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YIELD AND QUALITY OF COMMON BEANS IN DIFFERENT STRATEGIES OF PODS MATURATION

Francisco Braz Daleprane[1]; Fábio Cunha Coelho[2]; Antônio Fernando de Souza[1]; Marcus Vinicius Sandoval Paixão*[1]; Ismail Ramalho Haddade[1] and Marilene Holz Daleprane[1]

[1]Instituto Federal de Educação, Ciência e Tecnologia do Espírito Santo, Campus Santa Teresa, Santa Teresa, Espírito Santo, Brazil
[2]Universidade Estadual do Norte Fluminense Darcy Ribeiro, Campos dos Goytacazes, Rio de Janeiro, Brazil

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Corresponding author:
Marcus Vinicius Sandoval Paixão

ABSTRACT

Grain productivity and quality of Common beans can be compromised in the event of rainfall during the harvest phase. The objective was to evaluate the productive yield and the quality of grains in common bean genotypes by stratification in different pod maturation patterns. The work was carried out between harvest of the waters in two environments of altitude, being 174 and 733 meters. The experimental design was in randomized blocks with 15 treatments and four replications. Flowering, physiological maturity, cycle, productivity and pod maturation pattern were evaluated in each genotype. The data were subjected to joint analysis of variance and comparison of means using the Scott-Knott test at 5% probability. For the two cultivation environments, the genotypes Palhaço Vermelho, Terrão NM, Roxinho AV and Cimentão DP showed higher maturity regularity. The genotypes Palhaço Vermelho, Nova Planta and Capixaba Prematura expressed the highest average productivity simultaneously in the lowest and highest altitude environment, together with the genotype Vermelho JV showed the highest percentages in sieve yields in both environments. Falso Terrinha was the genotype that showed the lowest sieve yields in both cultivation environments.

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INTRODUCTION

Common beans (*Phaseolus vulgaris L.*) is a very widespread crop throughout the Brazilian territory. Its cultivation is distributed in three crops throughout the year, the water harvest; the dry season and the autumn-winter season. Culture stands out for playing an important role in the population's diet and also in generating income for small producers who use the family workforce. The national average productivity of the crop is just above 1,000 kg.ha^{-1} (Companhia Nacional de Abastecimento, 2018). It is a culture very susceptible to climatic adversities. In the vegetative, flowering, pod production and grain filling periods, the crop needs water more regularly. However, in the maturation and harvest phases, the incidence of rain or an increase in the humidity level of the growing environment becomes a problem. The incidence of rain during the bean harvest can cause losses, increasing the number of sprouts and the appearance of spots on the grains during drying (Pereira *et al*., 2012), therefore, the harvest is a critical phase, and, if, the crop is ready for harvest, a few rainy days are enough to generate losses that can reach the total production if the beans are not harvested in a timely manner. Losses due to excess moisture during the harvest have become increasingly recurrent among producers, depreciating the product and making it infeasible for commercialization and consumption. A common practice observed among many family farmers when harvesting beans in producing regions, especially in family-based properties, is to delay the harvest or wait until most of the crop plants lose their leaves and dry completely. During this waiting period, the occurrence of rains has often caused considerable losses in the production of grains, which end up germinating or becoming "rainy" (with excess moisture). Silva *et al*. (2016), highlighted that the harvest at the ideal time of maturation is of paramount importance to achieve maximum seed quality due to the risks of deterioration in the field. On the other hand, the anticipation of the harvest in order to avoid the incidence of rain on the pods, which are already at the stage of harvest maturity, has not always been a possible decision, or a more correct one, due to the irregularities of maturation between some cultivars, and the presence of a significant volume of pods on plants still in the process of maturation. Ramalho *et al*. (2014) highlighted the importance of genetic improvement work with the objective of obtaining cultivars with greater uniformity of pod maturation and adequate yields and yields, therefore, studies are needed that generate more accurate and safer information for farmers on aspects of bean maturation. Among the studies, it is essential to insert questions that address the differences between cultivars and between cultivation environments, with regard to the maturation dynamics. Concomitantly, it is important to relate to this dynamic the volume of pods in different strata (patterns) of maturation at the time of harvest, the ability to maintain the commercial quality of the grains and the contribution to productivity between the various strata of maturation. This information can serve as an aid, guiding producers, in choosing the most appropriate cultivar in terms of maturity regularity for the growing season and region, planning and defining the best harvest point for the crop, ensuring higher yields and ensuring better quality of grain. The objective of this work was to evaluate the productive yield and the quality of grains in common bean genotypes through stratification in different pod maturation patterns.

