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Combining ability for quality and seed parameters in ridge gourd [*Luffa acutangula* L. Roxb.]

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Abstract
Combining ability in ridge gourd, eight different parental lines were selected, they were mated in half diallel fashion, resultant 28 hybrids were developed. Analysis of variance is significant due to GCA and SCA were observed for quality and seed parameters, which indicates the predominance of additive and non-additive gene action and which suggested that ample scope for direct selection or heterosis breeding. Among eight parents, DMRG-25, DMRG-36 and DMRG-22 were found to be best general combiners. Significant *sca* effects were positive in direction, maximum positive significant *sca* effects were observed in the cross DMRG-22 × DMRG-44(0.77) for rind thickness, the cross DMRG-36 × Arka Sumeet (1.99) for flesh thickness, the cross DMRG-36 ×Arka Sumeet (36.72) for ascorbic acid, the cross DMRG-22 × DMRG-15(3.65) for calcium content, the cross DMRG-36 × ArkaSumeet (24.75) for number of seed per fruit, the cross Arka Sumeet × DMRG-15 (2.28) for hundred seed weight.

Keywords: Combining ability, half diallel, hybrid, *gca* effect, *sca* effect and additive and non-additive gene action

1. Introduction

Ridge gourd [*Luffa acutangula* (L.) Roxb.], belong to the genus *Luffa* and family is cucurbitaceae and has chromosome number 2n = 26 and is native to India, also called as angled gourd, ribbed gourd and chinese okra. Seeds are reported to be posses' purgative, emetic and antihelmintic properties due to the secondary metabolite cucurbitacin [1]. Isolation of Ribosome Inactivating Proteins (RIPs), and luffaculin from ridge gourd seeds and its crystallographic studies, RIPs have received wide attention for their potential applications in medicine as they posses various pharmacological activities including abortifacient, antifungal, antitumor, antivirus and HIV-1 integrase inhibitory properties [2]. The ridge gourd is used as cooked vegetable in green immature stage. Ridge gourd being a monoecious and cross-pollinated crop, it exhibits considerable heterozygosity in population and does not suffer much due to inbreeding depression resulting in natural variability in the population. Thus, provides ample scope for utilization of hybrid vigour on commercial scale. These, wide range of genetic variability in plant for quality and seed parameters and also produce large number of hybrid seed at reasonable cost, very little work has been done to exploit the hybrid vigour in this crop. The concept of combining ability for the evaluation of parents in a crossing programme is of immense important. It has been originated through intensive hybridization work in maize. Hybridization is the most potent technique for breaking yield barriers and evolving varieties having high yielding potential. Selection of parents on the basis of phenotypic performance alone is not a sound procedure, since phenotypically superior lines may not lead to expected degree of heterosis. Therefore, the present investigation was undertaken in ridge gourd to obtain information about estimates of general combining ability. The combining ability estimates were calculated by using [3]. Thus, one of the potential tools for identifying prospective parents for hybridization and shifting productive hybrids from a set of crosses in F_1 generation is the analysis of combining ability [4].

2. Materials and Methods

An experiment was conducted at Department of Vegetable Science, K.R.C. College of Horticulture, Arabhavi, University of Horticultural Sciences, Bagalkot during *kharif* and *rabi*, 2014-2015. Experimental contain eight parents *viz*; DMRG-22, KRCCH-1, Arka Sumeet, DMRG-1, DMRG-15, DMRG-44-36 and DMRG-25.

28 hybrids were developed through half diallel mating design during *kharif* 2014. All the 28 hybrids along with their parents were evaluated in Randomised Block Design with two replications during *rabi* 2014-2015. Observations were recorded for various quality and seed parameters of parents and hybrids. The observations were recorded on tagged selected five plants in each replication.

3. Results and Discussion

The analysis of variance for combining ability revealed that mean squares due to GCA and SCA were highly significant for all the traits, but GCA non-significant for flesh thickness, indicated the importance of both additive and non-additive genetic components for most of the traits. Similar results were reported by [5] and [6] in ridge gourd. Further, the estimated components of variances for *sca* was larger than *gca* variance component for all the traits (Table 1), indicating the predominance of non-additive gene action for most of the characters.

