

Agronomic performance of four cowpea (*Vigna unguiculata* L. Walp) varieties under different inter-row spacings in Buea, Cameroon

ABSTRACT

Aims: Cowpea is a major staple food crop in sub-Saharan Africa. The yields obtained on farmers' fields are usually low because the crop is often planted at irregular spacings. to investigate the effect of inter-row spacing on the growth and yield of cowpea.

Study design: The first trial was set up as a randomized complete block design with three replications. The second trial was set up as a split-plot arrangement in a randomized complete block design and the treatments were replicated three times.

Place and Duration of Study: Field studies were conducted at the Teaching and Research Farm of the University of Buea in 2014 and 2016–2017.

Methodology: In the first trial, the variety VYA was grown at three inter-row spacings (45cm, 75cm and 90cm). The second trial involved three inter-row spacings (45cm, 60cm and 75cm) and four varieties (RIL69, RIL79, RIL265 and VYA). In both trials, the intra-row spacing was 25cm.

Results: Inter-row spacing significantly influenced ($P<0.05$) the performance of cowpea. In 2014, inter-row spacings of 75cm and 90cm led to the production of more leaves and fodder yield than 45cm. In both trials, inter-row spacings of 60cm, 75cm and 90cm gave taller plants with larger stems than 45cm. However, grain yield increased with a decrease in inter-row spacing for all varieties and the highest was recorded at 45cm. Among the varieties, the highest grain and fodder yields were recorded for RIL69.

Conclusion: Cowpea should be sown at an inter-row spacing of 45cm for optimum grain yield production.

Keywords: Cameroon, cowpea, inter-row spacing, performance

1. INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp) also known as southern pea or black eye pea is an important grain legume in the tropics. It is a valuable component of the traditional cropping systems in the semi-arid tropics covering Asia, Africa and Central America [1][2]. It is second in importance after



groundnut in West and Central Africa, and Nigeria accounts for 70% of the total production in the world [3]. In Cameroon, cowpea is the third most important legume after groundnut and common bean [4]. All parts of the plant used as food are nutritious and provide protein and vitamins; immature pods and leaves are used as vegetables while several snacks and main dishes are prepared from the grains [5].

Cowpea grain yield in farmers' fields is low in West Africa due to several biotic and abiotic factors which include poor soil fertility, drought, inadequate planting systems/practices, inappropriate cultivars and lack of inputs [6]. However, higher yields have been reported in the savannas of Africa [7][8][9]. Among the various agronomic factors that limit yield, plant population is considered the most important [10]. An increase in crop yield can be attained by maintaining the appropriate plant spacing/density through different hectare patterns. Therefore, the optimization of plant density for high yielding genotypes through the use of suitable inter- and intra-row spacing is essential.

It is also necessary to determine the optimum plant density for different locations and varieties [11]. Low cowpea population per unit area has been reported as a major factor responsible for the poor yields obtained from the small holder farming systems in sub-Saharan Africa [12]. According to Ndiaga [13], cowpea varieties with different types of morphology require different optimum densities to express their full seed yield potential. Researchers have also shown that seeding rate and cultivar are important factors that affect the yield and quality of grain legumes [14][15][16].

The optimum density for cowpea depends on the growth habit, morphology and maturation period. Previous studies have indicated that erect types gave reasonable yield at a high population, whereas semi-erect types gave optimal yield at a low population [17]. Plant spacing is an efficient management tool for maximizing grain yield by increasing the amount of solar radiation captured within the canopy [18]. Although there are reports in literature on the effect of plant spacing/ density on the performance of cowpea [19] elsewhere, this information is lacking in Cameroon.

The objectives of this study were to determine the effect of inter-row spacing on the agronomic performance of four cowpea varieties, and if the response to different spacings depends on the varieties. It is hoped that results obtained would help farmers to adopt the appropriate inter-row spacing for the varieties available, in order to obtain the appropriate yield and profit.

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59 2. MATERIALS AND METHODS

60 2.1 Experimental Site

61 Two trials were conducted at the University of Buea Teaching and Research Farm in the rainy season
62 from March to June 2014 and the dry season from November 2016 to March 2017. Buea is found in
63 the mono-modal humid forest agro-ecological zone of Cameroon with an equatorial climate and two
64 major seasons (Rainy season and dry season). The rainy season runs from March to October and the
65 dry season from November to March. The temperature ranges from 21.45 to 32.75°C, the annual
66 rainfall is 2,500 to 4,000 mm and relative humidity is 85–90%.