MATERIAL AND METHODS

Two experiments were carried out in the harvest of waters in two altitude environments in the municipality of Santa Teresa-ES. The first environment is located at coordinates, latitude 19º48’21”S, longitude 40º40’44”W andheight of 174 meters, being classified as a tropical climate, with hot and dry winter and hot and rainy summer, (Koppen Classification) (Alvares*et al*., 2013).The second environment is located at the coordinates, latitude 19º56’12”S, longitude 40º35’28” and height of 733 meters, being classified according to Köppen (Alvares*et al*., 2013), tropical climate with dry winter with rainy season in summer, and clear dry season in winter. In each cultivation environment, 15 local genotypes of common beans were evaluated, from agricultural properties in the state of Espírito Santo, and which make up the Ifes community seed bank - Campus Santa Teresa / ES. A randomized block design with four replications was used, totaling 60 experimental units. Each experimental unit consisted of four sowing lines, each line four meters long, with a spacing of 0.60 m. In each row, 60 seeds were sown, 15 per linear meter. The useful area of each experimental unit was 3.6 m^2, the two central lines being considered, discounting 0.50 m on each front side of the two lines, for the purpose of border.

The seeds were purchased from the Ifes Santa Teresa community seed bank, all genotypes coming from family farmers in some locations in the state of Espírito Santo. The use of soil correction and sowing and cover fertilization followed the recommendation of Prezotti*et al.* (2007) based on results of soil analysis that revealed for the environment 1, levels of P: 105 $mg.dm^{-3}$; K: 240 $mg.dm^{-3}$; Ca: 4.8$cmol_c.dm^{-3}$; Mg: 0.6$cmol_c.dm^{-3}$; pH. H_2O: 6.8 e V%: 71.6; and for environment 2, levels of P: 16 $mg.dm^{-3}$; K: 67$mg.dm^{-3}$; Ca: 3.0$cmol_c.dm^{-3}$; Mg: 0.6$cmol_c.dm^{-3}$; pH. H_2O: 5.7 e V%: 56.8. In the preparation of the soil were applied 0.5 $t.ha^{-1}$of Limestone on the soil of the environment with higher height, while on the soil of the environment with lower height there was no need for application. The sowing fertilization was carried out using the formula NPK 4-30-10 in the amount of 320 $kg.ha^{-1}$on the environment with lower height and of 245 $kg.ha^{-1}$ on the environment of higher height. A cover fertilization was performed at 25 days after sowing using 40 $kg.ha^{-1}$ of nitrogen for each cultivation environment.

In regard of the rainy season, with concern about losses of grain quality, in a preventive way, the decision was made to anticipate the harvest, carrying it out in a staggered way between the genotypes. When deciding which genotype to be harvested on each occasion, the priority was always given to the one with the highest volume of pods in the state of harvest maturity and physiological maturation. There was a differentiation between genotypes regarding the periods in days of anticipation of the harvest in relation to the final cycle (harvest maturation), being, in the environment of lower height:Palhaço Vermelho: 9 days; Mamoninha: 12 days; FalsoTerrinha: 12 days; Nova Planta: 7 days; Vermelho NM: 12 days; Vermelho M: 12 days; Terrão NM: 8 days; Cimentinho: 3 days; Roxinho AV: 5 days; Cimentão DP: 9 days; Vermelho JV: 10 days; Esmeralda: 7 days; Vermelho LP: 7 days; TerrinhaVd: 3 days; CapixabaPrecoce: 11 days. In the highest height environment: Palhacinho Vermelho: 5 days; Mamoninha: 4 days; FalsoTerrinha: 5 days; Nova Planta: 5 days; Vermelho NM: 5 days; Vermelho M: 4 days; Terrão NM: 4 days; Cimentinho: 3 days; Roxinho AV: 6 days; Cimentão DP: 4 days; Vermelho JV: 5 days; Esmeralda: 5 days; Vermelho LP: 11 days; TerrinhaVd: 5 days; Capixaba Precoce: 9 days. 72 plants per genotype were harvested for evaluation in the useful area in each experimental unit. The pods of all harvested plants were detached manually and individually, quantifying the number of viable and non-viable pods (aborted or empty) per plant. Then, viable or full pods were selected (stratified) in four maturation patterns (PM) from the R8 stage of the bean phenological scale, the first pattern (PM1) being: pods in harvest maturation (final stage of R9), the second pattern (PM2): pods in full physiological maturation (beginning of stage R9); the third standard (PM3); pods at the beginning of physiological maturation (end of stage R8) and the fourth standard (PM4): green pods in the stage of grain filling (from beginning to end of stage R8).

