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# Combining Ability Analysis for Yield and its Components in Bottle Gourd

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**ABSTRACT**

*The investigation entitled "Genetic analysis of yield and its attributes in F3 generation of 5 X 5 half diallel set in bottle gourd (Lagenaria siceraria (Molina) standley)" was carried out with the objective to identify superior parents and F3 cross combinations and to propose a viable and effective breeding strategy for yield improvement in bottle gourd in a randomized block design with three replications during rabi at horticultural garden, S.V. Agricultural college, Tirupati. The experimental material consisted of five parents viz., Arka Bahar (AB), Pusa Summer Prolific Long (PSPL), Pratik, IC-92330 and Tirupati-local and their ten F3 crosses derived from 5X5 half diallel set. The analysis of variance for combining ability revealed that both gca and sca effects were significant for all the characters except hundred seed weight. Estimates of components of variances revealed that the variance due to sca was greater than the variance due to gca indicating the preponderance of non additive gene action for all the twelve characters studied. The estimates of gca effects indicated that IC-92330 was the best general combiner for yield per vine (0.23**). The estimates of sca effects indicated that AB X IC-92330 was the best specific* $F_3$ *cross for number of branches per vine (3.40**), number of fruits per vine (0.54**), fruit weight(0.33**),fruit length (5.48**), fruit girth (1.02**), yield per vine (1.29**) and could be of promising for further yield improvement in bottle gourd through selective diallel mating programme.*

***Key words:*** *Bottle gourd, Analysis of variance, Combining ability analysis, Yield.*

## INTRODUCTION

Bottle gourd *(Lagenaria siceraria* (Molina) Standley) being monoecious is cross pollinated crop and heterosis in cross pollinated crops has long been known to offer good potentialities for increased yield. In Any breeding programme, knowledge of gene action for yield and yield contributing characters is necessary to plan and adopt appropriate selection techniques[9]. Combining ability analysis is a powerful tool in the selection of superior parents and identification of superior cross combinations.

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For identifying promising pure lines in the segregating progenies, estimation of gca of parents is important and it is attributed to fixable gene effects including additive X additive interaction. On the other hand, sca is non-fixable and caused by non-additive gene action including dominance and epistatic interaction excluding additive X additive gene action. The analysis of combining ability helps in selecting suitable genotypes as parents for hybridization and crosses for characterizing the nature and magnitude of gene action involved in quantitative traits. Hence an attempt was made to study the estimates of general and specific combining ability in bottle gourd through diallel cross.

## MATERIAL AND METHODS

The experimental material includes five parents viz., Arka Bahar (AB)-P1, Pusa Summer Prolific Long (PSPL)-P2, Pratik-P3, IC-92330-P4, Tirupati local (TPT local)-P5 and their ten direct crosses. These were evaluated for yield and their attributing traits. The F3 seeds along with its respective parents were selected for study in a randomized block design with three replications during *rabi*. Twenty plants for each cross and ten plants for each parent were raised in each replication. Two healthy vigorous seedlings were maintained per pit. Interrow spacing 2.5m and intrarow spacing 1.1m was given. Standard horticultural operations were followed uniformly to all genotypes viz., Arka Bahar (AB)-P1, Pusa Summer Prolific Long (PSPL)-P2, Pratik-P3, IC-92330-P4, Tirupati local (TPT local)-P5, Arka Bahar (AB)-P1 X Pusa Summer Prolific Long (PSPL)-P2, Arka Bahar (AB)-P1 X Pratik-P3, Arka Bahar (AB)-P1 X IC-92330-P4, Arka Bahar (AB)-P1 X Tirupati local (TPT local)-P5, Pusa Summer Prolific Long (PSPL)-P2 X Pratik-P3,Pusa Summer Prolific Long (PSPL)-P2 X IC-92330-P4,Pusa Summer Prolific Long (PSPL)-P2 X Tirupati local (TPT local)-P5, Pratik-P3 X IC-92330-P4, Pratik-P3 X Tirupati local (TPT local)-P5, IC-92330-P4 X Tirupati local (TPT local)-P5.

