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RESEARCH ARTICLE

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Effect of Fruit Load on Seed Quality of Cowpea Varieties [*Vigna unguiculata* (L.) Walp. (Fabaceae)]

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ABSTRACT

Background: The development of cowpea cultivation needs to be given priority because, in developing countries, cowpeas make up for many protein deficiencies. Producing quality seeds of this legume would be an essential objective if food security is to be achieved. This study aimed to establish the appropriate fruit load for optimum production of quality cowpea seed.

Methods: To achieve this, the impact of five different fruit loads (10, 20, 30, 40 and 50 pods per plant) on the yield of four cowpea varieties (KVx745-11P (V1), KVx775-33-2G (Tiligré) (V2), Gourgou (V3) and KVx780-6 (V4)) was assessed. The seeds' germination capacity and the seedlings' vigor were then assessed for each of the four varieties.

Result: Findings showed that seed length, width, thickness and weight changed significantly with increasing load in all varieties. The shortest time to emergence was recorded in the V1 variety for seeds from fruit loads of 20, 30, 40 and 50 pods per plant. For the ten pods per plant fruit load, the shortest emergence time was achieved with the V4 variety. The varieties V1, V2 and V4 studied produced excellent agronomic quality seeds when the pod was harvested with a load of 10 pods per plant. The fruit load significantly affected the seed quality and yield across all four varieties. Seeds from the minor C10 load for varieties V1, V2 and V4 and C_20 for variety V3 exhibit high seedling vigour.

Key words: Food security, Seed germination, Seed viability, Seedling vigour.

INTRODUCTION

Vigna unguiculata [L.] Walp. called cowpea is an important leguminous plants grown and consumed in tropical and subtropical areas of Africa, Asia, Europe and America (Taffouo *et al.,* 2008). This legume has enormous agronomic and food potential. Compared to standard beans and soybeans, the principal interest of cowpeas is their heat resistance (Taffouo *et al.,* 2008). It is a valuable source of protein, vitamins and minerals, making it an essential component of food security in developing countries (Dey *et al.,* 2024; Kargiotidou *et al.,* 2019).

According to FAO (2021), 8.9 million metric tons of cowpeas are produced yearly worldwide. In West Africa, cowpea accounts for 85% of the area under pulses and 10% of total cultivated land (Alene *et al.,* 2006). In Côte d'Ivoire, cowpea remains a marginalized crop, despite its nutritional and cultural importance (N'gbesso *et al.,* 2013). Production is around 36.310 tonnes/year, representing less than 2% of African production. In conventional cultivation, yields rarely exceed 500 kg of seed per hectare (Langyintuo *et al.,* 2003). The low yields are a result of several constraints, including poor seed quality.

The seed is a productivity factor that alone could contribute to 40% of yield improvements (FAO, 2008). Quality seeds are necessary to meet food, nutrition and economic challenges. Thus, improving the living conditions of small producers through a sustainable increase in the performance of their farms requires implementing efficient seed systems that consider their needs (Djamen and Ouattara, 2017). Research has yielded significant results for yield improvement, but much remains to be done (Oumarou *et al.,* 2017). It is in this perspective that the present study was initiated in the commune of Bédiala, Centre-West of Côte d'Ivoire, to set up a seed production system of acceptable quality, allowing rural producers to produce quality seeds.

The study aims to enhance food security by creating a technical process for producing high-quality cowpea seeds. More specifically, this study aims to determine the variety and the appropriate fruit load for good agronomic quality of cowpea seeds.

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MATERIALS AND METHODS

Experimental site and plant material

The work was conducted by Nangui Abrogoua University, specifically in the West-Central Region of Côte d'Ivoire from 13 April 2022 to 29 July 2023.

Seeds from four different cowpea varieties (Table 1) were collected from the Institute for Environment and Agricultural Research (INERA) in Burkina Faso. Seeds used for germination tests were obtained after three months of cultivation (from April to June).