67 2.2 Experimental Design, Inter-row Spacings and Cowpea Varieties

68 The first trial was set up as a randomized complete block design with three replications. The trial
69 consisted of one variety of cowpea 'VYA' and three inter-row spacings (45 cm, 75 cm and 90 cm).

70 The intra-row spacing was 25 cm. The plants were spaced as follows:

- 71 i. 45 cm × 25 cm: 88,888 plants/ha (high population density)
- 72 ii. 75 cm × 25 cm: 53,333 plants/ha (medium population density)
- 73 iii. 90 cm × 25 cm: 44,444 plants/ha (low population density)

74 The second trial was set up as a split-plot arrangement in a randomized complete block design and
75 the treatments were replicated three times. There were three inter-row spacings and four cowpea
76 varieties. The main plots consisted of the inter-row spacings while the sub-plots were the varieties.

77 The intra-row spacing was also 25 cm. The spacings used are as outlined;

- 78 i. 45 cm × 25 cm: 88,888 plants/ha (high population density)
- 79 ii. 60 cm × 25 cm: 66,666 plants/ha (medium density population)
- 80 iii. 75 cm × 25 cm: 53,333 plants/ha (low population density)

81 The four cowpea varieties used were: RIL 69, RIL 265, RIL 79 and VYA. The first three are early-
82 maturing varieties (65–75 days) that were developed by the International Institute of Tropical
83 Agriculture. The fourth is a medium-maturing (75–85 days) variety, which is a local variety commonly
84 grown on farmers' fields.

85 2.3 Land Preparation, Planting and Crop Maintenance

86 For both trials, the land was ploughed using a tractor and beds were raised manually using a hoe.
87 The size of each plot was 4 m × 3 m. Two seeds of each cowpea variety were sown per hole and the
88 seedlings were thinned to one per stand two weeks after planting (WAP). Weeds were controlled

manually by hoeing after every two weeks from 2 to 8 WAP. The insecticide K-Optimal [Lamda-cyhalothrin (15 g/l) and Acetamipride (20 g/l)] was applied to control insect pests weekly from 2 to 7 WAP in the first trial, and at 2, 4 and 6 WAP in the second trial.

2.4 Evaluations

Ten plants were randomly selected from the centre rows of each plot to obtain data on growth, phenology and yield parameters of the different cowpea varieties. The growth data were collected at 7 WAP from plant height, number of trifoliate leaves, number of branches, stem diameter. The phenology data obtained were number of days to 50% flowering and number of days to 90% maturity. The yield data were collected at maturity on number of pods/plant, number of seeds/pod, grain yield, 100-seed weight and fodder yield.

Plant height (cm) was measured from the surface of the soil to the tip of the leaf using a metre rule. The number of trifoliate leaves was determined by counting those that were fully expanded. The number of branches was obtained by counting. The stem diameter (mm) was measured using a Vernier caliper from the base of the plant about 5 cm above the soil.

The number of days to 50% flowering was obtained by counting the days from planting to when 50% of the plants in each plot produced at least one flower. Number of days to 90% maturity was obtained by counting the days from planting to when 90% of the plants in each plot were matured.

At maturity, the dry pods were harvested, threshed and weighed to obtain the grain yield (t ha^{-1}). The pods on each sampled plant were counted before being threshed. The number of seeds/pod was obtained from ten pods randomly selected from each plot and threshed. The seeds were counted and the mean number of seeds/pod calculated. The 100 seed weight (g) was estimated by counting 100 seeds at random from each plot three times and weighed using an electronic balance. Grain yield data for variety VYA could not be obtained as a result of damage by birds. However, the fodder yield was obtained. The leaves and stems from the harvested plants were sun dried on each plot for one week after which they were weighed to determine the fodder yield.

2.5 Statistical Analyses

The data collected were subjected to analysis of variance (ANOVA) using SPSS version 21 and the differences in treatment means were separated using the Tukey HSD test at 5% level of probability.

3. Results and discussion

3.1 Growth parameters

3.1.1 Plant height

The results of the first trial revealed that plant height for variety VYA differed significantly ($P=0.05$) at the different spacings at 7 WAP (Table 1). Plants sown at inter-row spacings of 75 cm and 90 cm were taller than those sown at 45 cm. These observations indicate that the plants were taller when sown at wide than at close spacing.

