

CROSS-COMPATIBILITY OF CULTIVATED COWPEA VARIETIES AND THEIR WILD RELATIVES: IMPLICATIONS FOR CROP IMPROVEMENT

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ABSTRACT

*Hybridization programmes that potentially exploit the variability existing in the wild germplasm of *Vigna unguiculata* L. Walpers could be of great potential for the future of plant breeding. Bearing this in mind, four cultivated cowpea varieties (Achi shuru, Ife Brown, Kanannado and Zebra bean) were crossed to two of their wild relatives: subsp. *dekindtiana* var. *pubescens* and subsp. *unguiculata* var. *spontanea* to ascertain the cross compatibility, reproductive potential and possible heterosis in the F_1 generations. Results showed that the cultivated varieties hybridized relatively well with their wild relatives showing pod set range of 42.9% to 52.3% in crosses with subsp. *dekindtiana* var. *pubescens* and 40.0% to 52.0% in crosses with subsp. *unguiculata* var. *spontanea*. The F_1 hybrid plants showed high heterosis in plant height, number of leaves per plant, number of flowers per plant, number of pods per plant and percentage pod set. They also produced viable seeds for F_2 generations. These results are indications of a good reproductive potential of the hybrids thus making the wild relatives, good sources of important gene pool for the improvement of the cultivated populations.*

Keywords: cowpea, F_1 hybrids, *pubescens*, heterosis, *spontanea*.

<https://dx.doi.org/10.4314/jafs.v19i1.8>

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp), one of the most important pulse crops native to West Africa, belongs to the family Fabaceae. Cultivated cowpea, which is in subspecies *unguiculata*, is divided into five cultivar groups namely: *Unguiculata*, *Sesquipedalis*, *Textilis*, *Biflora* and *Melanophthalmus* (Boukar *et al.*, 2018). The commonly cultivated cowpea belongs to cultivar group *Unguiculata* while members of cultivar group *Textilis*, characterized by long peduncles are grown in some parts of Nigeria for production of fibre. Cowpea is a diploid with $2n = 22$ and a genome size of about 620 million base pairs. Kouam *et al.* (2012) and Xiong *et al.* (2016), stated

the area of maximum diversity of land races and cultivated cowpeas to be West and Central Africa. Cowpea is called vegetable meat due to high amount of protein in grain(s) with better biological value on dry weight basis. Cowpea grains contain 23% to 32% percent protein, 1.8 per cent fat and 60.3 per cent carbohydrates and a rich source of minerals and vitamins (Hall *et al.*, 2003). Besides this, cowpea forms excellent forage and gives a heavy vegetative growth that covers the ground so well that it checks soil erosion and weeds. As a leguminous crop, it fixes about 70 - 240 kg per ha of nitrogen per year (Usman *et al.*, 2018). Cowpea is native to West Africa where wild and weedy forms exist in many parts of the region (Ogunkanmi *et al.*, 2008). Cop wild relatives are used in their wild state. A number of wild cowpea species (*Vigna* spp.) in Africa contribute directly to food security through consumption of their tubers, fruits and seeds (Biodiversity International, 2012). Crop wild relatives (CWR) are important for maintaining genetic diversity and preventing loss of germplasm due to genetic vulnerability. Wild relatives of crop species are often sourcing of genes for disease and insect resistance, increased yield, improved product quality, earliness and wide adaptations (Khoury and Guarino, 2010). Wild forms and closely related species of cowpea, therefore, have great potential as an additional source of useful germplasm for cowpea improvement (Boukar *et al.*, 2020). The first crossings between crop wild relatives and cultivars to obtain disease resistant varieties date back to the 1890's (Biodiversity International, 2012), with pest and disease resistance currently remaining the highest priority for breeders and CWR being used primarily for this purpose.