Methods

The study of the fruit load was conducted on a completely randomized plot that included 20 boards of dimension 13 m×6.25 m. The boards of 0.75 m equidistant plots comprised two lines of five seed sowing spaced 0.5 m apart. Each row was seeded with points that were 0.4 meters apart. The seeds were planted with two seeds per seed pot at a depth of 3 cm. Then, a dismarriage was carried out at the five-leaf stage, leaving only one vigorous plant per seed sowing. In total, 200 plants were retained. Five levels of fruit loads have been pre-defined for this study: specifically, 10, 20, 30, 40 and 50 fruits per plant. Once a given plant's desired fruit load level was reached, new flowers were systematically eliminated until the retained fruits matured. This elimination was done manually by destroying the flower buds.

A completely randomized experimental plot was used for germination tests. This plot contained 20 boards of 0.6 m×0.45 m each. The ploughed and levelled boards had 20 seed points, each equidistant 10 cm. For germination tests carried out on the four varieties of cowpea

Table 1: Descriptions of the four cowpea varieties from INERA, along with their morpho-phenological characteristics.

Variety	Varietal code	Average duration of the growth cycle (days)	Type of flowering	Plant growth form
V1	KVx745-11P	70 days after sowing	Spread	Erected
V2	KVx775-33-2G (Tiligré)	70 days after sowing	Grouped	Semi-erected
V3	GOURGOU	75 days after sowing	Grouped	Erected
V4	KVx780-6	64 days after sowing	Grouped	Semi-erected

Table 2: Cowpea variety evaluation parameters and measurement methods.

Parameters	Codes	Measurement methods
Performance		
Pod weight (g)	PFr	Average weight of ten pods per plant by fruit load level and variety
Number of seeds / pod	Ngr/Fr	An average number of seeds with ten pods per plant varies by fruit load level and variety
Seed weight / pod (g)	Pgr/Fr	Average weight of seeds from ten pods per plant, by level of fruit load and by variety
Seed weight (g)	Pgr	Average weight of five seeds per pod per level of fruit load and 200 seeds for the different harvesting times for each variety.
Seed length (mm)	Lgr	Distance from base to top of seed
Seed width (mm)	lgr	Distance between the lateral edges of the seed
Seed thickness (mm)	Egr	Distance between the top and bottom surfaces of the seed
Weight of 100 seeds / plants (g)	P100	Average weight of five replicates of 100 mature seeds at 12% humidity
Morpho-phenological		
Emergence time (d)	TEm	Number of days observed from sowing to emergence of the seedling on the soil surface
Emergence rate (%)	TxEm	Proportion of seedlings that have emerged in relation to the total number of seeds sown
Germination time (d)	TeGe	Number of days observed from sowing to seed germination
Germination rate (%)	TxGe	Proportion of seeds germinating 14 days after sowing in relation to the total number of seeds sown
Height of seedling (mm)	HaP	Distance from soil surface to tip of tallest leaf, measured two weeks after sowing
Length of central leaflet (mm)	LFo	Distance from the point of insertion of the three leaflets to the apex of the central leaflet
Width of central leaflet (mm)	lFo	Lateral distance of the central leaflet of the leaves
Leaf area $(mm)^2$	SFo	Product of the length and width of the central leaflet
Diameter at collar (mm)	Dcol	Measurement of the distance between two diametrically opposed points at the neck of the plant two weeks after sowing.

(V1, V2, V3 and V4), seeds in good physical and sanitary condition from five fruit load levels (10, 20, 30, 40 and 50 pods/plant) were used.

Data collection and analysis

Seventeen agro-morphological parameters were evaluated in this study (Table 2). These result from several previous works (Vaggar *et al.,* 2022). For each variety, a batch of 10 pods and five seeds randomly selected per plant were selected for each fruit load for the eight yield parameter measurements. Vigor and viability were assessed regarding seed germination and normal seedling production (Egli and Tekrony, 1995) on three weeks after planting.