Table 1: Effects of inter-row spacing on the growth parameters of cowpea at 7 weeks after planting and fodder yield in 2014 in Buea, Cameroon

Inter-row spacing (cm)	Plant height (cm)	Number of trifoliolate leaves	Number of branches	Stem diameter	Fodder yield (t ha^{-1})
45	102.8b	94.3b	7.7	10.9b	5.3b
75	119.7a	111.2b	7.7	11.9a	7.2a
90	126.0a	122.2a	7.3	12.2a	5.0b
<i>P</i>	0.021	0.04	0.50	0.032	0.045

In the second trial, there was no significant ($P=0.05$) interaction between inter-row spacing and variety for plant height at 7 WAP. However there were significant ($P=0.05$) differences between the inter-row spacings and cowpea varieties. Plants sown at inter-row spacings of 75 cm and 60 cm were taller than those sown at 45 cm (Table 2). These results indicated that at 7 WAP, the plants were taller at wide than at close spacing. Hence the results of the second trial are consistent with those of the first trial. However, they do not agree with previous findings which indicated that intra-row spacing did not affect the height of cowpea [20]. For all plants the mean height increased with the advancement of plant growth (data not shown). Varieties VYA and RIL 79 had similar and taller plants than RIL 69 and RIL 265 which also had comparable height (Table 3). The former varieties were 1.6 times taller than the latter ones. Previous studies have also reported that there were differences in the height of cowpea genotypes when sown at different spacings [20].

Table 2: Effects of inter-row spacing on the growth parameters of cowpea at 7 weeks after planting and some phenological and yield traits from 2016 to 2017 in Buea, Cameroon

Inter-row spacing (cm)	Plant height (cm)	Number of trifoliolate leaves	Number of branches	Stem diameter	Days to 50% flowering	Days to 90% maturity	Number of pods/plant	100-Seed weight (g)
45	81.9b	31.8	4.2b	10.4	42.4	61.7	27.2	15.7
60	90.5a	33.6	4.1b	9.5	42.1	61.4	24.9	15.3
75	94.0a	28.0	5.6a	10.4	42.1	61.4	24.6	15.2
<i>P</i>	0.049	0.40	0.01	0.60	0.80	0.61	0.54	0.48

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Table 3: Effects of cowpea varieties on the growth parameters of cowpea at 7 weeks after planting and some phenological and yield traits in Buea, Cameroon

Varieties	Plant height (cm)	Number of leaves	Number of branches	Stem diameter (mm)	Days to 50% flowering	Days to 90% maturity	Number of pods/plant	100-Seed weight(g)
RIL 69	77.18a	31.8	4.2b	10.4	41.7b	63.1a	30.54a	18.20a
RIL 79	116.8b	28.0	5.6a	10.4	41.5b	57.7b	24.12ab	13.07c
RIL 265	59.2a	33.6	4.1b	9.5	42.1ab	63.2a	21.98b	14.93b
VYA	102.0b	37.5	4.3b	9.4	43.5a	–	–	–
<i>P</i>	0.004	0.17	0.01	0.09	0.01	0.01	0.01	0.01

148

3.1.2 Number of trifoliolate leaves

Results of the first trial indicated that there were significant ($P=0.05$) differences in the number of trifoliolate leaves produced at the different inter-row spacings at 7 WAP (Table 1). Plants sown at inter-row spacings of 75 cm and 90 cm produced more leaves than those sown at 45 cm.

In the second trial, the interactions between inter-row spacing and variety had no significant effect ($P=0.05$) on the number of trifoliolate leaves produced at 7 WAP. Inter-row spacing had no significant effect on the number of trifoliolate leaves produced (Table 2). This observation is contrary to that obtained in the first trial. The mean number produced across the different inter-row spacings was 31.1 trifoliolate leaves. These results are in agreement with those of previous studies which indicated that inter-row spacing did not affect the number of leaves of cowpea [21][22]. The varieties significantly influenced the number of trifoliolate leaves produced. The highest number of trifoliolate leaves was recorded for varieties VYA and RIL 79 (Table 3). The varieties RIL 69 and RIL 265 had a similar number of trifoliolate leaves which was 1.3 times less than that produced by the other two.

3.1.3 Number of branches/plant

The number of branches did not differ significantly ($P=0.05$) at the different spacings in the first trial (Table 1). The average number across the different spacings was 7.6 branches/plant. These results are similar to those obtained by earlier researchers who reported that the number of branches/plant was not affected by plant spacing [23].

Results of the second trial revealed that there was no significant ($P=0.05$) interaction between inter-row spacing and variety for the number of branches/plant. Inter-row spacing significantly ($P=0.05$) affected the number of branches/plant (Table 2). Cowpea produced the highest number of branches at an inter-row spacing of 75cm. The number of branches produced at 45 cm $\times$ 25 cm and 60 cm $\times$ 25 cm was similar. These results suggest that the number of branches produced by cowpea was more at wide than close spacing. This observation contradicts that obtained in the first trial. However, this is not surprising because the first trial involves only one variety while the second trial involves several varieties which could respond differently due to their various growth habits. Previous studies have also indicated that number of branches was influenced by plant spacing [24]. The varieties also had a significant effect on the number of branches/plant (Table 3). The variety RIL 79 had the highest number of branches. Varieties VYA, RIL 69 and RIL 265 produced similar number of branches (4.2).

