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Heterosis Evaluation in Single Pair Wise F1 Progenies of Vernonia Species.

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ABSTRACT

Objective

The objective of this study was to examine the parent-hybrid relationships in single pair wise F1 crosses between Ikom and Riverine bitter leaf cultivars in Awka, Southeastern Nigeria.

Overview

The experiment was conducted during the 2024 and 2025 cropping seasons at the Teaching and Research Farm, Faculty of Agriculture, Nnamdi Azikiwe University, Awka. The one-way crosses involved Ikom x Ikom, Riverine x Riverine and Ikom x Riverine in a Pair-wise mating design which were replicated three times on a RCBD Experimental site. The leaves of the progenies were tested for phytochemical and proximate compositions at the Biotechnology Lab National Root Crop Research Institute Umuahia, Abia State.

Results

Evaluation at 5% degree level of significance showed that Ikom x Riverine (I_1 x R_1) hybrid progeny outperformed the Ikom x Ikom (I_1 x I_2), and Riverine x Riverine(R_1 x R_2) inbred lines in all the measured agronomic parameters showing high mid parent heterosis (MPH) estimate in plant height(65%), number of branches(73%), number of leaves (67%), measured leaf area(82%), stem girth(23%) and longest branch length(88%). Positive heterosis for fat (+60%), and vitamin C (+8.9%) showed nutritional superiority. Among the phytochemical parameters, the same hybrid progeny showed negative MPH in Alkaloids (-12%), Saponins (-20%) and Oxalates (-12%) which indicated better palatability and digestibility.

Conclusion

The Ikom x Riverine cross progeny high heterosis on agronomic and nutritional components makes it a high yielding and nutritious bitter leaf hybrid that is relatively less bitter and well situated for commercial production. Although F1 off springs are highly heterogeneous and tend to lose most of its desirable traits in further crosses, the progeny can conveniently be multiplied through cloning which retains most of these traits.

Keywords: Bitter leaf, MPH, cultivars, pair wise crosses, F1, proximate, phytochemicals

INTRODUCTION

Vernonia amygdalina is a perennial shrub of Asteraceae family and commonly called 'Bitter Leaf' because of the bitter taste of its leaves,Specifically, it is used to prepare the popular Nigerian bitter leaf soup, "Onugbo" and as spice in the Cameroon dish called "Ndole" (Jibrin *et al.,* 2024).Bitter leaf is cultivated in Nigeria mainly for its nutritional value in human diet, the presence of vitamins, phytochemicals and mineral salts which are useful for the maintenance of health, prevention and treatment of various diseases (Quasie et al,.2016). Phytochemicals are natural occurring bioactive compounds known for their health benefits (Luo et al., 2017).Several studies carried out on *V. amygdalina* had suggested that it contains different bio active compounds including flavonoids, saponins, alkaloids, tannins, phenolics, terpenes, steroidal glycosides, triterpenoids, and several types of sesquiterpene lactones which are useful in treatment of diseases such as malaria, infertility, diabetes, gastrointestinal problems and sexually transmitted diseases (Okolie, *et al.,* 2022). There are many cultivars based on environmental conditions and features like level of bitterness, size and colour of leaves (Alara et al.,2017). The type and quantity of phytochemicals in this plant is affected by the environment. In plant breeding, different types of crosses are used to combine desirable traits from parent plants. Pair-wise mating design is a crossing system where selected parents are crossed in specific pairs, rather than making all possible combinations (as in diallel). Each parent is deliberately mated with another parent based on breeding objectives. It is also called paired crossing or selective biparental crossing. Heterosis also known as hybrid vigor refers to the phenomenon where the offspring (hybrids) of two genetically distinct individuals exhibit improved or enhanced biological performance compared to their parents. Heterosis in plant breeding is described as the superiority of an F1 hybrid over both parents in terms of yield and other characteristics (Ammar, 2014). Heterosis results in superiority over its parents in adaptability, yield, quality, disease resistance, maturity, and general vigor. Positive heterosis is often seen as desirable. However, in some circumstances, negative heterosis is preferable. Negative heterosis for plant height, maturity time, and hazardous chemicals, for example, is beneficial in many circumstances since it demonstrates superiority over the parents. In most agricultural plants, heterosis of 40% or more over the superior parent is regarded as substantial from a practical standpoint. The three main genetic theories explaining why heterosis occurs are: Dominance Hypothesis: Harmful recessive alleles from one parent are masked (covered up) by dominant, beneficial alleles from the other parent, Over dominance Hypothesis: The combination of two different alleles at a specific gene locus makes the hybrid superior to either parent that has two identical alleles..(Wu et al.,2021). Epistasis Hypothesis: The interaction between the alleles of different locus .(Ammar et al., 2014). The aim of the research is to perform single pair wise crosses to combine the high growth and leaf yield traits of Ikom cultivar with the nutrients rich and low Alkaloids traits of Riverine cultivar.