An initial multivariate analysis of variance (MANOVA) was conducted to evaluate the significance of the overall effects of variety and fruit load on various agro-morphological parameters. ANOVA tests were performed to compare the means of each parameter against each other based on the factors considered. When a significant difference ($P< 0.05$) has been observed at the risk level $\alpha=0.05$, the Kruskal-Wallis test was used. The data collected was analyzed using R version 4.2.1.

RESULTS AND DISCUSSION

Evaluation of yield parameters based on fruit load

Overall effect of factors on performance parameters

Multiple variance analysis (MANOVA) showed a very significant influence ($P<0.001$) of variety, fruit load and their interaction (fruit load variety) on yield parameters (Table 3). Therefore, only the effect of the interaction was considered for analysis and interpretation of results. The analysis of variance (ANOVA) revealed that the combination of fruit load and variety leads to better performance of the evaluated yield parameters.

Combined effect of fruit load and variety on yield parameters

The analysis of variance (ANOVA) showed that the variety load interaction had a highly significant influence ($P< 0.001$) on the evaluated yield parameters (Table 4). According to the Kruskal-Wallis test, high fruit weight (PFr), number of seeds per fruit (Ngr/Fr), weight of seeds per fruit (Pgr/Fr), weight of seed (Pgr), length of seed (Lgr) and seed thickness (Egr) and low values at the seed width (lgr) and weight of 100 seeds were observed in seeds from the C20 fruit load. The average observed shows that V2 varieties recorded the highest fruit weights (PFr) at 20 pods per plant (C20) and 30 pods per plant (C30). The fruit load affected the number of seeds per pod (Ngr/Fr) and the highest value was obtained with the V1 variety at 20 pods per plant (C20) and 50 pods per plant (C50). As for the weight of seeds per fruit (Pgr/Fr), the most important value was obtained in the V3 and V4 varieties at the C20 load. About the weight of the seed (Pgr) and the length of the seed (Lgr), the variety V4 recorded the maximum values at load C10. For seed width (lgr) and seed thickness (Egr) the V2 variety recorded maximum values at loads of 30 pods and 50 pods per plant. The V3 variety recorded the highest weight of 100 seeds (P100) for the C50 load.

Assessment of vigor and viability parameters based on fruit loads

Overall effect of factors on vigor and sustainability parameters

The multiple variance analysis (MANOVA) revealed a highly significant ($P<0.001$) impact of variety and fruit load factors, as well as their interaction (fruit load variety) on seed vigour and seedling viability (Table 5). Only the variance analysis (ANOVA) based on the fruit load variety interaction was performed to elucidate the combination of fruit load and variety that leads to a better performance of the vigor and viability parameters studied.

Combined effect of fruit load and variety on seed viability

The analysis of variance (ANOVA) indicates that the fruit load and variety interaction showed a highly significant influence ($P<0.001$) on all viability parameters. The Kruskal-Wallis test indicated that variety V1 had high values for crop loads C10, C20, C40 and C50. However, for the C30 load, the highest value was obtained by the variety V2. The V3 variety achieved its best potential for viability at the C20 load. The best potential for viability of V4 is obtained at C20 and C40 (Table 6).

Combined effect of fruit load and variety on plant vigour

The ANOVA revealed a highly significant influence ($P< 0.001$) of the fruit load variety interaction on all parameters of seedling vigor (Table 7). The V1 variety recorded the lowest values for plantlet height (HaP: 23.42 mm), leaflet length (LFo: 9.53 mm), leaflet width (lFo: 3.91 mm), leaf surface (SFo: 25.06 mm) and collar diameter (Dcol: 2.81 mm) in seeds from the fruit load of 30 pods per plant (C30). Conversely, higher values (LFo: 14.35 mm; lFo: 5.38 mm; SFo: 49.34 mm; Dcol: 5.84 mm) respectively of these parameters were obtained with the seeds of the V4 variety for the C10 load, with a high value of plant height (HaP: 41.2 mm). For the V2 variety, the highest values of plant height, leaflet length, leaf area and collaring diameter were observed at load C10, while for these same parameters, the V3 variety performed best with a C20 load (Table 7). These results related to young plant vigour revealed that the V1 variety has the lowest values. The highest load is C10 with the varieties V2 and V4.