3.1.4 Stem diameter

In the first trial, the stem diameter for variety VYA differed significantly with inter-row spacing (Table 1). Plants sown at inter-row spacings of 75 cm and 90 cm had larger diameter than those spaced 45 cm $\times$ 25 cm. These results indicate that the stem diameter was large at wide than at narrow spacing.

Results of the second trial revealed that the interaction between inter-row spacing and variety had no significant ($P=0.05$) effect on the stem diameter of cowpea at 7 WAP. Also, the stem diameter was not influenced by inter-row spacing (Table 2). The average stem diameter obtained at the different inter-row spacings was 10.1 mm. Stem diameter was not significantly affected by cowpea varieties (Table 3). The average stem diameter across the four varieties was 9.9 mm.

3.2 Phenological parameters

3.2.1 Number of days to 50% flowering

The interaction between inter-row spacing and variety had no significant effect on the mean number of days for 50% of the plants to flower, in the second trial (Table 2). Inter-row spacing did not affect the number of days for 50% of the plants to flower. Across the different spacings, the mean number of days for 50% of the plants to flower was 42.2 days. These observations are similar to those obtained by Salih [25] who reported that the number of days for 50% of the plants to flower was similar when cowpea was sown at low and high densities.

The number of days for 50% of the plants to flower was significantly affected by the cowpea varieties (Table 3). Variety VYA took the highest number of days for 50% of the plants to flower (43.5). The other three varieties took a similar number of days (mean=41.8 days). This may be attributed to the genetic characteristics of the cowpea varieties. Thus, these three varieties are early-maturing varieties while VYA is not.

3.2.2 Number of days to 90% maturity

The interaction between inter-row spacing and variety also had no significant ($P=0.05$) effect on the mean number of days for 90% of the plants to reach maturity. Inter-row spacing did not influence the number of days taken by 90% of the plants to reach maturity (Table 2). Across the three inter-row spacings, 90% of the plants took 61.5 days to reach maturity.

Cowpea varieties significantly affected ($P=0.05$) the number of days for 90% of the plants to reach maturity (Table 3). The varieties RIL 69 and RIL 265 took more days than RIL 79. These results indicate that although these three varieties were early-maturing, RIL 79 took a shorter time for 90% of the plants to reach maturity than the others.

3.3 Yield and Yield Components

3.3.1 Number of pods/plant

The interaction between inter-row spacing and variety had no significant ($P=0.05$) effect on the number of cowpea pods/plant in the second trial. Inter-row spacing had no significant ($P=0.05$) effect on the mean number of pods/plant (Table 2). The average number of pods/plant across all inter-row spacings was 25.6.

The varieties were significantly ($P=0.05$) affected by the number of pods/plant (Table 3). The variety RIL 69 recorded the highest number of pods/plant. The varieties RIL 265 and RIL 79 had a similar number of pods/plant. These results are in line with those reported by earlier scientists [26].

3.3.2 Number of seeds/pod

The interaction between inter-row spacing and variety significantly affected the number of cowpea seeds/pod in the second trial (Figure 1). The variety RIL 69 had the highest number of seeds/pod and this was similar at the different inter-row spacings. The variety RIL 79 produced the least number of seeds/pod; the order was RIL 69>RIL 265>RIL 79. The number of seeds/pod in varieties RIL 265 and RIL 79 increased with an increase in the inter-row spacing and the highest was recorded when the crop was sown at 75 cm × 25 cm. Previous research has also revealed that the number of seeds/pod increased significantly with an increase in inter-row spacing [26]. However, these findings contradict those of other authors who found that plant population had little or no effect on the number of seeds per pod [25]. These observations further indicate that the response of plants to different spacings/densities depends on the morphology of the varieties involved.