Each pod maturation layer was placed to dry in the shade, and on newspaper, each layer was individually threshed after drying, separating sprouted, burnt and stained grains, according to normative instruction Nº 12, of March 28, 2008. selection of commercial common bean grains. Subsequently, the grains from each maturation layer were subjected to classification, passing through a set of sieves with oblong holes number 15 (15/64” pol.), 14 (14/64” pol.), 13 (13/64” pol.), 12 (12/64” pol.), 11 (11/64” pol.), 10 (10/64” pol.) and 3x19”. Grains smaller than the 3x19” sieve were classified as immature, based on normative instruction Nº 12, being considered discarded. For each pod maturation layer, the amount of grains retained in each sieve was weighed on a precision scale with three decimal places, for the evaluation of productivity by maturation layer and genotype. For the purpose of reference of commercial grain size, it was based on the work of Chicati*et al*. (2018), suggesting the possibility of using up to four sieves for common beans (P12, P13, P14 and P15), which are determined by the beneficiary, depending on the typical grain size. The sieve yield (RP%) was measured for each maturation layer, according to the equation suggested by Carbonell*et al*. (2010), describedbelow.

$$RP\% = \frac{P12 + P13 + P14 + P15}{P10 + P11 + P12 + P14 + P15 + Descarte} x\, 100$$

Where RP%: sieve yield; P10: weight (g) retained in a number 10 oblong hole sieve; P11: weight (g) retained in a number 11 oblong hole sieve; P12: weight (g) retained in a number 12 oblong hole sieve; P13: weight (g) retained in a number 13 oblong hole sieve; P14: weight (g) retained in a number 14 oblong hole sieve; P15: weight (g) retained in a number 15 oblong hole sieve; and PDescarte (immature grains): weight (g) passed through a 3 x 19" oblong hole sieve.The data were subjected to joint analysis of variance and the Scott – Knott cluster test, at a level of 5% probability.

RESULTS AND DISCUSSION

In interpreting the results of the variables evaluated, it was decided to group the genotypes with equal statistical values, interpreting and discussing them by the mean of each group. It is important to highlight that the bean maturation dynamics varies between cultivars. Some cultivars ripen more homogeneously, while in others maturation occurs very unevenly, which makes it even more difficult to make decisions about the best time to harvest. Bolina (2012) also suggests that the bean maturation period varies according to the cultivars. The number of viable and non-viable (aborted) pods per plant is an important regulating component of productivity, together with the number of grains per pod and the weight of 100 seeds. As for the number of viable pods, in this work it was found that the averages varied between 8.8 and 17.4 pods per plant in the lower altitude environment, with emphasis on the number of pods for the genotype Nova Planta. In the highest altitude environment, the average was between 8.5 and 11.6. In this environment, the highest numbers of viable pods per plant were observed in the group of genotypes Mamoninha, FalsoTerrinha, Nova Planta, Vermelho NM, Cimentão, TerrinhaVd and Capixaba premature and Terrinha VD (Table 1). These values can be compared to the work of Ribeiro *et al*. (2014), which found average variations from 9.1 to 13.3 pods per plant. Zilio *et al*. (2011), also found great variation in relation to the number of pods per plant among Creole bean genotypes and cultivation environments (Table 1).

greater variation in the number of unviable pods among the evaluated genotypes, which made it possible to distinguish four groups of genotypes with different averages between 4.9 and 28.0 pods per plant. In this cultivation environment, the Esmeralda genotype stood out with the highest number of unviable pods among the others (Table 1), and a productivity of 1552.1 kg.ha^{-1}, which can be considered low in relation to most genotypes in this cultivation environment. In this environment, the Mamoninha and Capixaba early genotypes presented, on average, the lowest number of non-viable pods per plant (Table 1). The high index of unviable pods presented by the Esmeralda genotype in the two altitude environments may be related to a lower tolerance to possible environmental stresses in the period between flowering and pod filling. Regarding grain productivity, in the lower altitude environment, variation between genotypes was observed.

In this environment, three groups of genotypes with different levels of average productivity were statistically identified. In the first group, with productivity of 2812.3 kg.ha^{-1}, the genotypes Palhaço Vermelho, Nova Planta, Roxinho AV, Vermelho LP andCapixabaPrecoce stood out. In the second group, the genotypes Mamoninha, FalsoTerrinha, Vermelho NM, Vermelho M, Terrinha VD, Cimentinho, Cimentão, Vermelho JV andTerrão NMshowed average productivity of 2093.6kg.ha^{-1}. In the higher height environment, less variation in the grain yield indexes was observed, with only two distinct groups among the genotypes. With an average yield of 2266.1 kg.ha^{-1}, it was possible to group the genotypes Palhaço Vermelho, Mamoninha, Nova Planta, Vermelho NM, Terrão NM, Cimentão DP, Terrinha VD and CapixabaPrecoce. In another group, the FalsoTerrinha, Vermelho M, Cimentinho, Roxinho AV, Vermelho JV, Esmeralda and Vermelho LP genotypes showed lower productivity, averaging 1659.4 kg.ha^{-1} (Table 1).

