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Evidence of heterosis in Okra (*Abelmoschus esculentus*) landraces from Burkina Faso

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ABSTRACT

In our study, 24 hybrids obtained by diallel cross between ecotypes of okra were subjected to analysis of their combining ability effects and hybrid vigor for different important traits for producers and consumers. Parents and hybrids differed significantly for gca effect. UAE 3 and UAE 20 were found to be the best general combiners for 50% day of flowering and number of fruits per plant. While UAE 25, UAE 3 and UAE 5 were best for seeds weight per fruit and yield per plant; between tester lines, UAE 19 shown good gca effect of number of seeds per fruit and fruit yield per plant, when UAE 22 is good for number of seeds per fruit. The most heterotic combinations for number of fruits per plant were those including UAE 22 in their combination. The same hybrids have shown medium heterobeltiosis effect for fruit length and in some of them (H22-20 and H22-5) was observed highest heterobeltiosis of yield per plant, varied from 59.90 to 77.57 respectively. The highest depression (non heterobeltiosis) was observed in hybrids with combination including H19 for number of seeds per fruit. Overall, the results discussed above indicated the fact that okra hybrid with UAE 22 has great potentialities of maximizing fruit yield while hybrid H3-19 and H22-3 have the smallest days of flowering. Similarly, the heterosis effect appeared in F_1 in these hybrids with UAE22 as a mother form keeps up to the third generation.

Key words: hybrid vigor, combining ability, okra, Burkina Faso.

INTRODUCTION

Young fruits of okra [*Abelmoschus esculentus* (L.) Moench] are very popular in Burkina Faso kitchen. For Karnataka (2008), okra is from the most useful vegetable in the world for thickening of soup and curry.

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Intensive cultivation of this plant is found in major cities around the country through the activities of the gardeners who supply urban dwellers with fresh okra. According to Sawadogo et al. (2009), studies imported hybrids like Indiana and Clemson Spineless are the most experienced on the plots of okra production in Burkina Faso around Ouagadougou city. Among others, they showed that there is a real need for production of varieties of fresh okra. Hybrids are much popular in this crop (Dhankhar, 2005). In spite of the fact that producers and consumers appreciate these hybrids imported, they bemoan the lack of local varieties taking into account their preference criteria that are earliness, fruit length, and low seed productivity. This requires hybridization to assess the combining ability (general and specific ability) of local ecotypes. The knowledge of combining ability helps in identifying best combiners, which may be either hybridized to exploit heterosis to accumulate gold fixable gene-through selection.

The heterosis revealed the type of gene action involved and it helps in the selection of suitable breeding methodology and parameters, which are employed for crop improvement programme (Nandan et al., 2007). According to Weerasekara et al. (2008), the application of biometrics to the analysis of crosses between lines and varieties tested is a powerful tool in the selection because it identifies the best combinations or crosses. Similarly, no study has yet been done on estimating the effect of heterosis in okra landrace from Burkina Faso. Therefore, our study has the objective to assess the level of variability of hybrid varieties of okra in Burkina Faso and focus on combining ability of local varieties of okra used in crosses for consumer preference traits.

MATERIALS AND METHODS

Four genotypes of okra are used as lines and two genotypes as testers. They are inbred lines obtained by okra improvement team from the University of Ouagadougou by crossing local ecotypes. The testers were crossed with each line in diallel crossing and sixteen hybrids were obtained (Table 1) and grown in randomized blocks design with three replications at experimental field of the University of Ouagadougou. In each replication, each genotype was grown in 3 rows, and each row of 3 m length was spaced at 60 cm and plants were spaced at a distance of 30 cm in the rows.

Recommended cultural practices were followed to raise a successful crop. The observations were recorded on fifteen (15) randomly selected plants from each genotype of each entry in each replication. The observations were done according to recommendations base on work done by Sawadogo et al. (2009). The following parameters were observed: 50 percent days to flowering, number of fruits per plant, fruit length, fruit diameter, number of seeds per fruit, seed weight per fruit and fruit yield per

Table 1: Vegetal material.