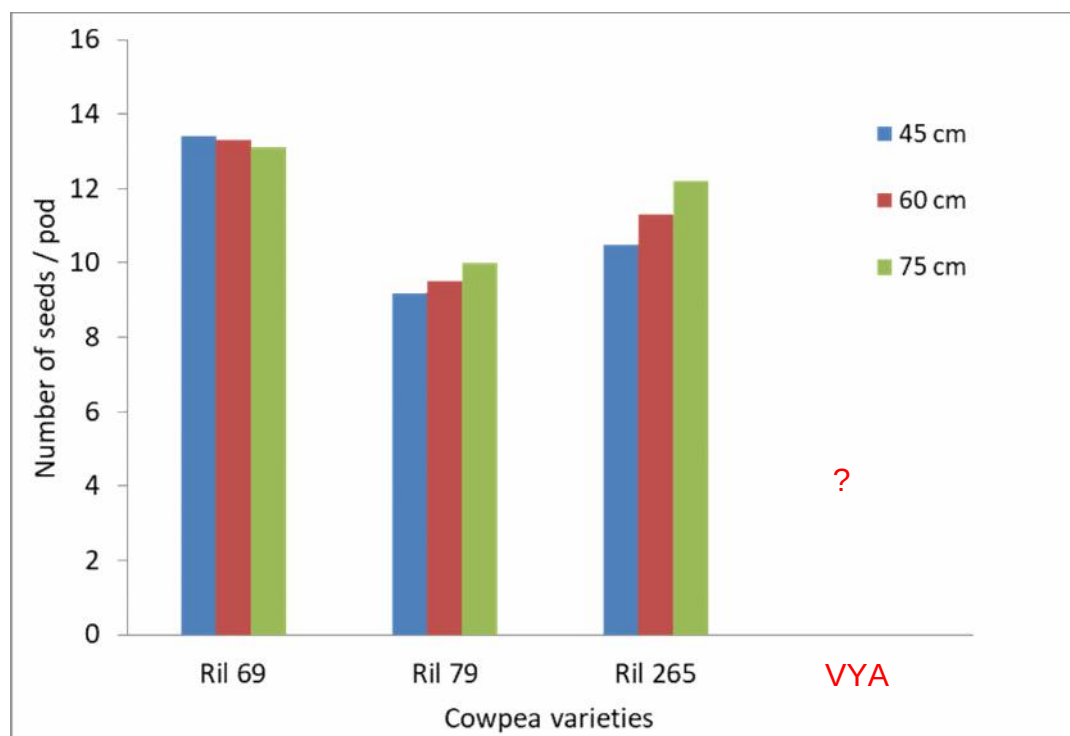


Figure 1: Effect of inter-row spacing and variety on the number of cowpea seeds/pod

3.3.3 Grain yield ($t\ ha^{-1}$)

There was a significant ($P=0.05$) interaction between inter-row spacing and variety for the grain yield of cowpea (Figure 2). These results suggest that the cowpea varieties performed differently at different inter-row spacings. In general, grain yield decreased with an increase in inter-row spacing. All the varieties had the highest grain yield when sown at an inter-row spacing of 45 cm $\times$ 25 cm and the lowest yield at 75 cm $\times$ 25 cm. These results showed that a decrease in inter-row spacing (or an increase in the plant population) led to a corresponding increase in grain yield. Results of some earlier studies also revealed that higher grain yield was obtained at close (high plant density) than at wide (low plant density) spacing [19][26] [27]. Overall, the highest grain yield was recorded for RIL 69 when sown at 45 cm $\times$ 25 cm. At the different inter-row spacings, RIL 69 also had the highest yield. The lowest yield was recorded for RIL 265 sown at 75 cm $\times$ 25 cm and RIL 79 sown at 60 cm $\times$ 25 cm and 75 cm $\times$ 25 cm. Previous studies have also indicated that there were significant differences in grain yield between cowpea genotypes [19].

