

## Original Research Article

# Physiological Maturity and determination of the harvest time of *Vigna unguiculata* L. Walp.

### ABSTRACT

The maturation process of seeds is genetically controlled and involves an organized sequence of physiological changes from the fertilization until the complete independence from the plant. It is recommended that the harvest occurs in the ideal moment, this way the seeds can express their full potential, with maximum dry matter accumulation, reaching high potential of germination and vigor. The objective of this study was to determine the physiological maturity point of cowpea bean seeds (*Vigna unguiculata* L. Walp.), cv. Corujinha, aiming to indicate the best harvesting period, in order to guarantee greater germination potential and seed vigor. Cowpea pods were harvested from the third until the twenty-first day after anthesis, with intervals of three days between the harvests. After each harvest, the following evaluations were carried out: fruit and seed color, number of seeds per pod, pod and seed biometry, pod and seed moisture, water content, germination, germination speed index, length and dry matter of the shoots and roots. The physiological maturity of cowpea seeds occurs rapidly, and the harvest is recommended at 15 days after anthesis, when the seeds show high germination and vigor.

**Comment [P1]:** Give a bit of information on the results of these measured parameters.

**Keywords:** Cowpean bean, physiological quality, germination, vigor.

### 1. INTRODUCTION

The cowpea (*Vigna unguiculata* L. Walp.) is cultivated throughout the North and Northeast of Brazil, where it is considered the main component of the agricultural production of these regions, constituting an important source of income and subsistence for small farmers who practice agriculture. In addition, this crop is used as a staple food for the population, which consumes it in the form of green and dry grains, being very appreciated due to the fast cooking and nutritional aspects, such as the quantity of proteins [1].

The difficulty of obtaining seeds of good physiological quality is among the limiting factors in the production of cowpea, since the seeds are one of the main inputs of the agricultural production, where the quality is an important factor to obtain stands of uniform and vigorous plants, directly reflecting the yield [2].

To express its full potential, it is essential that the harvest occurs at the ideal moment, with maximum dry matter accumulation, reaching high germination and vigor potential [3]. Therefore, the study of the physiological maturation process of seeds is very important to determine the ideal harvest time and, consequently, obtain seeds of high physiological quality [4].

The seed maturation process is genetically controlled and involves an organized sequence of physical, biochemical, physiological and morphological changes, from the fertilization until its independence from the plant, these changes also include a set of preparatory steps for

32 the process of germination, which are characterized by the synthesis and accumulation of  
33 nutrient reserves [5].

34 Several studies on the influence of physiological maturity on the seed quality and  
35 productivity of several crops have been carried out, such as the studies with pepper seeds  
36 (*Capsicum annuum* L.) [6] common bean (*Phaseolus vulgaris* L.) [7], ginger (*Sesamum*  
37 *indicum* L.) [8] and pumpkin (*Curcubita moschata* Duch) [9]. However, currently, for cowpea,  
38 there is little information on the maturation and the ideal harvest period of the seeds,  
39 justifying the need to perform this evaluation [2].

40 The objective of this study was to determine the physiological maturity point of cowpea  
41 seeds (*Vigna unguiculata* L. Walp.), cv. Corujinha, aiming to indicate the best harvesting  
42 time, in order to guarantee greater germination potential and seed vigor.

## 43 2. MATERIAL AND METHODS

44 The field experiment was performed with cowpea bean seeds, cv. Corujinha, between  
45 September 2015 and January 2016 at the Chã de Jardim Experimental Farm of the Centro  
46 de Ciências Agrárias of the Universidade Federal da Paraíba (CCA-UFPB), in Areia-  
47 Paraíba, located in the micro-region of the Paraíba, under the geographic coordinates  
48 6°58'12 "S and 35°42'15" W.

49 According to Graussem's bioclimatic classification, the predominant bioclimate in the area is  
50 the sub-dry Northeastern 3dfh with annual rainfall of approximately 1,400 mm. According to  
51 Köppen's classification, the climate is characterized as warm and humid, with autumn-winter  
52 rains. The average annual temperature ranges from 22 to 26 °C and relative humidity  
53 between 75 and 87% [10]. During the conduction of the experiment the minimum  
54 temperature was 20.3 °C and the maximum was 28.5 °C, with average relative humidity of  
55 76.4%. According to Embrapa [11], the soil of the experimental area is classified as a typical  
56 Psamitic Regolithic Neosols, of medium texture.

57 The pod and seed biometry, and also their physiological quality, were evaluated in the  
58 Laboratório de Análise de Sementes, also located in the previously mentioned Center.