Line	Tester line UAE 19		Tester line UAE 22	
	First crossing	**Second crossing**	**First crossing**	**Second crossing**
UAE 3	H19-3	H3-19	H22-3	H3-22
UAE 5	H19-5	H5-19	H22-5	H5-22
UAE 20	H19-20	H20-19	H22-20	H20-22
UAE 25	H19-25	H25-19	H22-25	H25-22

UAE 3- means variety University abelmoschus esculentus n°3;
H19-3 – means hybrid obtained by crossing tester UAE 19 with line UAE3.

plant. The analyses of general and specific combining abilities for the above characters were calculated as per the model suggested by Kempthorne (1957). Statistical analyses were done using XLSTAT software (version for evaluation).

RESULTS

Analysis of variance

Analysis of variance for combining ability of vegetal material shown in Table 2 bellow revealed significant (high and very high level) differences between line, tester and line x tester for all five (5) variables except 50% days to flowering (50%F), fruit length and diameter for line x tester (Table 1). The variation due to interaction between line x testers were highly significant for number of fruits per plant, number of seeds per fruit and fruit yield per plant. These results could indicate presence of variability and high degree of additive and dominance variance in our material.

Combining abilities

The result shown in Table 3 revealed:

- Good general combining ability (gca) effects of UAE 3, UAE 20 for 50% days to flowering and number of fruits per plant;
- Good gca effects of UAE 25, UAE 3 and UAE 5 for seeds weight per fruit and fruit yield per plant ;
- Between tester lines, UAE 19 shown good gca effects of number of seeds per fruit and fruit yield per plant, when UAE 22 is good for number of seeds per fruit.

Heterosis effect

Heterosis effect is shown in Table 4. 50% flowering among parents varied from 46 to 58 days, and 48 to 61 days among hybrids. Four hybrids (H19-3, H3-19, H22-3 and H22-5) only showed non favorable heterobeltiosis (depression). The highest heterobeltiosis for number of fruits per plant (from 33.28 to 92.29) was observed in hybrid combination including UAE 22 (H20-22, H22-20, H22-5, H5-22, H3-22 and H22-3). The same hybrids have shown medium heterobeltiosis effect for fruit length and some of them (H22-20 and H22-5) showed highest heterobeltiosis for fruit yield per plant, varying from 59.90 to 77.57 respectively.

The highest depressions (non heterobeltiosis) were observed in hybrids with combination including H19 for number of seeds per fruit. For exemple, hybrids H25-19 (-69.34), H19-20 (-30.05), H3-19 (-21.15), H20-19 and H5-19 (-20.40).

Best heterobeltiosis combination

Figure 1 shows the analysis of the contribution of parents in the expression of heterosis in the hybrid effects depending on the role played by each partner in the cross. Thus, among the best hybrid heterosis effects with certain desirable combinations with parents UAE 3, UAE 22, UAE 5 and 20 show a UAE through heterosis effect for the 6 preference criteria of consumers and producers. In each pair of these crosses, the hybrids H3-22 H3-22 and H20-22 have a force ranging from 80.33 to 180%, while the hybrids H22-3 H22-3 and H22-20 have a smaller force whose maximum is 83.33%.

Heterosis preservation during generation

Table 5 presents the evolution of the heterosis effect of the cycle (50% flowering) and number of fruits from F_1 to F_3.

The hybrids H19-3, H3-19, H22-3 and H22-5 show an effect of depression for the variable 50% flowering in the three generations (F_1, F_2 and F_3). Even if the depression is requested, it varies from one generation to another. Indeed, the hybrid H19-3 has a depressive effect on the date of flowering of -6.90% in F_1, -10.33% in F2 and -5.17% in F_3. Other hybrids present positive heterosis effect for cycle 50% flowering.

The number of fruits per plant also has a heterosis effect for three generations. The desired effect is observed for hybrids H19-5 H20-19 H22-3 H22-5 H22-20, H3-22 H5-22 and H20-22. In general, hybrid vigor is more important in F_2 (H19-5 H20-19 H22-3 H22-5 H22-20) than in other generations (F_1 and F_3). However, in some F_2 hybrids (H3-22 H5-22 and H20-22), the effect is greater in F1 and decreases in subsequent generations (F_2 and F_3).