MATERIALS AND METHODS

Experimental site. The experiment was conducted during the 2024 and 2025 cropping season at the Teaching and Research Farm, Faculty of Agriculture, Nnamdi Azikiwe University, Awka. Awka is located within latitude 6°16'N and longitude 7°07'E with an altitude of 422m and an average rainfall of 1650mm to 1824 per annum, a mean minimum and maximum temperature of 27^0C and 32^0C respectively, and a relative humidity of 75-80%. The rainfall distribution is bimodal, between April and July and between September and November with a short break in August.

Experimental Materials

a. Vernonia calvoana: Common names: (common upland bitter leaf, Ikom cultivar) Common in the Cameroon mountains edges, forest edges and farms of Cross Rivers State, Nigeria. It is a shrub that grows up to 4 m high and the most vigorous growing *Vernonia* cultivar, the leaves are less bitter than *V. amygdalina* (Jibrin et al., 2024). The accession that was used is Ikom.

b. Vernonia hymenolepis: Common names (Riverine, Sweet bitter leaf) is a kitchen-garden crop with broad leaves and are naturally found in Riverine communities in High Rainfall areas of Nigeria as either annual or perennial depending on the availability of moisture in the soil and most responsive to soil moisture and being non-bitter requires no maceration before use and very rich in nutrients (Okolie, *et al.,* 2022). The accession that was used is Riverine.

Pollination and Cultural Practices

The parental materials mature stems of Riverine and Ikom Cultivars were collected from Vernonia species germplasm farm at Nnamdi Azikiwe University, Awka. They were Planted differently on two strips and at different times (staggered planting) to ensure their flowering periods overlap. Stem cuttings of 15cm with 3-5 buds were planted horizontal at 1m x 1m (Ndukwe et.al.,2021). About 20 cuttings of each cultivar were planted. They started flowering in dry season around November and were crossed with hand in a single pair wise fashion in December 2024. *Vernonia* species exhibit protandry, those of the same capitulum do not mature at the same time. The central florets are usually younger than those at the periphery (Nguimkeng et al., 2015). Dry cotton buds were used to collect shed pollen dust for pollination of the desired florets that have already shed their pollens. Adjoining florets that were not hand pollinated were destroyed with the forceps sharp edge and muslin bags were used to cover pollinated florets and then properly tagged. Crosses were done in the early hours between 7am - 10 am when the pollen grains are still viable. In the Ikom x Riverine cross, the Riverine plants served as the female parent while in the in-bred crosses, Ikom x Ikom and Riverine x Riverine both served as male and female plants. The tagged pollinated flower seeds were harvested in January 2025 and then planted in separately a Nursery. Healthy seedlings were transplanted at 4 leaves stage to the field.

After clearing the site, soil samples will be collected uniformly and mixed to a composite for analysis. Nine (9) beds, that is, plots of 3m x 3m were made and incorporated with 9kg cured poultry manure per bed at 10t/ha (Ndukwe et al.,2021). The experiment was laid out in simple lattice design. Planting was done one week later.

i. Each plot was 3m x 3m (9m^2) with 9 stands of each progeny.

ii. Each replicate was 4m x13m (52m^2) with 27 stands of all the progenies.

iii. The experimental field was 13m x 13m (169m^2) with 81 stands of all the progenies.