3.1 Combining ability for quality and seed parameters (Tables 2 and 3)

3.1.1 Rind thickness

Among eight parents only two parents showed significant *gca* effects for rind thickness, of which one was in positive direction. Maximum positive significant *gca* effects were observed in parent of DMRG-44(0.26) and others were showed non-significant. Among 28 crosses, four crosses were significant *sca* effects of which one was positive in direction, maximum positive significant *sca* effects were observed in DMRG-22 × DMRG-44(0.77) and same finding reported by [7] in pumpkin.

3.1.2 Flesh thickness

Six parents showed significant *gca* effects for flesh thickness, of which, three parents were in negative direction. Maximum positive significant *gca* effects were observed in parents of DMRG-22 (0.31) followed by DMRG-25 (0.24), DMRG-1 (0.19) and others were showed non-significant. Among 28 crosses, eight crosses were significant *sca* effects of which six were positive in direction, maximum positive significant *sca* effects were observed in crosses of DMRG-36 × Arka Sumeet (1.99) followed by DMRG-25 × DMRG-1 (1.58), DMRG-22 × DMRG-1 (1.49), DMRG-22 × DMRG-15 (1.15), DMRG-25 × Arka Sumeet (1.05) and DMRG-25 × DMRG-22 (0.65) and flesh thickness is desirable quality trait of fruit, same kind of results report by [8-10] in pumkin, [11] in muskmelon [12], in cucumber.

3.1.3 Ascorbic acid

Among the eight parents, six parents showed significant *gca* effects for ascorbic acid, of which, three parents were in positive direction. Maximum positive significant *gca* effects were observed in parents of DMRG-25 (6.54) followed by DMRG-22 (6.26) and DMRG-36 (4.99) and others were showed non-significant. Among 28 crosses, 19 crosses were showed significant *sca* effects of ten were positive in direction, maximum positive significant *sca* effects were observed in crosses of DMRG-36 × Arka Sumeet (36.72) followed by DMRG-25 × Arka Sumeet (32.71), DMRG-22 × DMRG-15 (25.28), DMRG-36 × DMRG-22 (23.13), KRCCH-1 × DMRG-15 (23.02), DMRG-25 × DMRG-1(22.49), DMRG-25 × DMRG-22 (22.25), DMRG-22 × DMRG-1 (17.70), DMRG-36 × DMRG-25 (16.70) KRCCH-1 × DMRG-44 (7.02) and DMRG-36 × DMRG-44 (5.86) and similar reports found by [8] in pumpkin.

3.1.4 Calcium content

Eight parents showed significant *gca* effects for calcium content, of which four parents were in negative direction. Maximum positive significant *gca* effects were observed in parents of DMRG-25 (0.99) followed by DMRG-22 (0.84), DMRG-36 (0.41), DMRG-1 (0.35) and others were showed non-significant. Among 28 crosses, 23 crosses were showed significant *sca* effects of which nine were positive in direction, maximum positive significant *sca* effects were observed in crosses of DMRG-22 × DMRG-15 (3.65) followed by DMRG-25 × Arka Sumeet (3.57), DMRG-36 × DMRG-25 (3.38), DMRG-25 × DMRG-1 (3.26) DMRG-36 × Arka Sumeet (1.82) DMRG-25 × DMRG-22 (1.76), DMRG-22 × DMRG-1 (1.41) and KRCCH-1 × DMRG-44 (1.14) and earlier reports show same results by [13] in ridge gourd.

3.1.5 Number of seeds per fruit

Among eight parents, four parents showed significant *gca* effects for number of seeds per fruit of which, two were negative in direction, maximum positive significant *gca* effects were observed in parent of DMRG-22 (6.77) followed by DMRG-36 (5.99), DMRG-25 (4.47) and DMRG-1 (3.67). Among 28 hybrids, seven hybrids shown significant *sca* effect of which four were in positive direction. Maximum positive significant *sca* effects were observed in crosses of DMRG-36 × Arka Sumeet (24.75) followed by DMRG-15 × DMRG-44 (21.23), DMRG-25 × DMRG-1 (18.93) and DMRG-22 × DMRG-15 (18.61) and similar finding were made by [9] in pumpkin and [14] in bitter gourd.