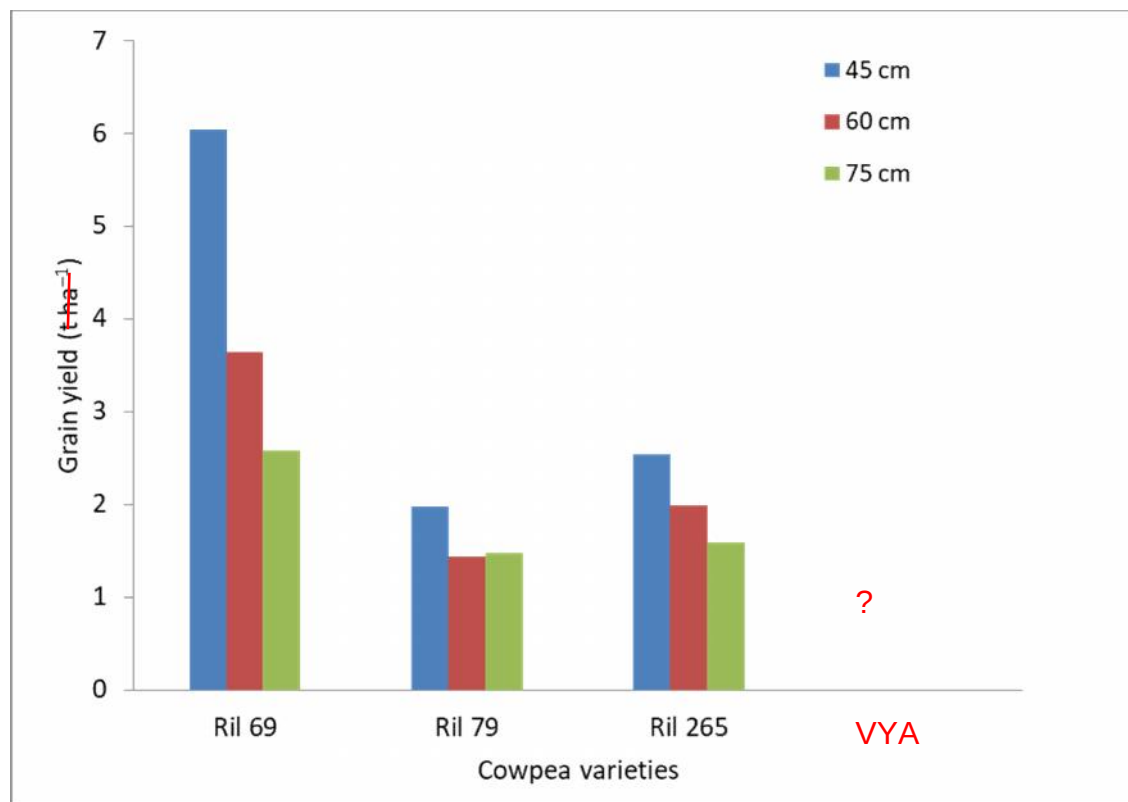


Figure 2: Effect of inter-row spacing and variety on the grain yield of cowpea

3.3.4 100-Seed weight

The interaction between inter-row spacing and variety was not significant ($P=0.05$) for 100–seed weight of cowpea. Inter-row spacing had no significant effect ($P=0.05$) on 100–seed weight (Table 2). The average value for 100–seed weight across all spacings was 15.4 g. There were significant variations among the cowpea varieties for 100–seed weight (Table 3). One hundred seed weight for RIL 69 and RIL 265 was higher than that for RIL 79. Variety RIL 69 had the highest 100–seed weight (18.20g) while RIL 79 had the least (13.07 g). These results are similar to those of other researchers who reported that cowpea genotypes were significantly affected by the mean 100–seed weight [19].

3.3.5 Fodder yield ($t\ ha^{-1}$)

During the first season, there were significant ($P=0.05$) differences in fodder yield at the different inter-row spacings (Table 1). Plants sown at inter-row spacings of 75 cm $\times$ 25 cm and 90 cm $\times$ 25 cm had higher fodder yield than those sown at 50 cm $\times$ 25 cm. These results indicate that the fodder yield was

more at wide than at close spacing. These findings do not agree with those of other studies which indicated that cowpea fodder yield was more at close than at wide spacing [19].

During the second season, there was no interaction between inter-row spacing and variety for cowpea fodder yield. Inter-row spacing had no influence on fodder yield. The mean fodder yield across the various inter-row spacings was 2.8 t ha^{-1} . The varieties had a significant effect ($P=0.05$) on the fodder yield. Variety RIL 69 had higher fodder yield than VYA and RIL 265 (Fig 3). The fodder yield for the different varieties was in the order RIL 69>RIL 79>RIL 265=VYA.