There was 1m x 1m intra plot spacing walkways. Weeding and other post planting activities were done as need be.

Estimation of Heterosis:

Heterosis was estimated based on Mid-parent heterosis (Ht) using the method suggested by (Shull, 1908) and used by Singh et al., (2021).

Mid-parent heterosis (%) = {(F1-MP)/MP} X 100.Where F1 is the mean value of F1, and MP is the mean value of the two parents involved in the cross. Testing whether heterosis value was significant or not was done following the procedure given by Panse and Sukhatme (1961) which explains the respective heterosis value (Calculated ’t’ value) was computed as: MPH (t) = (F – MPV) / SE , then compering this calculated ’t’ value with that of tabulated ‘t’ (using the error degree of freedom) can differentiate whether heterosis value is significant or not. i.e., If the calculated ’t’ value greater than the tabular one, H is significant and if less no-significant Panse and Sukhatme (1961)

Data Collection: After transplanting, the seedlings plant height (cm), leaf number, measured leaf area (cm), number of branches, stem girth (cm) was measured monthly. After four months the leaves were collected and tested for proximate and phytochemical contents. Proximate phytochemical compositions of the leaves were analyzed at the Biotechnology Lab of National Root Crop Research Institute Umuahia, Abia State covering terpenoids (terpenins), alkaloids (quinolin), polyphenols (tannins, phenols, flavonoids), glycosides (Saponins, cynogenic glycosides) and oxalates using the standard methods of the Association of Official Analytical Chemists (AOAC, 2005).

Data Analysis: All the data collected was analyzed using GenStat 12 edition and means were separated using Least significance difference (L.S.D) at 0.05 level of significance.

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Plate 1: CROSS at 2MAT Plate 2: IKOM at 2MAT Plate : RIVERINE at 2MA

RESULTS

The F1 progeny stem height (cm) and stem girth (cm).

Table 1 showed that the progeny of Riverine x Ikom cross (R_1 x I_1) significantly had the longest stem length throughout the course of the study, 20 cm at 4WAT, 90 cm at 8WAT and 122 cm at 12WAT. This was followed by Ikom x Ikom inbred lines (I_1 x I_2) which had stem height of 80 cm at 12WAT. The least came from Riverine x Riverine (R_1 x R_2) in bred lines which had 68 cm at 12WAT. Similar trend was followed stem girth; the hybrid (R_1 x I_1) had the widest girth at 4WAT (4 cm), 8WAT (7 cm) and 12WAT (8 cm). At 4WAT, I_1 x I_2 and R_1 x R_2 Progeny girth were the same (2.5 cm) and the same at 12WAT (6 cm).

Table 1:The F1 progeny stem height (cm) and stem girth (cm)

Crosses	Stem Height (cm)			Stem Girth (cm)		
	4WAT	8WAT	12WAT	4WAT	8WAT	12WAT
Ikom x Ikom	17.4	54.47	80.53	2.55	3.67	6.80
Riv x Riv	13.4	41.21	68.28	2.50	5.67	6.60
Ikom x Riverine	20.32	90.44	122.27	4.0	7.00	8.33
LSD	0.27	0.22	0.22	1.247	1.99	0.78

The F1 progeny Leaf number and Measured Leaf area (cm^2)

The Riverine x Ikom cross (R_1 x I_1) hybrid progeny had the largest number of number of leaves throughout the course of the project at 4WAT (14), 8WAT (132) and 12WAT (215). This trend was followed by (R_1 x R_2) in bred progeny which had at 8WAT (72) and 12WAT (144). The least number of leaves came from Ikom x Ikom inbred line (I_1 x I_2) which had 114 leaves at 12WAT. The same trend was followed in measured leaf area, the (R_1 x I_1) hybrid progeny at 4WAT (257 cm^2), 8WAT (653 cm^2) and 12WAT (677 cm^2). This was followed by R_1 x R_2 crosses that had 442 cm^2 (12WAT). The least values came from I_1 x I_2 progeny which had 300 cm^2 at 12WAT.