3.1.6 Hundred Seed weight

Among eight parents, two parents were significant *gca* effects of which, only one was negative in direction, maximum positive significant *gca* effects were observed in parent of DMRG-36 (0.63) and others were showed non-significant. Among 28 crosses, five crosses were showed significant *sca* effects of which, only one was positive in direction, maximum positive significant *sca* effects were observed in crosses of Arka Sumeet × DMRG-25 (2.28) and similar finding reported by [9] in pumpkin, [14] and [15] in bitter gourd.

4. Conclusion

Among eight parents, DMRG-36, DMRG-25 and DMRG-22 were found to be best general combiners. Among 28 crosses, the cross DMRG-22 × DMRG-44 (0.77) for rind thickness, the cross DMRG-36 × Arka Sumeet (1.99) for flesh thickness, the cross DMRG-36 ×Arka Sumeet (36.72) for ascorbic acid, the cross DMRG-22 × DMRG-15 (3.65) for calcium content, the cross DMRG-36 × ArkaSumeet (24.75) for number of seed per fruit, the cross Arka Sumeet × DMRG-25 (2.28) were exhibited high *sca* effects.

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6. Author contributions

K. Muthaiah-Conception and design of the research programme, data collection, crossing work, data analysis and

interpretation, critical revision of the article, drafting the article, final approval of the version to be published and acted as corresponding author.
V.D. Gasti-Helped during crossing work, data collection, data analysis and interpretation,
Sumalatha Akkalareddy-Critical revision of the research article
Arindam Das-Critical revision of the research article
Sanganamoni Mallesh-Critical revision of the research article

Table 1: Analysis of variance due to general combining ability and specific combining ability for different parameters in ridge gourd

Characters	Mean sum of squares			σ^2_g	σ^2_s	σ^2_g: σ^2_s
	GCA	SCA	Error			
Quality parameters						
Rind thickness (mm)	0.17**	0.09**	0.03	0.01	0.06	0.22
Flesh thickness (cm)	0.75	0.67*	0.09	0.06	0.57	0.115
Ascorbic acid (mg/100g)	348.23**	388.00**	4.63	34.36	383.37	0.09
Calcium (mg/100g)	5.78**	3.88**	0.07	0.57	3.81	0.15
Seed parameters						
Number of seeds per fruit	339.03**	221.80**	74.53	26.45	147.27	0.18
Hundred seed weight (g)	2.02**	1.15**	0.60	0.14	0.54	0.26

*And **indicates significance of value at p= 0.05 and p=0.01, respectively.

Table 2: Estimation of gca effects of parents with respect to quality and seed characters in ridge gourd

Parents	Quality parameters				Seed parameters	
	Rind thickness	Flesh thickness	Ascorbic acid	Calcium content	Number of seeds per fruit	Hundred seed weight
DMRG-36	-0.16 **	0.1	4.99 **	0.41 **	5.99 *	0.63 **
DMRG-25	-0.04	0.24 *	6.54 **	0.99 **	4.47*	-0.21
KRCCH-1	0.09	-0.42 **	-6.93 **	-0.43 **	-5.86 *	0.12
DMRG-22	-0.06	0.31 **	6.26 **	0.84 **	6.77 *	0.01
Arka Sumeet	0	0.1	1.14	-0.36 **	-3.70*	0.17
DMRG-1	-0.1	0.19 *	-0.02	0.35 **	3.67*	-0.12
DMRG-15	0.01	-0.22 *	-3.22 **	-0.70 **	-3.46*	0.29
DMRG-44	0.26 **	-0.29**	-8.76 **	-1.11 **	-7.86 *	-0.9**
S. E. M	0.07	0.13	0.96	0.11	3.86	0.34
CD at 5 Percent	0.3	0.21	1.5	0.18	0.43	0.54
CD at1 Percent	0.44	0.31	2.22	0.27	8.93	0.8

