insects to the roots is sporadic.

The shape control is carried out by treatment of seeds and / or pesticide applications. Therefore, as a sporadic pest in the roots, it is not recommended preventive treatment (SILVA; CARNEIRO; QUINDARÉ, 2005).

Figure 1. Adult Kitty: *Diabrotica speciosa*.
Source: SILVA; CARNEIRO; QUINDARÉ (2005).

Green leafhopper (Empoasca kraemeri)

The leafhopper is a sucker, which is housed on the underside of leaves. The plants attacked by leafhoppers are shown stunted, yellowish sheets with bent edges and ridges down or up, cup-shaped or scoop due to the sap sucking and injection toxin (Figure 2).

The symptoms can be confused with viruses, but in the case of viruses, although the leaves are presented deformed do not get spoon-shaped. At high populations cause yellowing and shriveling the edges of the leaves, affecting the normal development of plants, which are reduced in size.

As a control measure is best to avoid planting too sensitive cultivars such as "jalo," for example. In most cases, the only alternative is the use of chemicals, including systemic insecticides applied at sowing act have been the most efficient (MARINHO, 2001).

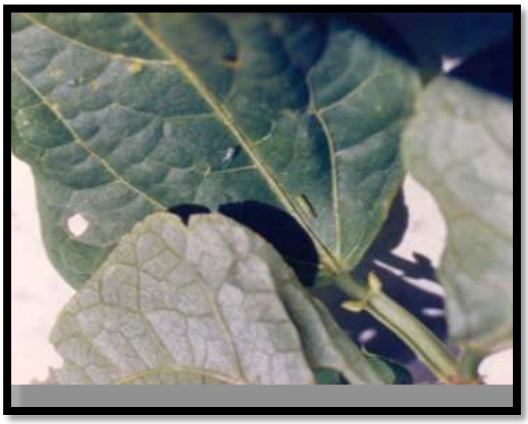

Figure 2. leafhopper and symptoms of their attack on the bean crop.
Source: MARINHO (2001).

Bacterial blight (CBC)

This disease is caused by the bacterium *Xanthomonas axonopodis* pv. *phaseoli* (Smith) and has been frequently observed in common bean crops, which is favored by the high temperatures and humidity. This attacks the entire shoot, but symptoms are observed mainly in the leaves and are characterized by the occurrence of dry and brittle remarkable lesions surrounded by a yellow halo (Figure 3).

Its control includes performing cultural practices, use of chemicals and genetic resistance. Among the cultural practices, the acquisition of healthy seeds is the most important. Crop rotation also helps to reduce the inoculum of the disease in the area. Regarding the genetic resistance to cultivate "Black Diamond" is considered resistant (FERNANDES; SOUZA; RAMALHO, 2005).

Figure 3. Plants showing symptoms of common bacterial blight. Material collected in an experiment in the city of Porto Velho, RO.
Source: FERNANDES; SOUZA; RAMALHO (2005).

Fusarium wilt

The causal agent of wilt fungus Fusarium is *Fusarium oxysporum* Schl. f. sp. *tracheiphilum* (EF Smith), Synd. & Hans (Figure 4). Among the symptoms are: chlorosis, decreased growth and development of plants, the premature fall of leaves and subsequent death of the plants. As a means of disease control is used as measures: the choice of mold-free location, the proper definition of planting time to avoid excessive humidity and high temperatures, the establishment of a plane of rotation of crops, the use of certified seed free of the disease and the use of resistant cultivars (SOBRINHO; BELMINO, 2008).

Figure 4. cowpea plants showing early symptoms of fusarium.
Source: VIEIRA JÚNIOR (2010).

Root rot

The causal agent of root rot fungus is Fusarium solani (Martius) Appel & Wr. (Figure 5). The characteristic symptom of the disease begins in the main root having discrete reddish progressing in intensity and expansion, rotting of the internal root tissue, disintegration of the vascular bundles, the sap circulation switching emerging general yellowing, wilting, dried and death plant (SOBRINHO; BELMINO, 2008).

Figure 5. Root rot.
Source: SOBRINHO; BELMINO (2008).

Conclusions

Research has shown a greater adaptation of the cycle of some crops to GDD than the number of calendar days, and can estimate more easily cycle time, as well as establish the planting season due to the most appropriate time to harvest. The cultivar BR-17 Gurguéia has at least nine vegetative and reproductive stages having the lowest cumulative thermal demand stage V1 and reproductive stages require a greater number of degree-days compared to vegetative.

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