59 Soil preparation was performed by cleaning the area with garden hoes and opening of pits at  
60 a depth of 4 cm, spaced 0.30 m between plants and 1.0 m between rows. The sowing  
61 consisted of three seeds/pit, followed by thinning, leaving one plant/pit, the plants were  
62 monitored periodically to follow the flowering, while the cultural treatments were  
63 recommended for the crop.

64 Fifty-four days after sowing, when approximately 70% of the plants started the anthesis they  
65 were identified using wool yarns. The plants were monitored until fruiting and, every 3 days  
66 were harvested, with a total of seven harvests, manually performed, avoiding mechanical  
67 injuries in the pods and seeds. After harvesting, the pods were packed in plastic bags,  
68 identified and sent to the laboratory.

69 After each harvesting, four replicates of 15 pods and 25 seeds were submitted to direct  
70 measurements with the aid of a digital caliper, in which measurements of length, width and  
71 thickness were performed, the results were expressed in millimeters, only the length of the  
72 fruit was expressed in centimeters.

73 After each harvesting, by using a sample of 40 pods the number of seeds per pod was  
74 determined by manual counting, and the results were expressed as number of seeds per  
75 pod<sup>1</sup>.

76 The water content of the pods and seeds were obtained by the stove method at 105 °C for  
77 24 hours [12], using four replicates of 25 seeds and four replicates of 5 pods at each  
78 harvesting period, the results were expressed in percentage.

79 The dry matter of the pods and seeds were determined together with the water content, at all  
80 harvesting time, after placing the samples in a stove at 105 ± 3 °C for 24 hours [12], the  
81 results were expressed in grams.

82 The germination test was performed following the requirements of the Rules for Seed  
83 Analysis - RSA [12], using 200 seeds per treatment, distributed in four replicates of 50  
84 seeds, placed in a paper towel substrate (germtest<sup>®</sup>) moistened with sterilized distilled water  
85 in a quantity equivalent to 2.5 times the dry paper weight, distributed on two sheets of paper,  
86 covered by a third and organized in the form of rolls, which were packed in transparent  
87 plastic bags to avoid the loss of water by evaporation. The rolls were placed in germination  
88 chamber of the Biological Oxygen Demand type (B.O.D.) regulated at a constant  
89 temperature of 25 °C. The counting was performed five to eight days after the test,  
90 considering the normal seedlings, characterized by having a long, thin primary root coated  
91 with absorbent hairs along the entire surface, well defined lateral roots and well developed  
92 shoot, presenting the potential to continue its development and give rise to normal plants,  
93 the results were expressed in percentage.

94 The first germination counting was carried out concurrently with the germination test,  
95 counting the germinated seeds on the 5th day after sowing [12].

96 For the germination speed index, daily countings were performed at the same time, five to  
97 eight days after the test, and the index was determined according to the equation proposed  
98 by Maguire [13].

99 At the end of the germination test, the normal seedlings of each replicate were measured  
100 with a ruler graduated in centimeters, the length of the seedlings were measured, and the  
101 results were expressed in centimeters per seedlings. The seedlings previously measured  
102 were packed in Kraft paper bags type, taken to a stove regulated at 80 °C for 24 hours and,  
103 after that period, weighed in an analytical scale with an accuracy of 0.001 g, the results were  
104 expressed in g.plantula<sup>-1</sup>.

105 The experimental design used in the field was a randomized block, and completely  
106 randomized at the laboratory, the results were submitted to analysis of variance and  
107 polynomial regression to evaluate the characteristics described previously, the linear and  
108 quadratic model were tested, where the significant model of higher order was selected to  
109 express the results.

110

### 111 3. RESULTS AND DISCUSSION

112 Changes in the coloration of the pods and seeds were observed during the maturation  
113 process (Table 1), varying from dark green to brown with small dark brown dots. According  
114 to Lopez et al. [4], the color of the pods and seeds has been used as a good indicator of the

115 harvest point, however, environmental factors must be observed since the differences in  
 116 coloring can also be caused by its influence.