Data were recorded for 20 plants in each crosses and 10 plants in each of the parents in a replication for twelve quantitative characters viz., vine length, number of branches per vine, node at which first female flower appeared, days to first female flower opening, sex ratio (female to male flowers), fruits per vine, fruit weight (Kg), fruit length (cm) , fruit girth (cm), yield per vine(Kg), seeds per fruit, hundred seed weight (g). The combining ability estimates were calculated according to method 2, model I of Griffing [4]. Fruit weight, fruit length, fruit girth and yield of edible fruit was recorded. Fruits were considered edible when the skin or rind was soft enough to be easily punctured with a finger nail. Data on seeds have been recorded from the fruits left for seed.

## RESULTS AND DISCUSSION

Combining ability analysis was carried out for twelve characters based on plot means for five parents and ten $F_3$ crosses. The estimates of mean squares due to general combining ability, specific combining ability and the estimated components of variance are furnished in Table 1. The variance among the parents and crosses was partitioned into those due to general combining ability (gca) and specific combining ability (sca) and are furnished in Table 2 & 3 respectively.

**Combining ability and gene action :** The mean sum of squares due to gca and sca were significant for all characters except hundred seed weight in case of gca. The magnitude of mean sum of squares of gca were higher than that of sca for the characters node bearing the first female flower, days to first female flower opening, sex ratio, number of fruits per vine and fruit weight while mean sum of squares of sca were greater than that of gca for vine length, number of branches per vine, fruit length, fruit girth, yield per vine, number of seeds per fruit and hundred seed weight. The ratio between variances due to gca and sca varied from 0.1485 to 0.1818, the highest being with sex ratio (0.1818) and the lowest with node at which first female flower appeared (0.1485).The estimates of component variances revealed that the specific combining ability variance components were higher than the general combining ability variance components for all the characters studied, indicating predominance of non-additive gene action in the inheritance of these characters. Similar results were reported for vine length, days to first harvest, fruits per vine, fruit length and yield per plant[5,14] and for fruit length[6].

The contribution of non-additive gene action in controlling vine length is evident from preponderance of sca variance component than gca variance component. This is in conformity with the results in bottle gourd[1,2,3,7], and in bitter gourd[12]. The estimates of gca effects for vine length varied from -0.87 (IC-92330) to 0.78 (PSPL) and highly significant and positive effect was observed in PSPL (0.78), Among the parents Pratik and IC-92330 recorded high negative gca effects for vine length and could be useful in obtaining the plant types with shorter vine length. For vine length the sca effects ranged from -0.07 (PSPL x TPT local) to 5.50 (AB x PSPL). The crosses viz., AB x Pratik (average x poor), PSPL x IC-92330 (good x poor) and PSPL x TPT-local (good x poor) exhibited negative sca effects for vine length. These combinations could be used for breeding genotypes with shorter vine length to produce more number of branches due to suppression of apical dominance. Since non-additive gene action was predominant for this trait, reciprocal recurrent selection would be a right choice for breeding of dwarf varieties.

Estimates of variance components due to sca was higher than that of gca indicating that number of branches per vine was largely under the influence of non-additive gene action, thus confirms the findings in bottlegourd[1,7]. For number of branches per vine the gca effects ranged from -0.95 (IC-92330) to 0.71 (TPT-local) and highly significant and positive gca effect was observed in TPT-local (0.71) followed by PSPL (0.64), indicating that they are the best general combiners for number of branches per vine. High sca effect was observed for number of branches per vine in PSPL x Pratik (4.25) and low with AB x PSPL (-0.48). The crosses PSPL x Pratik (good x poor), AB x IC-92330 (poor x poor) and AB x Pratik (poor x poor) recorded significant positive sca effects indicating the importance of non-additive gene action. This trait can be improved by choosing breeding method such as selective diallel mating or biparental mating. Predominance of non-additive gene action for node at which first female flower appeared was evident from the higher estimate of sca variance component than gca variance component[1,3]. The estimates of gca effects ranged from -0.43 (IC-92330) to 0.56 (AB). The genotype AB was found to be good general combiner exhibiting high per se performance for this trait. The parents Pratik, IC-92330 and TPT-local displayed negative gca effects indicating that they are best general combiners for node at which first female flower appeared. For node at which first female flower appeared the sca effects ranged from -1.12 (PSPL x IC-92330) to 1.89 (AB x PSPL). The $F_3$ crosses PSPL x IC-92330 and Pratik x TPT-local showed significant negative sca effects and the other five crosses viz., AB x Pratik, AB x IC-92330, AB x TPT-local, AB x Pratik and PSPL x TPT-local showed non-significant negative sca effects in desirable direction. The crosses PSPL x IC-92330 (good x poor) and Pratik x TPT-local (poor x poor) recorded significant negative sca effects indicating the importance of both additive and non-additive gene action for this trait. This trait can be improved through pedigree breeding which utilizes both additive and non-additive gene effects.