The intra-hybrid variation, estimated through the standard deviation shows a significant variation in F_2 compared to F_1 and F_3. Indeed, the standard deviation varies from 0.12 in F_1 (in H22-3) to 4.12 (in H19-20), while F_2 when it fluctuates from 3.17 (in H19-5) at 12.33 (in H19-3). The variability decreases significantly in F_3 in all hybrids, which is expressed by small values of standard deviation (from 0.01 to 5.44).

Table 2: Analysis of variance for combining ability of vegetal material.

Source of variation	Line	Tester	Line x Tester	Error (S.E)
50%F	8,32*	4,40	1,22	0,13
Number of fruits per plant	18,99**	8,47*	13,55**	11,06
Fruit length	1,05**	2,33**	0,87	1,03
Fruit diameter	0,48**	0,52*	0,11	0,10
Number of seeds per fruit	66,88**	22,12**	48,76**	12,92
Seed weight per fruit	52,11**	47,78*	49,19*	0,47
Yield per plant	768,95**	1245,55**	9023,05**	332,20

*- the difference is significant; **- the difference is highly significant

Table 3: General combining ability effects of parents.

Var	50% flowering	Number of fruits/ plant	Fruit length	Fruit diameter	Number of seeds/ fruit	Seeds Weight/ fruit	Yield per plant
Line							
UAE 3	-0.78**	8.47**	-0.12 ns	-0.39**	20.64**	33.11**	319.84**
UAE 5	-0.56**	2.11 ns	0.62 ns	1.15*	12.40**	22.79**	99.22**
UAE 20	-0.84**	4.69**	1.27**	0.82 ns	8.29*	14.20*	-11.67**
UAE 25	0.24 ns	-0.16 ns	-0.42 ns	0.96*	33.76**	71.35**	178.91**
S.E.±	0.346	1.116	0.406	0.167	7.283	12.112	45.142
Tester							
UAE 19	0.09 ns	-2.54*	0.69 ns	-0.12**	-3.55 ns	11.64*	123.77**
UAE 22	0.12**	3.12*	0.37 ns	0.08 ns	-6.22**	9.15**	94.26 ns
±S.E.	0.152	0.876	0.112	0.107	3.356	2.881	37.676

Table 4: Mean value and heterosis effects of okra hybrids.

H	50% Flowering (days)		Number of fruits/plan		Fruit length (cm)		Fruit diameter (cm)		Number of seeds/fruit		Fruit yield per plant	
	Mean	HHT (%)	Mean	HHT (%)	Mean	HHT (%)	Mean	HHT (%)	Mean	HHT (%)	Mean	HHT (%)
H19-3	54,00	**-6,90**	3,16	-57,78	4,27	**64,86**	0,52	15,56	58,20	**-23,09**	3268,94	-50,76
H19-5	58,94	17,88	7,60	**1,59**	3,20	**79,78**	0,67	0,00	77,00	1,76	7864,92	**18,46**
H19-20	60,12	17,88	5,33	-28,77	0,87	-36,50	0,25	**-50,98**	52,93	**-30,05**	5514,40	-16,94
H19-25	59,45	26,49	6,92	-7,52	5,33	**60,06**	0,95	58,33	67,20	**-11,19**	7159,25	**0,80**
H20-19	59,56	16,78	8,45	12,97	3,45	**6,63**	0,88	95,56	60,23	**-20,40**	6234,35	-6,10
H5-19	54,23	8,46	6,45	-13,77	3,05	**71,35**	0,77	14,93	60,23	**-20,40**	6432,12	-3,12
H25-19	59,00	25,53	3,08	-58,88	0,66	-80,18	0,23	**-61,67**	23,20	**-69,34**	3183,33	-55,18
H3-19	49,00	**-15,52**	6,28	-16,05	4,33	**67,18**	0,75	66,67	59,67	**-21,15**	6498,97	-2,11
H22-3	48,00	**-17,24**	6,90	**8,91**	4,53	**74,90**	0,67	74,94	56,20	**-9,54**	7146,27	**8,94**
H22-5	51,00	**-1,92**	6,48	**51,45**	3,40	**76,17**	0,86	28,36	62,27	34,40	7859,12	**77,57**
H22-20	58,11	11,75	9,01	**87,71**	2,07	**7,25**	0,62	63,16	87,93	79,93	7944,34	**59,90**
H22-25	52,00	0,00	4,87	-35,42	3,10	-6,91	0,57	**-5,00**	52,60	**-2,53**	5039,62	-29,05
H3-22	58,29	0,50	8,45	**33,28**	3,67	**41,70**	0,25	**-34,21**	60,01	**-3,41**	7402,54	**12,84**
H5-22	59,56	14,54	6,45	**50,70**	3,08	**59,59**	0,56	**-16,42**	45,67	**-1,42**	6432,23	**45,33**
H20-22	61,26	17,81	9,23	**92,29**	1,97	**2,07**	0,23	**-39,47**	67,23	37,57	6345,28	**27,72**
H25-22	59,76	14,92	6,23	-17,37	3,55	**6,61**	0,57	**-5,00**	68,23	**-5,41**	7234,34	**1,85**
P-3	58,00		6,34		2,59		0,20		62,13		6559,94	
P-5	50,00		4,28		1,78		0,67		46,33		4426,05	
P-20	51,00		4,80		1,20		0,20		48,87		4968,28	
P-25	46,00		7,54		3,33		0,60		72,13		7102,66	
P-19	47,00		7,48		1,37		0,45		75,67		6639,10	
P-22	52,00		3,95		1,93		0,38		38,73		4083,59	