Table 3: MANOVA results demonstrate the significant impact of fruit load, cowpea variety and their interaction on yield parameters.

Factors	DL	*F*	P
Fruit load	4	2775	< 0.001
Variety	3	3704	< 0.001
Fruit charge×variety	12	7440	< 0.001

DL: Degree of liberty, F: Fischer F-statistic and P: Probability associated with the test.

Table 4: Effect of fruit load × cowpea variety interaction on yield parameters.

Fruit load	Variety	Pfr (g)	Ngr.fr	Pgr.fr (g)	Pgr (g)	Lgr (mm)	Lgr (mm)	Erg (mm)	P100 g (g)
C10	V1	1.40±0.392b	10.70±3.064b	1.07±0.363b	0.20±0.448a	7.14±0.442b	5.28±0.377b	3.81±0.277b	9.99±0.142b
	V2	1.95±0.557b	7.37±2.157b	1.33±0.516b	0.19±0.026a	9.62±0.545a	6.39±0.343a	5.03±0.305a	20.74±0.508b
	V3	1.67±0.734b	7.17±3.029b	1.24±0.636b	0.17±0.031a	8.68±0.843b	6.38±0.415a	4.69±0.289b	18.12±0.899b
	V4	2.40±0.785a	8.80±2.613b	1.68±0.592b	0.21±0.036a	9.76±0.790a	6.53±0.454a	5.03±0.355a	21.36±0.121b
C20	V1	1.48±0.204b	12.77±2.112a	1.14±0.191b	0.10±0.030b	6.90±0.336b	5.16±0.199b	3.78±0.153b	10.35±0.526b
	V2	2.50±0.557a	10.40±2.673b	1.86±0.502b	0.19±0.020a	9.64±0.361a	6.41±0.276a	4.90±0.237a	19.88±1.069b
	V3	2.25±0.432a	10.43±1.590b	1.72±0.382a	0.18±0.044a	8.43±0.631b	6.47±0.386a	4.78±0.381b	17.14±1.168b
	V4	2.35±0.673a	8.97±2.400b	1.72±0.562a	0.20±0.024a	9.48±0.565a	6.43±0.254a	5.00±0.236a	20.50±1.631b
C30	V1	1.44±0.278b	11.36±2.907a	1.10±0.254b	0.10±0.013b	6.98±0.282b	5.13±0.217b	3.76±0.152b	10.46±0.515b
	V2	2.49±0.503a	9.73±2.050b	1.81±0.419b	0.20±0.026a	9.62±0.565a	6.47±0.362a	5.09±0.324a	20.46±0.251b
	V3	1.93±0.582b	9.65±2.332b	1.50±0.531b	0.16±0.030a	8.01±0.648b	6.30±0.396b	4.76±0.381b	17.28±0.083b
	V4	1.98±0.500b	9.27±2.532b	1.50±0.438b	0.18±0.023a	9.07±0.560b	6.33±0.338a	4.91±0.296a	21.16±1.401b
C40	V1	1.40±0.264b	11.97±2.189a	1.04±0.236b	0.10±0.011b	6.85±0.286b	5.08±0.187b	3.84±0.188b	10.46±0.209b
	V2	2.22±0.427a	9.80±2.091b	1.67±0.378b	0.19±0.039a	9.29±0.401b	6.24±0.205b	4.88±0.187a	19.97±0.474b
	V3	2.03±0.571b	9.93±2.840b	1.48±0.477b	0.18±0.031a	8.02±0.653b	6.44±0.400a	4.91±0.330a	20.00±1.392b
	V4	2.04±0.434b	8.87±2.096b	1.51±0.388b	0.19±0.021a	9.33±0.558b	6.22±0.206b	4.97±0.254a	21.33±1.983b
C50	V1	1.56±0.313b	12.03±2.606a	1.16±0.298b	0.12±0.114a	6.83±0.291b	5.25±0.213b	3.97±0.179b	11.08±0.141b
	V2	2.33±0.654a	9.47±2.460b	1.70±0.603b	0.19±0.038a	9.43±0.705a	6.40±0.370a	4.92±0.220a	20.49±1.155b
	V3	1.96±0.459b	9.33±1.936b	1.46±0.435b	0.18±0.038a	8.07±0.678b	6.54±0.452a	4.88±0.449a	22.07±0.477a
	V4	1.74±0.365b	8.57±1.654b	1.25±0.331b	0.16±0.038a	8.73±0.819b	6.20±0.350b	4.79±0.317b	18.07±1.158b
Statistics	*F*	226.79	154.01	166.08	322.47	451.56	356.25	360.01	508.19
	P	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