For days to first female flower opening the variance due to sca was predominant compared to that of gca indicating the inheritance of days to first female flower opening was mostly governed by non-additive gene action [1,3,10,11]. Since earliness is a desirable trait, the parents having negative and significant gca effects should be selected for improving this character. For days to first female flower opening the gca effects ranged from -1.35 (Pratik) to 2.38 (AB). The genotypes *viz*., Pratik, IC-92330 and TPT-local recorded negative gca effects and were found to be good general combiners for this traits. Magnitude of sca effects for the days to first female flower opening ranged from -3.03 (PSPL x Pratik) to 9.24 (AB x PSPL). Among the crosses, PSPL x Pratik (average x poor) recorded significant negative sca effects whereas AB x Pratik (good x poor) recorded non-significant negative sca effects indicating the importance of both additive and non-additive gene effects in governing this trait. Intermating between them followed by selection may be useful for exploitation of this trait in these crosses. The sca variance component was higher than gca variance component for sex ratio, indicating the presence of non-additive gene action [1,3,10]. For sex ratio the gca effects ranged from -0.02 (PSPL and Pratik) to 0.02 (TPT-local and IC-92330). The parents IC-92330 and TPT-local were found to be good combiners. Estimates of sca effects of sex ratio ranged between -0.05 (Pratik x IC-92330) and 0.09 (AB x TPT-local). The cross AB x TPT-local (poor x good) exhibited positive sca effect having TPT-local as one of the parent with positive gca effect. This combination could be used for breeding genotypes with higher sex ration. This trait can be improved through a selective diallel mating or biparental mating in early segregating generations and advance through pedigree method in later generations.

Predominance of non-additive gene action for number of fruits per vine is evident from the preponderance of sca variance component than gca variance component [1,3,7,12,13]. The lowest estimate of gca effect was recorded in PSPL (-0.24) and the highest estimate of gca effect in IC-92330 (0.19). Among the parents, IC-92330 recorded high gca effect for number of fruits per vine and was found to be good general combiner. For this trait, the sca effects ranged from 0.54 (AB x IC-92330) to 0.08 (PSPL x TPT-local and Pratik x IC-92330). Among the crosses, AB x IC-92330 (poor x good) and Pratik x TPT-local (average x poor) recorded significant positive sca effects. The crosses with significant positive sca effects are of considerable importance in improving the number of fruits per vine through recurrent selection by progeny testing. A comparision of estimates of gca and sca components of variance for fruit weight revealed the importance of non-additive gene action [1,2,3,7]. The genotype PSPL recorded significant gca effect for fruit weight along with high per se performance. The crosses AB x PSPL (poor x good), AB x IC-92330 (poor x poor), Pratik x TPT-local (poor x poor) recorded significant sca effects. This trait can be improved by choosing breeding methods such as selective diallel mating or biparental mating.