117 **Table 1. Color of the pods and seeds of cowpea (*Vigna unguiculata* L. Walp.), cv.**  
 118 **Corujinha, at different times of harvest.**  
 119

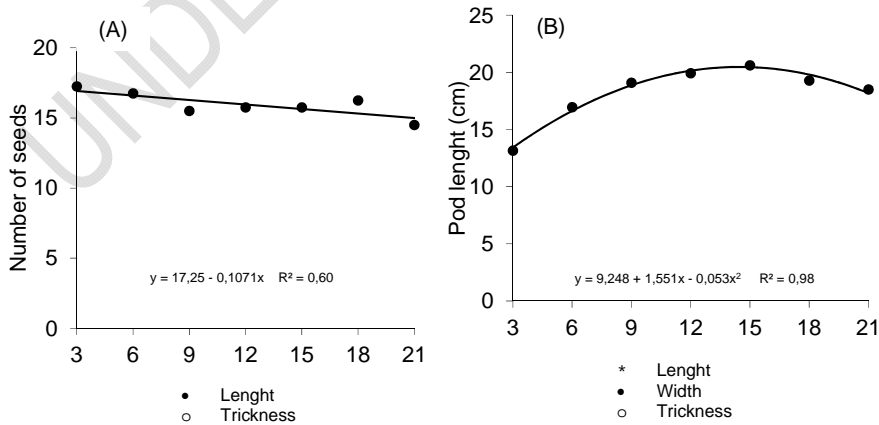
Harvest time	Days after anthesis	Color	
		Pods	Seeds
1 <sup>st</sup>	3	Dark green	Dark green
2 <sup>nd</sup>	6	Dark green	Dark green
3 <sup>rd</sup>	9	Light green	Dark green
4 <sup>th</sup>	12	Light green	Light green
5 <sup>th</sup>	15	Light green	Light green
6 <sup>th</sup>	18	Light brown	Light brown
7 <sup>th</sup>	21	Brown (dots)	Brown

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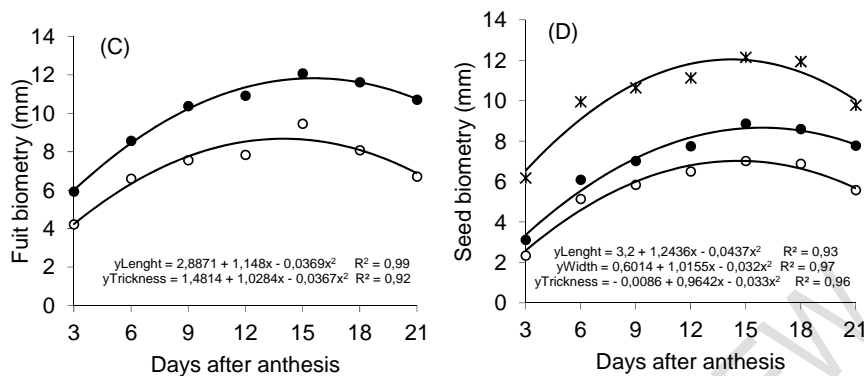
121 For the number of seeds per fruit, a decreasing linear behavior is observed as a function of  
 122 the harvesting time (Figure 1A) and, in relation to the size of the pods and the seeds, the  
 123 data were adjusted to the quadratic model, with maximum length of (20.6 cm), width (8.8  
 124 mm) and thickness (11.8 mm) of the pods obtained at 15 days after anthesis (Figures 1A  
 125 and B). For the seeds, the maximum length (12 mm), width (8.6 mm) and thickness (7.0 mm)  
 126 were also verified at 15 days after anthesis (Figure 1D).

127 Similar results were found by Botelho et al. [7] when studying the ideal harvest time for  
 128 beans (*Phaseolus vulgaris* L.) where was verified a direct relation between seed size and  
 129 physiological quality, in which seeds of lower size negatively influenced the seed quality of  
 130 the lot.

131 Padua et al. [14] also verified that larger seeds originated higher soybean plants than plants  
 132 originated from smaller seeds. According to Carvalho and Nakagawa [15], larger seeds were  
 133 better nourished during their development, have well-formed embryos and a greater amount  
 134 of reserves, with greater potential for germination and more vigorous plants when compared  
 135 to smaller seeds.



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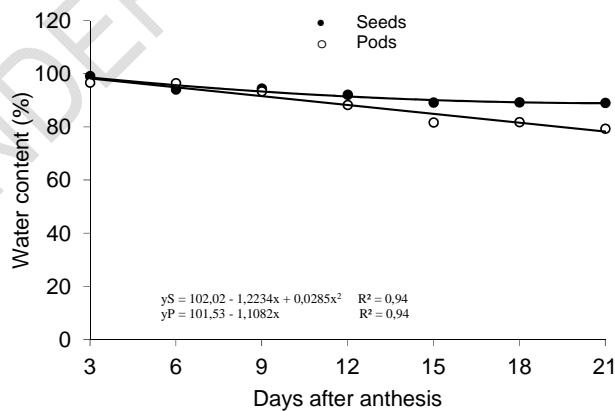


137

138 **Figure 1. Number of seeds (A), pod length (B), Fruit biometry (C) and biometry of the**  
 139 **seeds (D) of Cowpea bean (*Vigna unguiculata* L. Walp.), cv Corujinha, at different**  
 140 **times of harvest.**

141 The water content of the pods presented a linear behavior and the seed water content  
 142 presented a quadratic behavior according to the harvest times, in which, in the first  
 143 harvesting, at three days after the anthesis, the water content was high in the pods (96.7%)  
 144 and seeds (99.0%). Then, there was a gradual decrease until the last harvesting, 21 days  
 145 after anthesis (18% for pods and 10% for seeds) (Figure 2). Botelho et al. [7] found similar  
 146 results, and verified a decrease in water content of common bean seeds during the  
 147 physiological maturation process.