C: Number of pods per plant; V: Variety; Pfr: Pod weight; Ngr.fr: Number of seeds / pod; Pgr.fr: Seed weight / pod; Pgr: Seed weight; Lgr: Seed length; lgr: Seed width; Erg: Seed thickness; P100g: Weight of 100 seeds / plants; Fischer's F-statistic and *P*: Probability associated with the test.

± S: Standard error. For each parameter the mean values followed by "a" were the highest means and the mean values followed by "b" were the lowest means on the Kruskal-Wallis test at 0.05.

High-quality seed production is crucial for ensuring food security, especially for directly seeded plants (Copel and and McDonald, 2001). The study aimed to assess how fruit loading affects seed quality in four cowpea varieties. The species or variety of a plant, the treatments applied and the timing of application can influence its morphological and phenological behavior (Chaves *et al.,* 2002). To this end, the study showed that seed treatments applied to cowpea varieties affected them both quantitatively and qualitatively.

All yield parameters recorded for the four cowpea varieties were influenced by fruit load. To this end, work has shown that the resulting fruit is significant when the load is reduced (Choi *et al.,* 2010). In this fruit load study, the expression of yield parameters under the effect of applied fruit loads differed for each variety. For instance, at the lowest plant load (C10) at the load (C20) and the load (40), the V4 variety produced the most giant seeds (length, width and thickness) of seeds and average weight of seeds. At C30 and C50 the variety V2 presented larger seed sizes. The V1 variety has small seed sizes from the lowest (C10) to the highest (C50) plant load, while the V3 variety has intermediate-sized seeds. This agronomic potential inherent to each variety could result from genetic factors. Pod size, seed size, weight of 100 seeds and number of seeds per pod in cowpeas are highly heritable genetic traits (Khanpara *et al.,* 2016; Singh *et al.,* 2016; Amusa *et al.,* 2019).

Table 5: Result of MANOVA indicating the overall effect of factors on vigor and viability parameters.

Factors	DL	*F*	P
Fruit Load	4	786	< 0.001
Variety	3	1052	< 0.001
Fruit Charge×Variety	12	2412	< 0.001

DL: Degree of liberty, F: Fischer F-statistic and P: probability associated with the test.

Based on our results analysis, the fruit load interaction influenced all yield parameters. Except for the number of seeds per fruit and the weight of 100 seeds, which did not show a regular evolution, the average values of the length, width and thickness of the seed and the average weight of the seed tended to decrease linearly with the increase in fruit load for all varieties. Indeed, the higher C50 load indicates a decrease in size (length, width and thickness) and weight of seeds per fruit. This may mean that the more fruit a plant bears, the less resources it has to provide for seeds (Kumari *et al.,* 2020). These results show that a reduction in fruit load per plant is compensated by producing large seeds with a high average weight for all varieties. This would likely result from the fact that the threshold load at which resources become a limiting factor has not been reached. The fruitful profile indicates that the weight of 100 seeds was higher in fruits with lower seed yield. This result may be attributed to the fact that early

Table 6: Average values of seed viability parameters for cowpea based on fruiting loads and variety.