Reports (Mohammed *et al.*, 2010; Nwosu and Awa, 2013), have shown that wild and the weedy subspecies of cowpea (*V. unguiculata* subsp. *dekindtiana*, *stenophylla* etc.) hybridize easily with the cultivated forms and produce viable hybrids. Mohammed *et al.* (2010) reported successful crossing between cultivated cowpea varieties and their wild relative (var. *pubescens* TVNu 110-3A). In order to utilise wild relatives of cowpea effectively for cultivar improvement, their cross compatibility and reproductive potential need be ascertained.

Members of the var. *pubescens* have been known to confer some degree of insect resistance on cowpea (Fatokun and Singh, 2001) owing to the presence of hairs (hence the name *pubescens*) on the plants. The wild cowpea variety subsp. *dekindtiana* var. *pubescens* used in this study is extremely hairy while var. *spontanea* is hairy. Therefore, transferring the hairiness trait from the wild lines to the cultivated varieties will be of great interest in cowpea improvement for

insect resistance and thus avoidance of pathogens transmitted by such insects. This natural occurring physiological mechanism of incompatibility in some plants enforces their out breeding and has been known to be widespread throughout the families of flowering plants (Lewis, 2008). Moreover, authors have noted the narrow genetic base of cowpea despite large number of germplasm available in gene banks (Li *et al.*, 2001, Boukar *et al.*, 2020). This they attributed to cowpeas high self-pollinating characteristic and consistent improvement of the crop using elite lines. The Knowledge of the genetics and physiology of self and cross incompatibility is prerequisite to planning an improvement program for a species possessing an incompatibility system (Townsend and Taylor, 2015; Muñoz-Sanz *et al.*, 2020). The objectives of this study, therefore, were to determine the cross compatibility between four cultivated cowpea varieties and two wild cowpea relatives: subsp. *dekindtiana* var. *pubescens* and subsp. *unguiculata* var *spontenea* as well as to ascertain the viability, reproductive potential, and heterosis of the F₁ hybrids from these crosses.

MATERIALS AND METHOD

Six cowpea lines, comprising four cultivated and two wild varieties, were used in the study. The cultivated varieties are Achi shuru (landrace), Kanannado (both are cultivated widely in the Savannah region of Nigeria), Ife Brown and Zebra bean (are cultivated in the western rainforest region of Nigeria). The properties of the wild variety subsp. *dekindtiana* var. *pubescens* (collected from ATBU, Bauchi) and subsps. *unguiculata* var. *spontenea* (collected from the National Gene bank in NACGRAB, Ibadan) are described in Table 1.

The experiments were conducted in the Screen house at National Centre for Genetic Resources and Biotechnology (NACGRAB), Moor Plantation, Ibadan (7° 22'N and 3° 50'E). The first Experiments involved hand crossing each of the four cultivated cowpea varieties to the wild varieties. This exercise was carried out between October and November 2011 as modified by Nwosu and Awa (2013). The wild varieties were used as pollen parents. Pods containing F₁ seeds were harvested at maturity. Number of flowers emasculated and pollinated and number of mature pods set were recorded and compared using percentages. Parents and F₁ seeds were sown in the second experiment at the NACGRAB Mesh House. Seeds from each of the six parents and their eight F₁ generations were sown in poly pots measuring 35cm in height and 18cm in

diameter. Two seeds were sown per pot and replicated five times in a completely randomized design. Seeds of the wild variety were mechanically scarified before sowing. The pots were watered regularly and weeds were hand removed. Data on mean plant height, number of leaves per plant, mean number of flowers and number of pods plant⁻¹ were recorded, compiled and subjected to Analysis of variance (ANOVA) using Statistics for Agricultural Systems (SAS) 9. Means with significant differences were separated using Turkey's test. Pod set was also compared using percentages.