*And **indicates significance of value at p= 0.05 and p=0.01, respectively

Table 3: Specific combining ability effects for quality and seed parameters in ridge gourd

Hybrids	Quality parameters				Seed parameters	
	Rind thickness	Flesh thickness	Ascorbic acid	Calcium content	Number of seeds per fruit	Hundred seed weight
DMRG-36 × DMRG-25	-0.14	-0.1	16.70**	3.38 **	7.78	0.72
DMRG-36 × KRCCH-1	0.1	-0.28	-13.28 **	-1.69 **	-4.82	-0.58
DMRG-36 × DMRG-22	0.03	0.55	23.13**	0.29	11.77	0.37
DMRG-36 × Arka Sumeet	-0.19	1.99 **	36.72 **	1.82 **	24.75**	1.09
DMRG-36 × DMRG-1	0.16	-0.28	-10.10 **	-2.20**	-20.17 *	0.13
DMRG-36 × DMRG-15	0.01	-0.29	-1.98	-1.42 **	-11.33	-1.58 *
DMRG-36 × DMRG-44	-0.23	-0.17	5.86 **	-0.67 **	-10.05	0.06
DMRG-25 × KRCCH-1	-0.05	-0.35	-2.9	-2.14 **	0.09	-0.21
DMRG-25 × DMRG-22	-0.04	0.65 *	22.35 **	1.76 **	-11.82	-0.61
DMRG-25 × Arka Sumeet	-0.26	1.05**	32.71 **	3.57 **	13.69	-0.48
DMRG-25 × DMRG-1	-0.51 **	1.58**	22.49 **	3.26 **	18.93 *	0.79
DMRG-25 × DMRG-15	0.31	-0.38	-15.07 **	-1.60 **	-8.64	0.79
DMRG-25 × DMRG-44	-0.26	-0.44	-8.76 **	-1.26 **	-1.18	0.1
KRCCH-1 × DMRG-22	0.16	-0.61 *	-8.77 **	-1.85 **	-24.40**	-0.44
KRCCH-1 × Arka Sumeet	0	-0.04	-4.42 *	-0.82 **	-4.66	-0.74
KRCCH-1 × DMRG-1	0.14	-0.04	9.05 **	0.41	2.02	-0.18
KRCCH-1 × DMRG-15	0.21	0.29	23.02 **	0.87 **	-14.48	-0.17
KRCCH-1 × DMRG-44	0.02	0.33	7.02**	1.14 **	-9.19	0.92
DMRG-22 × Arka Sumeet	0.06	-0.85 **	-13.01 **	-1.64 **	-16.60 *	-0.34
DMRG-22 × DMRG-1	-0.2	1.49**	17.70**	1.41 **	12.92	0.92
DMRG-22 × DMRG-15	-0.51 **	1.15 **	25.28 **	3.65 **	18.61 *	0.62
DMRG-22 × DMRG-44	0.77 **	-0.05	-3.86	-1.01**	3.48	-2.06 **
Arka Sumeet × DMRG-1	0.15	-0.44	0.97	-1.34 **	-10.01	-0.58
Arka Sumeet × DMRG-15	0.31	-0.16	-7.36**	-0.33	7.49	2.28 **
Arka Sumeet × DMRG-44	-0.40 *	-0.1	-0.28	0.11	-13.05	0.83
DMRG-1 × DMRG-15	0.24	-0.32	-3.88	-0.96 **	-14.41	-2.01 **
DMRG-1 × DMRG-44	0.31	-0.2	0.88	-0.62 *	-12.52	-1.73 *
DMRG-15 × DMRG-44	0.03	0.14	5.62 **	0.32	21.23 *	0.4
S. E. M	0.23	0.4	2.88	0.35	11.58	1.04
CD at 5 Percent	0.33	0.57	4	0.49	16.06	1.45
CD at 1 Percent	0.44	0.77	5.41	0.67	21.69	1.96

*And **indicates significance of value at p= 0.05 and p=0.01, respectively.

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