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Table 2:The F1 progeny Leaf number and Leaf area (cm^2)

Crosses	Leaf number			Measured Leaf Area (cm^2)		
	4WAT	8WAT	12WAT	4WAT	8WAT	12WAT
Ikom x Ikom	12	50.33	114	101.03	277.9	300
Riv x Riv	11	72	144	114.63	340.1	441.67
Ikom x Riverine	14	132.67	215	257.7	653.2	677.33
LSD	1.76	1.489	1.762	6.164	7.06	4.034

The F1 progeny branch parameters

The Riverine x Ikom cross (R_1 x I_1) hybrid progeny had the largest number of branches throughout the course of the work. 11 branches at 4WAT,19 at 8WAT, and 26 at 12WAT. This was followed by R_1 x R_2 crosses that had 11 at 8WAT and 17 at 12WAT. The least values came from I_1 x I_2 progeny which had 8 branches at 4WAT, 9 at 8WAT and 13 at 12WAT. The (R_1 x I_1) had the longest branch length (64 cm), R_1 x R_2 (35 cm) and I_1 x I_2 (33 cm) at 12WAT.

Table 3: The F1 progeny branch parameters

Crosses	Number of branches			Longest branch at 12WAT (cm)		
	4WAT	8WAT	8WAT	4WAT	8WAT	12WAT
Ikom x Ikom	8	9	13	-	-	33
Riv x Riv	5	11	17	-	-	35
Ikom x Riverine	11	19	26	-	-	64
LSD	1,3	2,618	2,267	-	-	1.309

Proximate Analysis of the F1Progeny

Proximate analysis on ash revealed that the R_1 x R_2 crosses was (8.4 Mg/100 g) and (R_1 x I_1) (9.4 Mg/100 g). The hybrid progeny was significantly the same but higher than I_1 x I_2 (8.5 Mg/100g). R_1 x R_2 (8.37%) had more moisture content than I_1 x I_2 progeny (6.7 %). The least came from R_1 x I_1 (6.1% %). R_1 x R_2 crosses had higher crude fiber (8.5 %) followed by (R_1 x I_1) (7.8 %) and I_1 x I_2 (6.7 %). While the later had higher crude protein (27 %) followed by R_1 x I_1 (25 %) and R_1 x R_2 (23 %). R_1 x I_1 progeny had more fat (4.2 %) than R_1 x R_1 (2.8 %) I_1 x I_2 (1.96 %). R_1 x I_1 significantly had more carbohydrates (43 Mg/100g) than I_1 x I_2 (43Mg/100g) and R_1 x R_2 (40 Mg/100g). Also, the dry matter in R_1 x I_1 (95 %) was higher than I_1 x I_2 (93 %) and R_1 x R_2 (90 %).

Table 4: Proximate Analysis of the F1. Progeny

Crosses	MC(%)	CP(%)	CF(%)	FAT(%)	ASH Mg/100g	CHO Mg/100g	DM (%)
Ikom x Ikom	6.733	29.49	8.44	3.99	8.507	42.69	93.56
Riverine x Riverine Ikom x Riverine	8.377 6.133	28.10 29.13	11.56 6.87	3.31 5.4	8.40 9.40	40.27 43.20	90.033 95.213
LSD 0.05	0.152	0.127	0.089	0138	0.115	0.378	0.087

MC - Moisture Content, CP - Crude Protein, CF - Crude Fiber, CHO - Carbohydrate, DM - Dry Matter.