Fruit load	Variety	TeGem (j)	TxGem (%)	TeEm (j)	TxEm (%)
	V1	3.33±0.002b	80.1±0.224a	9.05±0.224b	70.05±0.224b
C10	V2	4.49±0.045b	51.7±0.076b	9.33±0.022b	51.7±0.076b
	V3	4.53±0.082b	21.7±0.139b	9.28±0.135b	21.55±0.269b
	V4	4.46±0.002b	21.7±0.139b	8.86±0.069b	20.17±0.408b
	V1	4.49±0.045b	74.9±0.447b	8.89±0.025b	71.1±0.447a
C20	V2	4.17±0.031b	65±0.224b	9.05±0.011b	65.05±0.224b
	V3	4.47±0.125b	43±0.224b	9.68±0.076a	41.68±0.076b
	V4	4.2±0.188b	60.1±0.224b	8.95±0.224b	58.36±0.150b
	V1	4.1±0.025b	35±0.045b	8.66±0.002b	31.68±0.076b
C30	V2	4.18±0.076b	38.3±0.074b	9.05±0.013b	34.95±0.224b
	V3	3.72±0.139b	19.8±0.408b	9.3±0.343b	11.72±0.139b
	V4	4.16±0.002b	11.8±0.261b	9.17±0.408b	11.72±0.139b
	V1	4±0.324b	70.1±0.224b	8.95±0.224b	68.33±0.002b
C40	V2	4.71±0.143a	18.3±0.135b	9.6±0.139a	13.28±0.135b
	V3	4.24±0.179b	38.3±0.074b	9.39±0.027b	33.26±0.297b
	V4	4.05±0.224b	60.1±0.224b	9.53±0.112b	51.68±0.076b
	V1	4.1±0.025b	71.6±0.371b	8.79±0.186b	65.05±0.224b
C50	V2	3.5±0.002b	20.2±0.408b	9.42±0.204b	10.17±0.408b
	V3	3.86±0.069b	18.3±0.135b	9.28±0.135b	18.44±0.274b
	V4	4.08±0.045b	18.4±0.274b	9.22±0.139b	15.17±0.408b
Statistics	*F*	264.73	286.58	264.7	286.62
	P	< 0.001	< 0.001	< 0.001	< 0.001

TeGe: Germination time, TxGe: Germination rate, TeEm: Emergence time, TxEm : Emergence rate, C: Number of pods per plant. V: Variety. *F*: Fischer's F-statistic and *P*: Probability associated with the test. ±S: standard error. Kruskal-Wallis.

Table 7: Mean Value±standard deviation of vigor parameters under the influence of fruiting load and cowpea variety interaction.