Table 1. Number of viable pods and non-viable pods per plant and productivity (kg.ha^{-1}) by genotype

Genotype	Viablepods		Inviablepods		Productivity	
	Env. 1	Env. 2	Env. 1	Env. 2	Env. 1	Env. 2
Palh. Verm.	14.5 b	8.8 b	9.2 b	13.8 b	3025.1 a	2316.4 a
Mamoninha	12.9 b	11.6 a	2.8 c	6.8 d	1872.0 b	2151.7 a
FalsoTerrinha	14.0 b	11.7 a	8.3 c	20.4 b	2137.9 b	1512.1 b
Nova Planta	17.4 a	13.0 a	7.8 c	10.1 c	2647.3 a	2263.1 a
Vermelho NM	11.5 c	10.7 a	5.5 c	12.6 c	2148.8 b	2155.7 a
Vermelho M	8.8 d	6.4 b	3.6 c	9.9 c	2096.2 b	1722.2 b
Terrão NM	10.8 c	8.4 b	12.8 b	15.3 b	2203.5 b	2170.2 a
Cimentinho	11.7 c	9.5 b	3.8 c	16.6 b	1755.7 b	1454.8 b
Roxinho AV	14.3 b	7.7 b	3.9 c	16.3 b	2929.4 a	1771.7 b
Cimentão DP	9.9 d	8.7 a	6.5 c	9.0 c	2285.3 b	2358.9 a
Vermelho JV	11.5 c	7.8 b	10.4 b	18.5 b	2256.0 b	1745.5 b
Esmeralda	7.7 d	9.3 b	17.4 a	28.0 a	1077.8 c	1552.1 b
Vermelho LP	14.2 b	9.9 b	4.7 c	16.1 b	2802.5 a	1857.8 b
TerrinhaVd	15.3 b	13.9 a	4.7 c	15.4 b	2087.1 b	2041.5 a
Cap. Precoce	14.5 b	11.4 a	1.8 c	3.1 d	2657.4 a	2672.0 a
Average	12.6	9.9	6.9	14.1	2265.5	1983.0
C.V. (%)	17.6	9.1	51.1	21.9	20.3	8.2

Average valuesfollowed by different letters differ from each other ($P < 0.05$) by the Scott –Knott test.

As for the number of unviable or empty pods per plant, the research revealed a wide variation between the two cultivation environments, oscillating on average from 4.8 to 17.4 pods between three groups of genotypes in the lower altitude environment, with emphasis on the Esmeralda genotype which presented in isolation the largest number of unviable pods in this cultivation environment. This justifies, in part, the low productivity presented by this genotype in relation to the others in this cultivation environment with 1077.8 kg.ha^{-1} (Table 1). In the higher altitude environment, there was a

In general, the productivity levels found for most of the studied genotypes exceed the results of Ribeiro *et al*. (2014), who found levels varying from 1333.0 to 1960.0 kg.ha^{-1} among genotypes. Another factor capable of influencing the bean grain yield, both in quantitative and qualitative aspects, is the degree or pattern of pod maturation (PM). This is a detail that deserves attention in the definition of the best time to carry out the crop harvest, aiming at decreasing the amount of immature grains in the total grain mass, which must be discarded in the process of processing production for trade and

Table 2. Percentage values of pods per genotype in each stratum pattern

Genotype	Pattern of maturation of pods							
	PM1		PM2		PM3		PM4	
	Env. 1	Env. 2	Env. 1	Env. 2	Env. 1	Env. 2	Env. 1	Env. 2
Palh. Verm.	66.9 a	65.7 a	19.1 a	13.0 c	3.5 a	6.6 b	1.2 b	0.9 c
Mamoninha	70.3 a	57.0 b	14.9 a	7.5 c	7.7 a	14.7 a	4.2 b	13.9 a
FalsoTerrinha	66.3 a	52.5 b	19.7 a	8.5 c	3.4 a	9.6 a	2.3 b	8.9 b
Nova Planta	69.4 a	60.0 b	6.8 b	10.0 c	8.4 a	12.3 a	7.7 b	7.6 b
Vermelho NM	80.7 a	44.5 b	4.2 b	14.8 c	3.1 a	11.4 a	6.4 b	16.7 a
Vermelho M	58.2 a	71.1 a	22.8 a	9.9 c	10.8 a	3.7 b	4.5 b	5.3 b
Terrão NM	67.6 a	68.5 a	12.1 b	6.7 c	5.1 a	6.5 b	2.4 b	2.9 c
Cimentinho	64.9 a	59.9 a	9.8 b	6.9 c	7.3 a	5.9 b	14.2 a	10.7 a
Roxinho AV	69.2 a	43.5 b	13.4 a	33.2 a	6.9 a	5.4 b	6.5 b	1.6 c
Cimentão DP	64.7 a	54.4 b	16.6 a	28.3 a	6.2 a	5.5 b	5.9 b	2.6 c
Vermelho JV	71.5 a	54.2 b	9.9 b	9.4 c	4.2 a	12.3 a	4.0 b	5.6 b
Esmeralda	60.2 a	46.1 b	3.8 b	8.1 c	4.1 a	8.3 b	14.4 a	9.4 b
Vermelho LP	74.9 a	46.6 b	10.6 b	11.1 c	6.2 a	8.2 b	3.6 b	17.9 a
TerrinhaVd	63.7 a	43.0 b	14.6 a	20.5 b	6.9 a	6.1 b	10.0 a	14.8 a
Cap. Precoce	68.6 a	74.9 a	13.1 a	13.5 c	6.9 a	3.1 b	9.4 a	5.3 b
Average	67.8	56.1	12.8	13.4	6.1	8.0	6.4	8.3
C.V. (%)	17.7	14.0	56.1	50.2	64.5	57.0	58.1	44.9