Phytochemical Analysis of the F1 Progeny

Phytochemical components analysis of the progenies showed that the alkaloids contents of I_1 x I_2 (3.6%) was higher and followed (R_1 x I_1) (2.%) and R_1 x R_2 (1.79%). Saponins in I_1 x I_2 (4.5 %) was also significantly higher in (R_1 x I_1) (3.2 %) and R_1 x R_2 (3.6 %). (R_1 x R_2) had higher flavonoids (5.7 %) followed by (R_1 x I_1)

(4.0 %) and I_1 x I_2 (3.7 %). Tannins contents of (R_1 x I_1) (1.36 %) and I_1 x I_2 (1.39 %) were significantly the same and higher than I_1 x I_2 (1.4 %) which also had the highest oxalate content (1.7 %). Phenol content was also higher in R_1 x R_2 (3.8 Mg/100 g) and least in I_1 x I_2 (2.6 Mg/100 g).

Table 5: Phytochemical analysis of the Vernonia spp. Progeny

Crosses	Flavonoids %	Anthroquinon %	Terpenoids %	Alkaloids%	Glycosides %	Saponin%	Tannins %	Phenols Mg/100 g	Oxalate Mg/100g
Ikom x Ikom	3.733	0.080	1.744	3.6	39.16	4.592	1.394	2.697	1.667
Riv x Riv	5.783	0.069	1.744	1.796	45.78	3.629	1.423	3.863	1.507
Ikom x Riv	4.05	0.136	1.761	2.183	37.06	3.282	1.363	3.20	1.567
LSD 0.05	0.728	0.013	0.0655	0.015	1.011	0.0588	0.0052	0.067	0.0376

Minerals composition Analysis of the F1 Progeny

Table 6 showed that R_1 x I_1 cross progeny significantly had more Nitrogen (180 Mg/100g) than I_1 X I_2 (172 Mg/100g) and R_1 x R_2 (144Mg/100g). The Calcium content was highest in R_1 x R_1 cross (74 Mg/100g) followed by I_1 x I_2 (71.58 Mg/100g),The

the same (3.7) the same trend was found in Magnesium (1.5). (R_1 x I_1) had higher Potassium content (1.7) followed by (R_1 x I_1) (1.3) and I_1 x I_2 (1.). (R_1 x I_1) (0.5) and R_1 x R_2 (0.4) had similar but higher Sodium content than I_1 x I_2 (0.3). Phosphorus contents in (R_1 x I_1) (0.56) and I_1 x I_2 (0.54) were the same but higher than that of R_1 x R_2 (0.34). R_1 x I_1 (7.56) also had more Zinc than I_1 x I_2 (4.9).

Table 6: Minerals composition Analysis of the F1Progenies

Crosses	CA Mg/100g	NA Mg/100g	MG Mg/100g	PMg/100g	K Mg/100g	FE Mg/100g	ZN Mg/100g
Ikom x Ikom	71.58	172.31	166.7	27.29	1.025	0.94	0.463
Riverine x Riverine Ikom x Riverine	74.16 70.643	144.03 180.48	153.27 162.41	16.91 22.153	1.308 1.7	0.86 0.609	0.467 0.45
LSD0.05	0.476	0.213	0.144	0.0707	0.397	0.042.	0.408

CA: Calcium, NA: Sodium, MG: Magnesium, P: Phosphorus, K: Potassium, FE: Iron, ZN: Zinc

Vitamins composition Analysis of the F1 Progeny

Table 7 showed Ascorbic acid content of R_1 x R_2 (12 Mg/100g) was significantly higher than I_1 x I_2 (8. Mg/100g) and least in R_1 x I_1 (6.7 Mg/100g). The Riboflavin content of (R_1 x I_1) (0.189 Mg/100g) was also higher than that of R_1 x R_2 (6) and I_1 x I_2 (0.21). (R1 x I_1) (0.26) had more Niacin than both I_1 x I_2 (0.13) and R_1 x R_2 (0.17) which were significantly the same. The same trend was found in Thiamine (R_1 x I_1) (0.23) and Retinol where (R_1 x I_1) had (0.13), I_1 x I_2 (0.024) and R_1 x R_2 (0.016).

Table 7: Vitamins composition Analysis of the F1 Progeny.