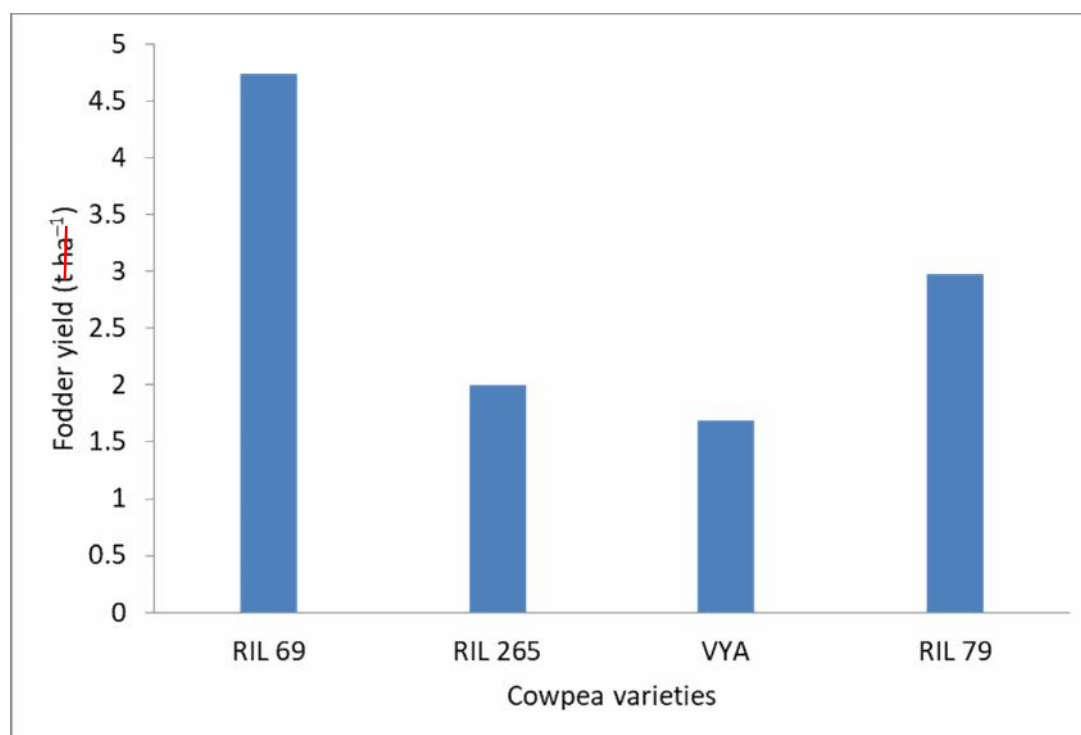


Figure 3: Effect of variety on the fodder yield of cowpea

4. CONCLUSION

The results of this study revealed that there was no significant interaction between inter-row spacing and cowpea varieties for the growth and phenological traits. This suggests that the varieties responded similarly to inter-row spacing. However, inter-row spacing had a significant influence on the yield of the cowpea varieties. All the varieties had outstanding yield performance when sown at a spacing of 45 cm × 25 cm. The variety RIL 69 when sown at 45 cm × 25 cm (88,888 plants/ha) gave

275 higher grain yield than all other varieties. Therefore sowing cowpea at close spacing resulted to an
276 increase in the grain yield.

277 **References**

- 278 1. Mortimore MJ, Singh BB, Harris F, Blade SF. Cowpea in traditional cropping systems. In:
279 Singh BB, Mohan Raj DR, Dasheill KK, Jackai LEN, editors. Advances in Cowpea
280 Research. Sayce Publishing, Devon, UK; 1997; pp. 99–113.
- 281 2. Van Ek GA, Henriët J, Blade SF, Singh BB. ~~(1997)~~. Quantitative assessment of traditional
282 cropping systems in the Sudan savanna of northern Nigeria II. Management and productivity
283 of major cropping systems. Samaru J Agric Res. 1997; 14:47–60.
- 284 3. Singh BB, Ehlers JD, Sharma B, Freire-Filho FR. Recent progress in cowpea breeding. In:
285 Fatokun CA, Tarawali SA, Singh BB, Kormawa PM, Tawo M, editors. Challenges and
286 opportunities for enhancing sustainable cowpea production. Proceedings of the World
287 Cowpea Conference III, 4–8 September 2000; International Institute of Tropical Agriculture
288 Ibadan, Nigeria, 2000; pp. 167–184.
- 289 4. Taffouo V, Kenne M, Fokam TR, Fotsop W, Fonkou TV, Amougou A. Variation de la
290 réponse au stress salin chez cinq espèces de Légumineuses. Int J Innov Scient Res 2004;
291 16:33–44.
- 292 5. Islam S, Cowmen RC, Ganer JO. Screening for tolerance of stress temperature during
293 germination of twenty-five cowpea (*Vigna unguiculata* L. Walp) cultivars. J Food, Agric
294 Env. 2006; 4(2):189–191.
- 295 6. Ajeigbe HA, Singh BB, Adeosun JO, Ezeaku IE. Participatory on-farm evaluation of
296 improved legume-cereals cropping systems for crop-livestock farmers: Maize-double cowpea
297 in northern Guinea savannah Zone of Nigeria. African J Agric Res. 2010; 5:2080–2088.