Average values followed by different letters differ from each other ($P < 0.05$) by the Scott –Knott test.

consumption. Therefore, it should be emphasized that the productive yield of the crop will be all the greater and the levels of grain losses will be all the lower the greater the homogeneity or regularity of maturation and the number of pods in an ideal state of maturity per plant at harvest. Bolina (2012), emphasizes that seed maturation is one of the main parameters for obtaining lots of high physiological quality, and that the term physiological maturation (MF) is used to define the plant's development stage, beyond which there is no more increase in matter dry on the seed. This signals that the physiological maturation can be the determining point from which the crop harvest can begin, preserving the best productivity standards. Silva *et al*. (2016), indicate the point of physiological maturation as the ideal time to harvest beans, also emphasizing that the delay in harvesting up to 14 days after physiological maturation can promote significant quality losses. Thus, the best genotypes must be those that present a more regular and homogeneous maturation process, with a greater volume of pods in the stages of physiological maturity and harvest maturity.

The stratification of the volume of viable pods harvested in each experimental unit in four decreasing categories of maturation patterns (PM1, PM2, PM3 and PM4), as (Table 2), allowed the comparison of quantitative and qualitative values of productivity between genotypes, identification of those genotypes with greater and lesser maturity regularity and in a concomitant manner also allowed to verify the contribution levels of each pod maturation pattern to the productivity of each genotype. Regarding maturity regularity, the analysis considering the first maturation stratum, PM1 (pods at the end of R9) or harvest maturity stage, did not reveal statistical difference between the genotypes in the lower altitude environment. Still, we can highlight the Vermelho NM genotype with the highest percentage of pods with this pattern of maturation, with 80.7% of the pods in PM1 (Table 2). Concomitantly, it was possible to observe a statistical difference in the maturation pattern between the genotypes for the highest altitude environment, allowing the formation of two distinct groups, with emphasis on the genotypes Palhaço Vermelho, Vermelho M, Terrão NM, Cimentinho and CapixabaPrecoce, which in group presented average of 68.0% of the pods with this maturation pattern (Table 2). In another group, the genotypes Mamoninha, FalsoTerrinha, Nova Planta, Vermelho NM, Roxinho AV, Cimentão DP, Vermelho JV, Esmeralda, Vermelho LP and TerrinhaVd presented approximately 50.2% of the pods in the PM1 stratum (Table 2). Following the stratification scale, maturation pattern two (PM2), referring to the physiological maturation of the pods (end of stage R8), presented with variations in the two cultivation environments. In the lower height environment, it was possible to distinguish two groups of genotypes with higher and lower percentage expression. In the first group, genotypes Palhaço Vermelho, Mamoninha, FalsoTerrinha, Vermelho M, Roxinho AV, Cimentão DP, TerrinhaVd and CapixabaPrecoce were among the first, with an average of 16,7% of pods in a physiological maturation layer (Table 2). The genotypes Nova Planta, Vermelho NM, Terrão NM, Cimentinho, Vermelho JV, Esmeralda and Vermelho LP together they represented an average percentage about two times lower of pods in PM2 in this environment (Table 2). In the higher height environment, there was an increase in variation between genotypes, in terms of stratification values for this pod maturation pattern. In this environment, the Roxinho AV and Cimentão genotypes together expressed the highest average. These combined genotypes represented 30.2% of the amount of pods in PM2, with the average of the two genotypes surpassing TerrinhaVd, which presented 20.5% of the pods in PM2, in addition to exceeding the joint average of other genotypes in about three times. At the percentage of pods in the maturation pattern (PM3), there were no differences between the genotypes in the lower height environment. Considering the importance of greater homogeneity or regularity of maturation, it is worth highlighting the genotype Vermelho M, with the highest percentage value among the others in this environment (Table 2).

In the highest height environment, the lowest percentage of pods stratified as PM3 was for the cluster that includes the genotypes Palhaço Vermelho, Terrão NM, Cimentinho, Roxinho AV, Cimentão DP, Esmeralda, Vermelho LP, TerrinhaVd and CapixabaPrecoce, together presented an average of 5.9%. This percentage is about twice as low as that observed in the next group with the genotypes Mamoninha, FalsoTerrinha, Nova Planta, Vermelho NM and Vermelho JV, that produced average of 12.0% of pods in this pattern of maturation (Table 2). Regarding the maturation pattern (PM4), there were differences in the two cultivation environments.