Crosses	VIT D Mg/100g	VIT A Mg/100g	VIT B1 Mg/100g	VIT B2 Mg/100g	VIT B3 Mg/100g	VIT C Mg/100g	VIT E Mg/100g
Ikom x Ikom	0.163	0.087	0.161	0.23	0.147	8..62	0.322

Riv x Riv	0.193	0.111	0.174	0.351	0.351	12.073	0.125
Ikom x Riv	0.22	0.054	0.189	0.203	0.203	6.71	0.22
LSD0.05	0.029	0.0019.	0.002	0.014	0.002	0.117	0.0088

VIT: Vitamin; VITB1 (Thiamine), VIT.B2 (Riboflavin), VIT.B3 (Niacin), VIT.C (Ascorbic acid), VIT. A1 (Retinol), VIT.A (Beta carotene), VIT. E (Tocopherol).

Heterosis Estimation on Agronomic parameters (%) at 12WAT

Heterosis estimate on main stem height was (65%), Number of branches (73%), Longest branch length (88%), Measured Leaf area (83%), Leaf number (67%). All these parameters showed high heterosis unlike stem girth that had low heterosis (23 %). All positive heterosis are high and significant at 0.05% level of significance. All positive heterosis are high and significant at 0.05% level of significance. Table 8.

Table 8: Heterosis estimation on Agronomic parameters (%) at 12WAT

Parameters	Heterosis estimation (%)
Stem length (cm)	65
Stem girth (cm)	23.1
Number of branches	75
Longest branch length (cm)	88
Leaf number	67
Measured Leaf area (cm)	82.5
Standard error	9.45
t- value at 0.05%	2.57

Heterosis estimation on Phytochemicals Parameters (%)

Anthraquinones showed high heterosis estimate (+83.92%) while Tannins (8%) and flavonoids (11%) showed low heterosis estimate, Alkaloids (-12%), Phenols(- 2.1) Saponins (-20%) and oxalates (-1.25%) all showed negative heterosis estimate. All positive heterosis were high and significant at 0.05% level of significance.Table 9.

Table 9: Heterosis estimation on Phytochemicals Parameters (%)

Parameters	Heterosis estimation (%)
Alkaloids	-12.45
Phenols	- 2.1
Saponins	-20
Tannins	-2.85
Oxalates	-1.26
Flavonoids	-15
Anthraquinones	+83.92
Terpenoids	+0.98

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Standard error	9.86
t- value at 0.05%	2.365

Heterosis estimation on Proximate Analysis (%)

Only Fat (60%) showed high heterosis estimate. Ash (12%), Calcium (25%) Crude fibre (13%) Carbohydrate (14%) Moisture Content (14%) Dry matter (3%) all showed low heterosis estimate. Crude protein (- 4 %) showed negative heterosis**.** All positive heterosis were high and significant at 0.05% level of significance. Table 10.

Table 10:Heterosis estimation on Proximate Analysis (%)

Parameters	Heterosis estimation (%)
Ash	12.5
Calcium	25
Crude fibre	12.5
Crude protein	- 4
Carbohydrate	14
Dry matter	3.2
Fat	60
Moisture Content	14
Standard error	6.44
t- value at 0.05%	2.365

Heterosis estimation on Minerals and Vitamins Analysis

On table 11,Potassium (70%), Magnesium (50%) ,Niacin (80%), Retinol(78%) and Riboflavin (67%) all had high heterosis estimate while Ascorbic acid (33%), Beta Carotene(16%),Iron(12%), Nitrogen (11%), Sodium(43%), Phosphorus (2%), Thiamine(28%), Zinc (33%) had low heterosis estimation

Table 11: Heterosis estimation on Minerals and Vitamins Analysis (%)

Parameters	Heterosis estimation (%)
Ascorbic acid	33.3
Beta Carotene	16
Iron	12
Potassium	70
Magnesium	50
Nitrogen	11.1
Sodium	42.8
Niacin	80
Phosphorus	1.8
Retinol	78
Riboflavin	66.7
Thiamine	27.7
Zinc	33.3
Standard error	7.45
t- value at 0.05%	2.179