- 298 7. Ajeigbe HA, Singh BB, Oseni TO. Cowpea-cereal intercrop productivity in the Sudan
299 savannah zone of Nigeria as affected by planting pattern, crop variety and pest management.
300 African Crop Sci J. 2005; 13:269–279.
- 301 8. Ajeigbe HA, Singh BB, Emechebe AM. Field evaluation of improved cowpea lines for
302 resistance to bacterial blight, virus and *Striga* under natural infestation in the West African
303 savannas. African J Biotech. 2008; 7:3563–3568.
- 304 9. Ajeigbe HA, Singh BB, Ezeaku IE, Adeosun JO. On-farm evaluation of improved cowpea-
305 cereals cropping systems for crop-livestock farmers: Cereals-cowpea systems in Sudan
306 savannah zone of Nigeria. African J Agric Res. 2010; 5:2297–2304.
- 307 10. Muhammad AN, Asghar A, Rashid SL, Mudassar M. Effect of different planting patterns
308 on growth, yield and quality of grain. Pakistan J Life Soc sci. 2002; 2(2):132–135.
- 309 11. Kamara AY, Sylvester UE, Tofa AI, Steve B. Agronomic response of soybean to plant
310 density in the Guinea savannahs of Nigeria. Agronomy J. 2014; 106:1051–1059.
- 311 12. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research. 2nd ed. New
312 York, John Wiley and sons, 1984; pp. 680.
- 313 13. Ndiaga C. Genotype × row spacing and environment interaction of cowpea in semi- arid
314 zones. African Crop Sci J. 2000; 9(2):359–367.
- 315 14. Shirtliffe SJ, Johnston AM. Yield-density relationships and optimum plant populations in
316 two cultivars of solid-seeded dry bean (*Phaseolus vulgaris*) grown in Saskatchewan. Canad J
317 Plant Sci. 2002; 82:521–529.
- 318 15. Kibe AM, Kamithi DK. Production potential of Desi chickpea grown under various
319 nitrogen and planting densities at Naivasha. Agric J. 2007; 2(4):520–527.

- 320 16. Dahmardeh M, Ramroodi M, Valizadeh J. Effect of plant density and cultivars on growth,
321 yield and yield components of Faba bean (*Vicia faba* L.). African J Biotech. 2010;
322 9(50):8643–8647.
- 323 17. Nangju D, Littls TM, Anjorin OA. Effect of plant density and special arrangement on
324 seed yield of Cowpea. J Amer Soc Hort Sci. 1975; 100:467–470.
- 325 18. Monneveux P, Zaidi PH, Sanchez C. Population density and low nitrogen affects yield-
326 associated traits in tropical maize. Crop Sci. 2005; 45:2–7.
- 327 19. Kamara A, Tofa A, Kyei-Boahen S, Solomon R, Ajeigbe H, Kamai N. Effects of plant
328 density on the performance of cowpea in Nigerian savannas. Expl Agric. 2018; 54(1):120–
329 132.
- 330 20. Toudou DAK, Atta S, Inoussa MM. Effect of plant density and genotypes of cowpea
331 (*Vigna unguiculata* (L.) Walp.) on the growth and yield of millet (*Pennisetum glaucum* (L.)
332 R. Br.). ARPN J Agric Biol Sci. 2016; 11(6):242–247.
- 333 21. El Naim AM, Hagelsheep AM, Abdelmuhsin MS, Abdalla AE. Effect of intra-row
334 spacing on growth and yield of three cowpea (*Vigna unguiculata* L. Walp) varieties under
335 rainfed. Res J Agric Bio Sci. 2010; 6(5):623–629.
- 336 22. Malami BS, Samai’la M. Effects of inter and intra row spacing on growth characteristics
337 and fodder yield of cowpea (*Vigna unguiculata* (L) Walp. Var. Kanannado) in the semi-arid
338 north-western Nigeria. Nigerian J Basic Appl Sci. 2012; 20(2):125–129.
- 339 23. Lazim MH and El Nadi AH. Growth and yield of irrigated sesame. I. Effects of
340 population and variety on vegetative growth. Exp Agric. 1974; 10(01):65–69.
- 341 24. Chatterjee R, Som MG. Response of French bean to different rates of P, K and plant
342 spacing. Crop Res. 1991; 4:214–217.
- 343 25. Salih FA. Effect of nitrogen application and plant population per hill on faba bean (*Vicia*
344 *faba* L.) yield. FABIS Newsletter. 1987; 17:27–30.

- 345 26. Jakusko BB, Anasunda UI, Mustapha AB). Effect of inter-row spacing on some selected
346 cowpea (*Vigna unguiculata* (L) Walp) varieties in Yola, Adamawa State, Nigeria. IOSR J
347 Agric Vet Sci. 2013; 2(3):30–35.
- 348 27. Ismail AM, Hall AE. Semi-dwarf and standard-height cowpea responses to to row
349 spacing in different environments. Crop Sci. 2000; 40:1618–1623.