In bolt desired heterobeltiosis. HHT – heterobeltiosis.

Table 5: Preservation of heterosis effect during generations.

Hybrid	**50% flowering (days)**			**Number of Fruits/plant**		
	F_1	**F_2**	**F_3**	**F_1**	**F_2**	**F_3**
H19-3	**-6,90**	**-10,33**	**-5,17**	-57,78±1,65	-52,34±12,33	-45,12±5,44
H19-5	17,88	25,56	15,77	**1,59±0,45**	**3,21±56,17**	**1,21±0,01**
H19-20	17,88	20,04	19,23	-28,77±4,12	-26,88±3,32	-20,00±1,65
H19-25	26,49	31,41	28,09	-7,52±0,34	-10,67±5,60	-9,23±1,65
H20-19	16,78	20,24	18,77	**12,97±0,12**	**20,23±5,23**	**11,12±2,34**
H5-19	8,46	12,23	7,91	-13,77±1,25	-17,75±5,65	-11,47±2,22
H25-19	25,53	28,55	19,34	-58,88±3,12	-63,33±5,63	-48,56±3,78
H3-19	**-15,52**	**-12,35**	**-0,76**	-16,05±1,00	-20,14±3,88	-15,55±1,02
H22-3	**-17,24**	**-15,10**	**-0,66**	**8,91±0,12**	**10,23±21,42**	**9,45 ±0,23**
H22-5	**-1,92**	**-3,57**	**-0,49**	**51,45±1,26**	**67,01±37,44**	**53,55 ±1,45**
H22-20	11,75	16,23	12,04	**87,71±2,95**	**89, 23±66,78**	**86,78 ±3,66**
H22-25	1,00	5,37	1,23	-35,42±2,76	-40,10±6,15	-36,27±2,55
H3-22	0,50	6,71	2,44	**33,28±0,66**	**21,23±9,65**	**16,59 ±2,92**
H5-22	14,54	28,34	17,21	**50,7±0,87**	**18,12±8,23**	**20,04 ±1,55**
H20-22	17,81	18,34	13,90	**92,29±3,67**	**88,08±15,42**	**21,62 ±5,23**
H25-22	14,92	17,12	10,23	-17,37±3,12	-21,09±7,23	-12,90±5,21