DISCUSSION

This study examined the parent-hybrid relationships in single pair wise F1 crosses between Ikom and Riverine bitter leaf cultivars. The one-way cross involved Ikom x Ikom, Riverine x Riverine and Ikom x Riverine which were replicated three times on a RCBD Experimental site. Results evaluated at 5%-degree level of significance showed that Ikom x Riverine (I_1 x R_1) progeny (CRS) outperformed the Ikom x Ikom (I_1 x I_2), and Riverine x Riverine (R_1 x R_2) inbred lines in all the measured agronomic parameters showing high mid parent heterosis estimate in plant height, number of branches, number of leaves, measured leaf area, stem girth and longest branch length.In a similar heterosis study on safflower by Emrullah and Burhan (2022),high heterosis (34.5%) on oil yield was obtained. The hybrid offspring often exhibits traits that are more robust than the average of the two parents, and in many cases, it will outperform the better of the two parents. High range of significant positive heterosis for 100-seed weight has been reported by Srivastava and Singh, (2003).This was also in line with the findings of Namita et al.,(2021) and Yazıcı and Yılmaz, (2020) that conducted research to access the heterosis in *Papaver somniferum* .Positive heterosis for crude protein, fat and vitamin C indicated that CRS could be nutritionally superior. In line with this, Soresa et al.(2020) reported on his work with tomato that Mid-parent heterosis (MPH) was highest and in desirable direction (29.2%) for number of marketable tomato fruit per plant. Heterosis results in superiority over its parents in adaptability, yield, quality, disease resistance, maturity, and general vigour (Hashimoto et al.,2021). Positive heterosis is often seen as desirable. Other phytochemical parameters showed positive heterosis: phenols, tannins and flavonoids. Phenols and flavonoids are good antioxidants and useful in human health since they mop up free radicals from the system (Okolie, et al.,2022). The minerals and vitamins all showed varying positive heterosis estimates with niacin being the highest while phosphorus was the least. Negative heterosis for crude fibre may be beneficial too (less fibre often means better digestibility).Also, among the phytochemical parameters, the (I_1 x R_1) (CRS) hybrid progeny showed negative heterosis estimates in Alkaloids,Saponins and Oxalates. Negative MPH for saponins, tannins, glycosides could be beneficial because these compounds often reduce palatability or digestibility and lower alkaloids signified why the CRS progenies were less bitter (Okolie, et al.,2022). Soresa et al.(2020) in a related study on tomato discovered that 18 crosses out of 28 showed negative MPH. This wss also in accordance with the findings of Chen et al., *(*2019) that noticed interspecific weakness in rice.; In some circumstances, negative heterosis is preferable. Negative heterosis for plant height, maturity time, and hazardous chemicals, for example, is beneficial in many circumstances since it demonstrates superiority over the parents. In most agricultural plants, heterosis of 40% or more over the superior parent is regarded as substantial from a practical standpoint. Negative heterosis might result due to traits that are not controlled by dominant genes or due to epistasis (Hochholdinger and Hoecker,2007).

RECOMMENDATION

The Ikom x Riverine cross progeny high heterosis on agronomic and nutritional components makes it a high yielding and nutritious bitter leaf hybrid that is relatively less bitter and so well situated for commercial production that will go a long way to enhance nutritional intake of the people, their social and economic wellbeing since it requires little maceration. Presently Anambra State exports processed bitter leaf through Anambra State Export Promotion Council (The Guardian Nigeria News,2016) but the impact is greatly hampered by the rigors of washing and the availability of large quantities of clean water. With the adoption of the Ikom x Riverine cross progeny more leaves will be produced, processed and packed commercially without the need of prolonged maceration with its attended nutrients losses. Although F1 offspring are highly heterogeneous and tend to lose most of its desirable traits in further crosses, $I_1 \times R_1$ (CRS) progeny good qualities can be conserved through cloning (vegetative propagation).It can also be used for further breeding works

Conflict Of Interest: There is also no conflict of interest between the authors.

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