Table 3. Levels of productivity ($kg.ha^{-1}$) presented by each genotype in each strata of pod maturation pattern and cultivation environment

	Productivity ($kg.ha^{-1}$)							
Genotype	PM1		PM2		PM3		PM4	
	Env.1	Env.2	Env.1	Env.2	Env.1	Env.2	Env.1	Env.2
Palh. Verm.	2361.9 a	1758.9 a	567.4 a	369.5 b	75.6 a	177.3 a	20.2 b	10.6 c
Mamoninha	1505.8 b	1526.5 b	254.6 b	207.1 b	83.5 a	284.7 a	28.0 b	133.4 b
FalsoTerrinha	1627.7 b	1111.1 b	451.6 a	168.9 b	42.8 a	138.5 a	15.7 b	93.5 c
Nova Planta	2053.3 a	1697.7 a	176.3 b	234.4 b	267.3 a	250.5 a	150.3 a	80.3 c
Vermelho NM	1960.0 a	1254.5 b	77.7 b	384.1 b	55.7 a	269.3 a	55.3 b	247.8 a
Vermelho M	1385.8 b	1433.8 b	518.9 a	191.1 b	146.0 a	55.5 a	45.3 b	41.7 c
Terrão NM	1741.8 b	1815.9 a	325.2 a	168.8 b	107.2 a	145.5 a	29.2 b	39.9 c
Cimentinho	1324.2 b	1131.8 b	193.3 b	146.1 b	103.8 a	90.0 a	134.4 a	86.8 c
Roxinho AV	2300.8 a	962.1 b	431.1 a	676.9 a	143.7 a	116.9 a	52.8 b	15.6 c
Cimentão DP	1636.8 b	1495.3 b	440.5 a	726.3 a	133.0 a	106.3 a	74.9 b	30.9 c
Vermelho JV	1940.3 a	1249.2 b	183.1 b	196.2 b	81.2 a	232.1 a	50.4 b	68.0 c
Esmeralda	909.8 b	1113.1 b	49.6 b	174.8 b	33.5 a	162.4 a	84.8 a	101.8 c
Vermelho LP	2337.3 a	1261.2 b	286.8 b	226.5 b	139.6 a	151.6 a	38.7 b	218.4 a
TerrinhaVd	1538.0 b	1227.5 b	263.7 b	526.6 a	190.7 a	117.7 a	94.5 a	169.6 b
Cap. Precoce	2001.6 a	2178.8 a	376.6 a	353.5 b	152.2 a	45.6 a	127.0 a	94.1 c
Average	1775.0	1414.5	306.5	316.7	117.1	156.3	66.8	95.5
C. V. (%)	25.1	1.,5	60.2	55.9	110.6	61.6	97.4	46.1

Average values followed by different letters differ from each other ($P < 0.05$) by the Scott –Knott test.

In the lower height environment, only two distinct groups of genotypes presented statistical differences in this pod maturation pattern. A larger group, represented by the genotypes Palhaço Vermelho, Mamoninha, FalsoTerrinha, Nova Planta, Vermelho NM, Vermelho M, Terrão NM, Roxinho AV, Cimentão DP, Vermelho JV and TerrinhaVd was the one that accounted for the lowest average percentage of pods in strata maturation PM4, with about 4.4% (Table 2). This represents a value three times lower in relation to the group of genotypes Cimentinho, Esmeralda, TerrinhaVd and CapixabaPrecoce, which together reached an average percentage of 12% of pods in PM4. In the higher height environment, the lowest statistical values were related to the genotypes Palhaço Vermelho, Terrão NM, Roxinho AV and Cimentão DP, which together constituted an average percentage of 2.0%. It is observed that this percentage is seven times lower than Mamoninha, Vermelho NM, Cimentinhoand Terrinha VD that grouped expressed an average of 14.8% of pods in PM4, the highest percentage presented in this crop (Table 2).

For the two cultivation environments, the analysis of productivity in each pod maturation pattern, shows the greater contribution of the PM1, PM2 maturation patterns, in relation to the other two patterns, in the final productivity of the genotypes. However, in some genotypes it was possible to observe in both environments, a considerable contribution also from the maturation stratum PM3. The lowest levels of contribution, in most genotypes, in the two cultivation environments were observed in relation to pods in the PM4 maturation layer (Table 3). It is also important to remember that, within the heterogeneity of pod maturation in greater or lesser intensity, normally presented by the common bean, some cultivars may stand out among others for their greater ability to maintain acceptable grain quality standards, even for those pods that are in a PM3 maturation pattern, that is, just below the physiological maturation. The sieve yield shown in Table 4 in each RP (PM) pod maturation pattern is also an important marker of the qualitative and quantitative aspects of productivity influencing the final classification of grains for trade. The research revealed a great variation in the sieve yield for the different genotypes in the two cultivation environments.