RESULTS AND DISCUSSION

The four cultivated cowpea varieties crossed well with their wild relatives by classical breeding, producing 219 (47.81%) mature pods out of total 458 flowers emasculated for crosses with var. *pubescens* and 170 (46.31%) mature pods of 367 emasculated flowers for var. *spontenea* (Table 2). This result compares well with mean percentage pod set (54.08%) for natural selfing of the female parents and is higher than that of the pollen parents (Table 2). Controlled crossing environment and careful handling are the likely reasons for this success. The pod set may be lowered by the pollen parents with lower pod set despite higher number of flowers (Table 2). The F₁ crosses mean percentage pod set of 56.248% and 77.89% for crosses with var. *pubescens* and var. *spontenea* respectively are higher than those of the parents (Table 2), showing heterosis for pod set in the crosses and thus cross-compatibility between the cultivated cowpea and their wild relatives. The results corroborate those of Mohammed *et al.*, 2010) and Nwosu and Awa (2013).

Viability of the F₁ seeds of all the crosses indicates good reproductive potential and is a good indication for progressive generations with improved traits. Number of flowers produced was significantly higher in the F₁ crosses as compared to the parents except for the wild genotypes (Table 2). The wild significantly produced more flowers and more pods per plant than all the other parents. However, the F₁ genotypes had a higher number of pods set than all the maternal parents. Higher number of pods leads to higher number of seeds per plant resulting in higher grain yield. This may be an indication that the high yielding capability of the wild cowpea is dominant and may have been inherited by the F₁ crosses. Achi shuru x *spontenea* produced significantly ($P < 0.05$) the greatest number of pods comparable to the wild

parents while Ife brown x *spontenea* had a significantly highest percentage pod set (Table 2). Similarly, the F₁ crosses had higher number of pods per plant and percentage mature pods per plant than most of the parents. However, results from percentage pod set show that more of the flowers of the wild parents were wasted as compared to the paternal parents and the F₁ crosses.

Zebra bean x *pubescens* plants were significantly ($P < 0.05$) taller than other genotypes while Kanannado x *spontenea* had significantly more leaves per plant than other genotypes (Table 3). Furthermore, plant height and number of leaves per plant were significantly higher in F₁ crosses as compared to the parents (Table 3). This result again confirms the reproductive vigour and heterosis of the F₁ crosses of cultivated cowpea and their wild relative var. *pubescens* over the parents. Generally, crosses with *spontenea* produced taller plants with more leaves, more pods and percentage pod set when compared to crosses involving *pubescens*. This may be an indication of good combining ability between the two subspecies.

The success of these crosses portends great potentials in the exploitation of rich gene pool of the wild to improve cultivated varieties of cowpea. This is more pertinent even now given the challenges of new diseases, pests, climate change and population explosion to food productivity and food security. Traits of resistance or tolerance to biotic and abiotic stresses could be introgressed into cowpea gene pool for improved productivity in the future.

CONCLUSION

The results show that cultivated varieties of cowpea are cross-compatible with their wild relatives; var. *pubescens* and var. *spontenea* producing viable F₁ seeds with high reproductive potential as well as good hybrid vigour. It is suggested, that the gene pool of wild cowpea varieties be sourced for improvement of cultivated varieties. The further implication of this is to broaden the hitherto narrow gene pool of the cultivated cowpea.

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APPENDICES

Table 1: Growth and physical characteristics of the four cultivated and their wild relatives used in this study.

Character	Variety					
	Var <i>pubescens</i>	Var <i>spontenea</i>	Achishuru	Ife brown	Kanannado	Zebra bean
Growth habit	Spreading	Spreading	Spreading	Semi- erect	Spreading	Spreading
Flower colour of wing	Purple	Purple	Purple	Purple	Purple margin	Spreading
Stem hairiness	Hairy	Hairy	Smooth	Smooth	Smooth	Smooth
Pod shape	Straight	Straight	Straight	Straight	Coiling	Straight
Seed coat colour	black	Coffee brown	brown	Brown	white	Brown with white stripes
Seed size	small	small	medium	Medium	large	medium

Table 2: Number of flowers hybridized, pod set and percentage of pod set in crosses between four cultivated cowpea and their two wild relatives.