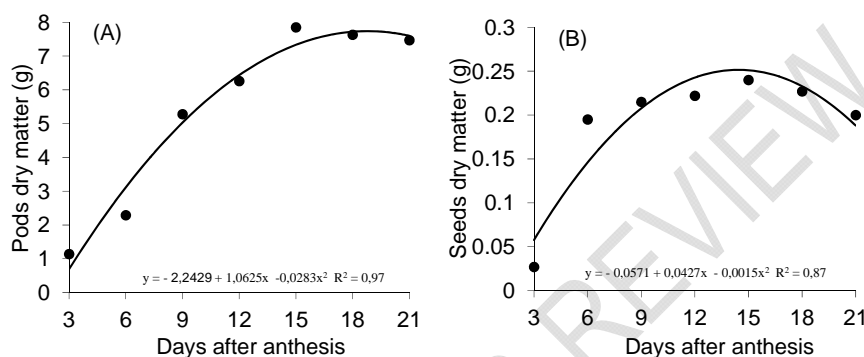
148 However, the water content at the time of harvesting was high and this permanence for a  
 149 long period can negatively affect the storage and commercialization of the seeds, which can  
 150 result in the reduction of the physiological quality, cause deformations and favor conditions  
 151 for the development of fungi, which are factors responsible that accelerate the deterioration  
 152 process [3].



153

154 **Figure 2. Water content of the pods and seeds of Cowpea bean (*Vigna unguiculata* L.**  
155 **Walp.), cv Corujinha, at different times of harvest.**

156 For the pods and seeds dry matter, data were adjusted to quadratic models, with maximum  
157 values of 7.85 and 0.240 g, respectively, reached at 15 days after anthesis (Figure 3A and  
158 3B). In the same harvesting time (15 days after anthesis) the maximum dry matter was  
159 observed in the pods and seeds, the water content of the seeds was high, above 80%, and  
160 the germination percentage reached the maximum values.

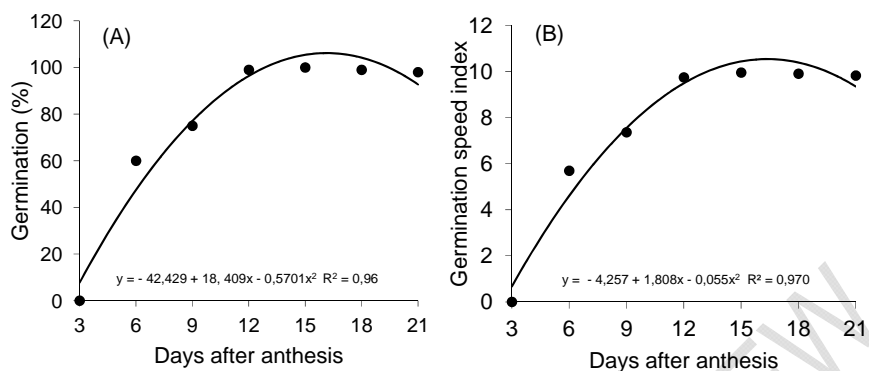


161

162 **Figure 3. Dry matter of the pods (A) and seeds (B) of Cowpea bean (*Vigna unguiculata***  
163 **L. Walp.), cv Corujinha, at different times of harvest.**

164 A similar behavior was described by Eskandari [16] in seeds of *Vigna sinensis*, Botelho et al.  
165 [7] and Bolina et al. [17] in common bean seeds and Nogueira et al. [2] in cowpea seeds.