Due to the great variation between the genotypes in the sieve yield values observed in relation to the PM1 maturation stratum in the lower altitude environment, it was possible to form five groups of genotypes with similar statistical behavior. The group composed of the genotypes Palhaço Vermelho, Roxinho AV, Cimentão DP and Vermelho JV was the one with the highest yields in the lowest altitude environment, with an average of 93.9%. These genotypes were accompanied by the Esmeralda genotype, which alone presented a yield of 81.6%. The genotypes Vermelho M and Vermelho LP together showed an average yield of 71.4%. The lowest sieve yields were presented by the group that brought together the genotypes Mamoninha, Nova Planta, Terrão NM, Cementinho, FalsoTerrinha, Vermelho NM, TerrinhaVd and Capixaba Precoce, which had a sieve yield below 50% (Table 4). In the highest height environment, six groups were observed with different variations in the sieve yield. In the main group, with an average sieve yield of 97.8%, the genotypes Palhaço Vermelho, Vermelho M, Roxinho AV, Cimento DP, Vermelho JV and Esmeralda stood out. Another prominent group, with an average sieve yield of 80,8%, included the genotypes Terrão NM and Vermelho LP. The genotypes Nova Planta and Cimentinho combined expressed an average yield of 55.2%. The genotypes Mamoninha, FalsoTerrinha, Vermelho NM, TerrinhaVd and CapixabaPrecoce showed the lowest yields, with an average well below 50%. Regarding the maturation stratification PM2, the genotypes Palhaço Vermelho, Roxinho AV, Cimentão DP and Vermelho JV, showed the highest sieve yield in the lower height environment, reaching an average of 93% yield (Table 4).

The genotypes Vermelho M, Esmeralda, Vermelho LP presented together, on average, 68.8% of sieve yield. With an average below 50%, the genotypes Mamoninha, FalsoTerrinha, Nova Planta, Vermelho NM, Terrão NM, Cimentinho, TerrinhaVd and CapixabaPrecoce presented the lowest yields (Table 4). In the highest height environment, the highest average sieve yield was 96.8%, referring to the group comprising the genotypes Palhaço Vermelho, Vermelho M, Roxinho AV, Cimentão DP, Vermelho JV and Esmeralda, being followed only by the genotypes Terrão NM and Vermelho LP which had an average yield of 70.4%. With yield below 50% the other genotypes appeared.

Table 4. Sieve yield (%) of genotypes in each pod maturation layer

Genotype	Sieveyield (RP%)							
	PM1		PM2		PM3		PM4	
	Env.1	Env.2	Env.1	Env.2	Env.1	Env.2	Env.1	Env.2
Palh. Verm.	95.8 a	99.3 a	95.0 a	99.2 a	79.2 a	97.8 a	47.2 a	53.5 b
Mamoninha	36.8 d	38.1 d	39.4 c	31.2 c	16.1 c	14.9 c	8.0 b	4.3 d
FalsoTerrinha	7.3 e	5.8 f	10.3 d	6.7 d	1.0 d	0.6 d	0.0 b	0.0 d
Nova Planta	31.8 d	5.0 c	35.1 c	38.9 c	23.9 c	29.2 c	9.9 b	5.7 d
Vermelho NM	11.2 e	5.8 f	4.0 d	11.1 d	3.0 d	1.6 d	0.9 b	0.3 d
Vermelho M	68.7 c	9.8 a	67.8 b	94.6 a	49.7 b	84.6 a	19.9 b	62.6 b
Terrão NM	25.8 d	8.,1 b	19.5 d	75.5 b	16.8 c	57.6 b	11.7 b	26.5 c
Cimentinho	38.2 d	5.5 c	38.9 c	34.1 c	20.4 c	18.9 c	10.3 b	2.6 d
Roxinho AV	90.4 a	9.1 a	85.1 a	97.9 a	54.6 b	88.7 a	21.6 b	69.9 b
Cimentão DP	93.0 a	9.4 a	90.8 a	97.4 a	71.8 a	89.8 a	34.7 a	53.1 b
Vermelho JV	96.4 a	9.1 a	95.3 a	98.5 a	79.5 a	97.8 a	36.1 a	86.2 a
Esmeralda	81.6 b	9.3 a	65.0 b	93.4 a	27.1 c	90.8 a	15.8 b	59.9 b
Vermelho LP	74.2 c	7.6 b	73.8 b	65.4 b	39.9 b	58.9 b	18.9 b	27.1 c
TerrinhaVd	9.1 e	2.1 e	6.6 d	8.4 d	4.8 d	3.1 d	1.4 b	0.9 d
Cap. Precoce	2.3 e	1.0 e	1.4 d	7.6 d	2.0 d	2.5 d	0.7 b	7.6 d
Average	50.8	63.4	48.5	57.3	32.7	49.1	15.8	30.7
C. V. (%)	17.2	7.6	24.8	17.8	37.3	16.2	79.7	53.1

Average values followed by different letters differ from each other (P <0.05) by the Scott –Knott test.