In bolt desirable heterosis effect

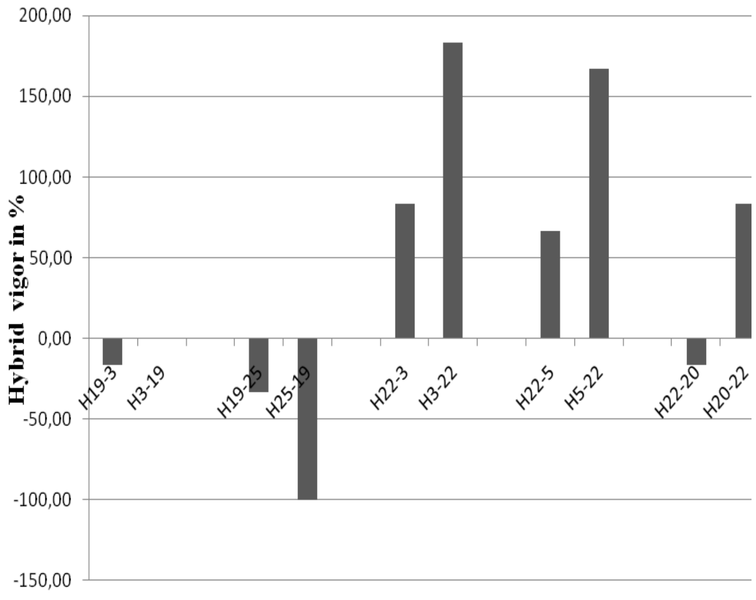

Figure 1: Mean contribution of hybrids in diallel crossing.

DISCUSSION

Analysis of variance showed a great variability among varieties for all parameters except the parameter of 50% flowering. Srivastava et al. (2008); Karnataka (2008) and Adeniji & Kehninde (2007) had similar results. Sawadogo et al. (2003) observed a large variability in okra from Burkina Faso. The lack of variability for the cycle (50% flowering) could be attributed to the action of selection. Indeed, the team of breeders working on okra in Burkina Faso has its primary objective that is the creation of short-season varieties and resistant to drought.

The analysis showed a good gca of UAE 3 and UAE 20 for 50% flowering; negative effects are considered to be desirable for days to 50 per cent flowering (as earliness is preferred over lateness) and number of seeds per fruit (Weerasekane et al., 2008). This has an importance in the selection process. Indeed, Sawadogo et al. (2009) have showed that the small number of seeds per fruit was an important criterion for consumers to choose okra variety. This makes these two varieties of good parents obtain hybrids with few seeds.

The study also showed that producing varieties with high yield such as UAE 25, UAE 19, UAE 3 did not produce the best hybrid combination for this character. Dhankar et al. (2001), Weerasekan et al. (2008) had reached a similar result showing that it is not because the parent varieties have a high gca they will necessarily give the best hybrid of this character.

From this analysis of heterosis effect, it is clear that hybrids containing UAE 22 as a parent have the greatest effect of heterosis for fruit number per plant and fruit size. This performance of UAE 22 in combinations shows that a variety could be taken into account in future work. This performance is undoubtedly due to its ability to water (Sawadogo et al. 2006; Nana et al., 2009).

The values of the heterosis effect and its preservation vary from one variable to another and from one generation to another. The desired effects (earlier flowering) acquired by the hybrid H19-3, H3-19, H22 and H22-3-5 was conserved from first to the third generation. Nevertheless, it should be noted that its effect in F_1 is substantially equal to that of F_2 but it greatly reduces the F_3 to take values less than 1% for the hybrids H3-19, H22-3 and H22-5.

The hybrid (H22-3, 5 and H22-H22-20) with UAE 22 as mother form, heterosis effects are more important in F_2 than F_1 and this is preserved from one generation to another. But, hybrids H3-22, H5-22 and H20-22 obtained with UAE 22 as pollen donor (paternal form) have a heterosis effect in F_1 decreases from generation to another.

The standard deviation shows the distribution of phenotypic values around the average of the population. Its small values indicate that individuals have very similar phenotypic values of the average phenotypic value of the population. If F_1 small values of standard deviation is easily explained by the homogeneity of the genotype of its individuals, that of F_3 could be due to the selection made in F_2, which was to retain for self-fertilization F_2 individuals with the phenotype being sought.

Conclusion

Okra of Burkina Faso has a large phenotypic variability that can be used in improving the culture to obtain hybrids desired by producers and consumers. The varieties UAE 22 and UAE 19 obtained by breeders at the University of Ouagadougou are good donor and could be used for improving okra to obtain hybrids with high performance for fruit yield and early maturity.

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