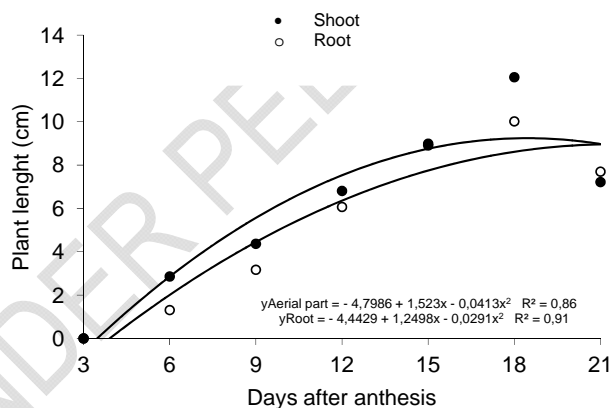
166 The germination percentage and germination speed index were adjusted to the quadratic  
167 model, with the highest values observed at 15 days after anthesis (100% and 9.9,  
168 respectively), remaining high until the last day of evaluation (21 days after anthesis) (Figure  
169 4A and B). Nogueira et al. [2] evaluating the development and physiological quality of  
170 cowpea seeds, cv. BRS Guariba, during the maturation process, observed that at 14 days  
171 after anthesis, the seeds reached their highest percentage of germination and germination  
172 speed index, remaining stable until the last harvest, corroborating with the results obtained in  
173 this work.



174

175 **Figure 4. Germination (A) and germination speed index (B) of seeds of Cowpea bean**  
 176 **(*Vigna unguiculata* L. Walp.), cv Corujinha, at different times of harvest.**

177 The shoot and root length data (Figure 5) were also adjusted to the quadratic model, where  
 178 a gradual increase was observed during the maturation process, with an estimated  
 179 maximum value for shoot (12.06 cm) and root (10.02 cm) at 18 days after the anthesis and,  
 180 with a subsequent small decrease.

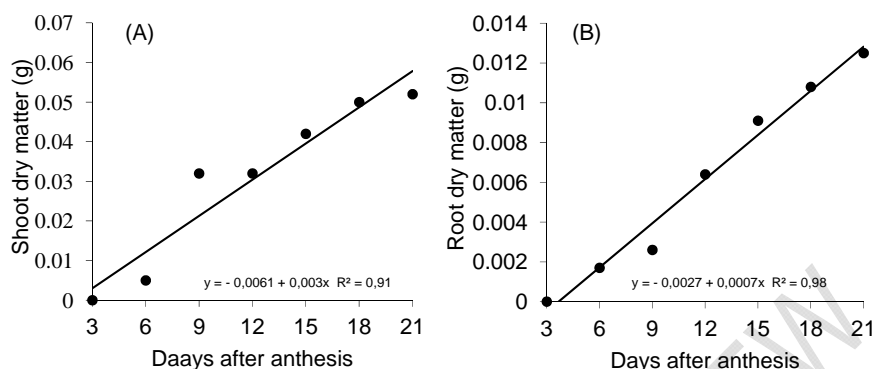


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182 **Figure 5. Shoot and root length of seedlings of Cowpea (*Vigna unguiculata* L. Walp.),**  
 183 **cv Corujinha, at different times of harvest.**

184 For the shoot (Figure 6A) and root (Figure 6B) dry matter, a linear and increasing behavior is  
 185 observed as a function of the harvest time, reaching its maximum value (0.052 g for shoot  
 186 and 0.0125 g for root), at the last harvest, at 21 days after anthesis, which is due to the  
 187 metabolic and catabolic events of accumulation in the reserves tissue throughout the  
 188 development of the seed.

189



190

191 **Figure 6. Shoot (A) and root (B) dry matter of seedlings of Cowpea bean (*Vigna***  
 192 ***unguiculata* L. Walp.), cv Corujinha, at different times of harvest.**

193 A direct relation between the seed size (Figure 1D) and physiological quality results could be  
 194 verified, where the seeds of higher size were also those with higher percentage of  
 195 germination (Figure 4A and 4B) and vigor (Figure 5 6A and 6B). According to Carvalho and  
 196 Nakagawa [15], the size of the seeds may influence the germination and vigor, since larger  
 197 seeds were well nourished during their development, usually have well-formed embryos,  
 198 have larger amounts of reserves and are potentially more vigorous.

199 Similar results were also observed by Padua et al. [14], where they evaluated the influence  
 200 of soybean seed size on the initial growth of plants and their effect on yield, they observed  
 201 that larger seeds presented higher percentages of germination, vigor and produce plants  
 202 with higher height at the harvesting time, with higher yield, when compared to smaller seeds.

203 Therefore, it is important to harvest the seeds when they reach their maximum size,  
 204 considering that it will result in higher seed quality, uniformity, more vigorous and productive  
 205 plant stands.

#### 206 4. CONCLUSION

207 The seeds of Cowpea bean, cv. Corujinha, reach the physiological maturity at 15 after  
 208 anthesis which coincides with a higher germination and vigor, being recommended as the  
 209 best period for harvest of this cultivar.

#### 210 COMPETING INTERESTS

211 Authors have declared that no competing interests exist.

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