As for the PM3 maturation stratum, in the lower height environment, only the genotypes Palhaço Vermelho, Cimentão DP and Vermelho JV presented an average percentage of sieve yield above 70%. The other genotypes expressed yield below 50% (Table 4). In the higher altitude environment, the group composed by the genotypes Palhaço Vermelho, Vermelho M, Roxinho AV, Cimentão DP, Vermelho JV and Esmeralda had a combined average yield above 90%. Then, only the genotypes Terrão NM and Vermelho LP managed to approach 60% yield.In the lower height environment, the majority of the genotypes gathered constituted a percentage average of only 12.7% in the sieve yield, lower than the sieve yield of the genotypes Palhaço Vermelho, Cimentão DP and Vermelho JV, whose joint average was 39.3%, highlighting in this case the genotype Palhaço Vermelho, which alone showed a sieve yield close to 50%, statistically higher than the other two.In the highest height environment, Vermelho JV was the genotype that alone presented the most significant sieve yield. A second group of genotypes represented by the Palhaço Vermelho, Vermelho M, Roxinho AV, Cimentão DP and Esmeralda also maintained an average yield above 50%. Through the joint observation of the two cultivation environments involving the sieve yields in all strata of pod maturation, it is possible to perceive that the genotype Vermelho JV was the most advantageous, surpassing the other genotypes in all strata of maturation pattern (Table 4). The high percentage yield of sieve revealed by this genotype indicates its great capacity to conserve the qualities of grains in all strata of maturation of pods, even harvested 10 days before the harvest maturity in the lower altitude environment and 5 days in the higher altitude environment. The FalsoTerrinha genotype showed the lowest percentage of sieves among all other genotypes in the two heights environments (Table 4), with the harvest being carried out 12 days and 5 days before the final maturity in the lower and higher heights environments, respectively.

Conclusions

The genotypes Palhaço Vermelho, Nova Planta e Capixaba Precoceshowed higher average productivity simultaneously in both cultivation environments. The genotypes Palhacinho Vermelho, Terrão NM, Roxinho AV e Cimentão DP showed greater maturity regularity in the two growing environments with lower percentages of green pods (PM4). The genotype Vermelho JV surpassed the others in sieve yield in all strata of pod maturation.

REFERENCES

Alvares CA, Stape JL, Sentelhas PC, Gonçalves JLM & Sparovek G. (2013). Köppen's climate classification map for Brazil. MeteorologischeZeitschrift, 22:711-728.

Bolina CC. (2012). Maturação fisiológica da semente e determinação da época adequada de colheita do feijão (*Phaseolus vulgaris* L). Revista Científica Indexada Linkania Master, 2:14-25.

Chicati MS, Chicati ML, Furlanetto RH & Freitas LSC. (2018). Colheita do feijoeiro: qual é o melhor sistema a ser escolhido? Revista Campo Digit@l,13:27-37.

Companhia nacional de abastecimento (2018). Perspectivas para a agropecuária. Disponível em: htpp://www.conab. gov.br/conabweb// AcessOctober, 11, 2019.

Pereira HS, Almeida VM, Melo LC, Wendland A, Faria LC, Peloso MJD & Magaldi MCS. (2012). Influência do ambiente em cultivares de feijoeiro-comum em cerrado com baixa altitude. Bragantia, 71:1-8.

Prezotti LC, Gomes JÁ, Dadalto GG & Oliveira JÁ. (2007). Manual de recomendação de calagem e adubação para o estado do Espírito Santo, 5ª aproximação. Vitória, Seea/Incaper/Cedagro.301p.

Ramalho MAP, Abreu AFB & Guilherme SR. (2014). Informações técnicas para o cultivo de feijoeiro-comum na região central brasileira: 2015-2017.In:Reunião da Comissão Técnica Central Brasileira de Feijão. Lavras: Universidade Federal de Lavras; Santo Antônio de Goiás: Embrapa Arroz e Feijão. 168p.

Ribeiro ND, Domingues LS & Zemolin AEM. (2014). Avaliação dos componentes da produtividade de grãos em feijão de grãos especiais. Científica, 42:178–186.

Silva RNO, Silva MG, Eberhardt PER, Silva MLE & Panozzo LE. (2016). Retardamento de colheita na qualidade fisiológica de sementes de feijão. Enciclopédia Biosfera, 13:1204-1212.

Zilio M, Coelho CMM, Souza CA, Santos JCP & Miquelluti DJ. (2011). Contribuição dos componentes de rendimento na produtividade de genótipos crioulos de feijão (*Phaseolus vulgaris* L). Revista Ciência Agronômica, 42:429-438.

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