Crosses	Number of flowers pollinated	Number of pods set	Percentage of pod set (%)
Achi shuru x var <i>pubescens</i>	120	58	48.3
Ife brown x var <i>pubescens</i>	132	69	52.3
Kanannado x var <i>pubescens</i>	108	50	46.3
Zebra bean x var <i>pubescens</i>	98	42	42.9
Total	458	219	47.81 (mean)
Achi shuru x var <i>spontenea</i>	102	53	52.0
Ife brown x var <i>spontenea</i>	100	48	48.0
Kanannado x var <i>spontenea</i>	85	37	43.0
Zebra bean x var <i>spontenea</i>	80	32	40.0
Total	367	170	46.31 (Mean)

Table 3: Plant height, number of leaves, number of flowers, number of pods, percentage of mature pods produced per plant in parents and F₁ crosses of cultivated cowpea and their wild relatives.

Treatment		Plant height	Number of leaves/plant	Number of flowers/plant	Number of pod/plant	Percentage pod set (%)
PARENTS						
Achi shiru		95.83 ^{b-d}	23.50 ^{cd}	29.75 ^{def}	15.75 ^e	53.30 ^{c-f}
Ife Brown		43.33 ^g	18.25 ^d	26.00 ^{ef}	16.25 ^e	64.08 ^{bcd}
Kanannado		39.93 ^g	25.75 ^{bcd}	29.00 ^{ef}	14.75 ^{ef}	50.75 ^{c-f}
Zebra bean		82.15 ^{d^{ef}}	19.25 ^d	20.25 ^f	9.50 ^f	48.20 ^{c-f}
Mean		65.31	21.69	26.25	14.06	54.08
<i>pubescens</i>		72.00 ^{ef}	19.25 ^d	90.00 ^a	35.75 ^a	39.49 ^{ef}
<i>spontenea</i>		70.00 ^f	21.00 ^d	92.00 ^a	34.00 ^a	36.94 ^f
F1 CROSSES						
Achi shiru	x	106.65 ^{bc}	25.75 ^{bcd}	58.75 ^b	30.25 ^{ab}	53.76 ^{c-f}
<i>pubescens</i>						
Ife Brown	x	92.60 ^{cd}	31.75 ^{ab}	47.00 ^c	27.50 ^{bc}	58.93 ^{b-e}
<i>pubescens</i>						
Kanannado	x	89.05 ^{cde}	20.00 ^d	36.25 ^{cde}	23.75 ^{bc}	67.81 ^{abc}
<i>pubescens</i>						
Zebra bean	x	129.33 ^a	32.50 ^{ab}	45.00 ^c	20.00 ^{de}	44.47 ^{def}
<i>pubescens</i>						
Mean		104.41	27.50	46.75	25.38	56.24
Achi shiru	x	106.85 ^{ef}	33.00 ^{ab}	44.75 ^c	35.00 ^a	79.42 ^{ab}
<i>spontenea</i>						
Ife Brown	x	107.68 ^{bc}	29.25 ^{bc}	32.75 ^{de}	30.25 ^{ab}	84.62 ^a
<i>spontenea</i>						
Kanannado	x	113.33 ^{ab}	38.00 ^a	40.25 ^{cd}	31.50 ^{ab}	78.31 ^{ab}
<i>spontenea</i>						
Zebra bean	x	103.13 ^{bc}	32.25 ^{ab}	45.25 ^d	30.00 ^{ab}	69.19 ^{ab}
<i>spontenea</i>						
Mean		107.75	33.13	40.75	31.69	77.89
SEM (0.05)		3.70	1.45	1.07	1.21	
F- value		18.03	7.83	38.15	19.40	
CV		13.58	17.4	15.4	15.4	

Means followed by the same letter(s) in the same column are not significantly different at 5% level of probability (Tukey's).