Fruit load	Variety	Hap (mm)	LFo (mm)	IFo (mm)	Sfo (mm^2)	Dcol (mm)
	V1	33.96±2.566b	12.66±0.619b	5.45±0.529a	44.23±5.437a	4.00±0.585b
C10	V2	43.45±4.527a	14.28±1.064a	5.26±0.638a	48.98±7.989a	5.35±0.750a
	V3	29.42±7.352b	10.67±2.569b	4.15±1.078b	29.64±14.876b	3.88±0.765b
	V4	41.2±1.860a	14.35±0.905a	5.38±0.504a	49.34±7.576a	5.84±0.685a
	V1	31.49±2.851b	11.79±0.914b	5.21±0.612a	39.59±7.078a	3.60±0.415b
C20	V2	40.99±3.157a	13.08±1.421a	4.80±0.597a	42.72±9.661a	4.51±0.467b
	V3	39.66±7.510a	12.77±2.251b	4.75±0.851a	39.60±13.157a	4.28±0.731b
	V4	42.53±4.272a	13.6±1.791a	5.21±0.639a	45.53±10.763a	4.96±0.954b
	V1	23.42±4.622b	9.53±1.956b	3.91±1.103b	25.06±11.233b	2.81±0.735b
C30	V2	39.68±4.896a	13.27±1.421a	4.83±1.107a	43.19±14.594a	4.77±0.795b
	V3	34.4±2.582b	11.77±1.213b	4.82±0.458a	36.45±7.562b	4.17±0.245b
	V4	37.57±5.281b	12.82±2.132b	4.9±0.972a	40.91±13.411a	4.61±0.682b
	V1	31.61±2.200b	12.1±0.835b	5.21±0.520a	40.50±6.375a	3.56±0.541b
C40	V2	32.5±5.566b	10.8±1.752b	3.7±0.837b	26.18±9.816b	3.66±0.430b
	V3	34.10±5.757b	11.53±1.668b	4.68±0.980b	35.21±11.698b	4.48±0.705b
	V4	34.56±3.709b	11.44±1.485b	3.88±0.537b	28.48±7.445b	4.33±0.626b
	V1	31.60±4.257b	11.76±1.745b	5.14±1.288a	40.02±16.075a	3.83±0.628b
C50	V2	34.88±8.713b	12.25±3.144b	4.25±1.282b	35.04±16.551b	4.77±0.906b
	V3	37.75±3.766b	12.98±1.829a	4.68±0.708b	38.92±9.701b	4.84±0.478b
	V4	37.12±1.889b	13.4±0.385a	5.27±0.753a	44.99±6.912a	4.28±0.474b
Statistique	*F*	166.8	107.01	80.993	86.467	151.63
	P	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

V: Variety Hap: Height of seedling; LFo: Length of central leaflet; IFo: Width of central leaflet; Sfo: Leaf area; Dcol: Diameter at collar; *F*: Fischer's F-statistic and *P*: Probability associated with the test. ± S: standard error. Kruskal-Wallis.

harvest densities during the fruit cell growth period may decrease fruit growth rate, affecting carbohydrate availability and reducing final fruit size. These data indicate that seed production requires a variety-specific fruit load for improved yield.

The fruit load treatment significantly affected the average germination time, germination rate, emergence time and emergence rate. According to Moravcová *et al*. (2005), this phenomenon is related to the quantity of nutrient resources in seeds. The number of seeds in fruits affects their nutrient mobilization and can increase seed germination capacity (Marcelis and Hofman-Eijer, 1997). The amount of reserves accumulated in seeds is essential when a fruit contains a high number of seeds. The high viability of V1 seed from treatments is due to many available resources in the V1 seed. However, the low viability of V3 seeds from C10, C20, C30 and C50 treatments is due to a small amount of available resources in these seeds at these treatments. We find a variation when we observe the impact of the variety load interaction on the plant vigor parameters. Seeds from the minor C10 load for varieties V1, V2, V4 and C20 for variety V3 have high seedling vigor. Beyond this specific load, the seeds of all four varieties produced seedlings of relatively low vigor.

These results suggest that a load optimum linked to each variety would allow the production of quality seeds capable of producing seedlings with greater vigor at emergence. Higher load levels than this optimum would, therefore, lead to seeds whose quality at maturity would negatively affect the vigor of seedlings at emergence.

CONCLUSION

Our focus was to assess the impact of fruit load on the seed quality of four cowpea varieties to determine the most suitable harvest stage. In conclusion, the fruit load significantly affected the seed quality and yield across all four varieties. The varieties V1, V2 and V4 studied produced excellent agronomic quality seeds when the pod was harvested with a load of 10 pods per plant. Seed viability and seedling vigor changes were closely related to seed weight. Thus, the weight of harvested cowpea fruit is a reliable indicator for seed selection and is closely related to the stage of maturation.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent *(we work on plant material)*

All animal procedures for experiments were approved by the Committee of Experimental Animal care
and handling techniques were approved by the University of Animal Care Committee.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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