For fruit length, the variance due to sca was predominant compared to that due to gca indicating that inheritance of fruit length was mostly governed by non-additive gene action [1,3,8]. The effects of fruit length ranged from -0.98 (AB) to 0.66 (PSPL). Among the parents, PSPL and IC-92330 were found to be good general combiners for the fruit length. Estimates of sca effects for fruit length ranged between 2.16 (PSPL x Pratik) and 6.63 (PSPL x TPT-local). The cross combinations PSPL x TPT-local (poor x poor), Pratik x IC-92330 (average x average) and AB x Pratik (poor x average) recorded significant sca effects. These cross combinations for this trait could be improved by intermating of the superior selections in the segregating generations in all possible combinations followed by pedigree method of breeding.The magnitude of sca variance was higher than gca variance for fruit girth indicated the importance of non-additive gene action [1,3,8]. The parents PSPL and TPT-local showed maximum (0.42) and minimum (-0.28) gca effects respectively for fruit girth. The Parent PSPL was found to be good combiner which has got positive significant gca effects for fruit girth. For this trait sca effects ranged from -0.08 (AB x TPT-local) to 2.90 (AB x PSPL). Among the cross combinations AB x PSPL (average x good), AB x IC-92330 (average x poor) Pratik x TPT-local (poor x poor) displayed maximum positive significant sca effects for fruit girth, indicated the scope for improvement of this trait governing both additive or additive x additive and non-additive gca effects through recombination breeding followed by selection. A comparision of estimates of gca and sca components of variance for yield per vine revealed the importance of non-additive gene action [1,2,3,8,12,13]. The gca effects for yield per vine ranged from -0.17 (AB) to 0.23 (IC-92330). The genotype IC-92330 displayed significant and positive gca effect (0.23). The parent IC-92330 exhibited significant gca effect along with high per se per plant in future breeding programme. High sca effect was observed in AB x IC-92330 (1.29) and low with AB x Pratik (0.05) for yield per vine. The cross AB x IC-92330 (poor x good) had high positive sca effect with high mean performance. This indicates the predominance of dominance gene action. In this cross the yield can be improved through a selective diallel mating or biparental mating.

Predominance of non-additive gene action for number of seeds per fruit and hundred seed weight is evident from the higher estimate of sca variance component than gca variance component [1,3]. The range of gca effects for number of seeds per fruit was -21.00 (PSPL) to 36.82 (AB) and for hundred seed weight ranged between -0.08 (TPT-local) and 0.09 (AB).The genotype AB was found to be good general combiner and recorded high positive gca effect and also high per se performance for number of seeds per fruit. For number of seeds per fruit the sca effects ranged from 0.83 (AB x TPT-local) to 115.57 (AB x PSPL). Among the crosses, AB x PSPL (good x poor), AB x IC-92330 (good x poor) and Pratik x TPT-local (poor x poor) had high sca effect with high per se performance indicating the predominance of dominance gene action. Magnitude of sca effects for hundred seed weight ranged from -0.45 (Pratik x IC-92330) to 1.29 (AB x TPT-local). Among the ten $F_3$ crosses only AB x TPT-local expressed significant positive sca effect. The cross AB x TPT-local (good x poor) exhibited significant positive sca effect for hundred seed weight indicating the importance of non-additive gene action. In these crosses number of seeds per fruit and hundred seed weight can be improved by choosing the breeding methods such as selective diallel mating or biparental mating.

A perusal of results of combining ability analysis indicated considerable non-additive gene action in the inheritance of majority of the attributes studied. Hence, breeding methods involving selection, intermating of selects and reselection in segregating generations followed by pedigree method of breeding may help to improve the characters. In addition, there is also scope to evolve pure lines through selection by progeny testing as well as to improve populations by recurrent selection methods. Some promising crosses involved poor x poor combiners had high sca effects. This may be attributed to selective nicking ability of the parents. These crosses could further be exploited by selective diallel matings as they are likely to throw transgressive segregants in advanced generations. Thus in general, it was observed that intensity of selection for yield components among better general combiners should not be very high to achieve better combining ability effects of crosses. Finally it was concluded that it would be better to select the crosses having at least one good combiner for economic traits and the other poor or average combiner to get good specific combiners, if the additive genetic systems present in the good parent and complementary epistatic effects in the cross combination acting in the same direction.

**Table 1: Analysis of variance for combining ability in $F_3$ generation of 5x5 half diallel of bottlegourd**

| S.No. | Character | Mean sum of squares | | | | | |
|---|---|---|---|---|---|---|---|
| | | **gca df=4** | **sca df=10** | **Error df=28** | **$\sigma^2$ gi** | **$\sigma^2$ sij** | **$\sigma^2$gi/ $\sigma^2$ sij** |
| 1. | Vine length | 3.2103** | 5.1251** | 0.0303 | 0.0035 | 0.0231 | 0.1515 |
| 2. | Number of branches per vine | 3.4691** | 10.5330** | 0.0548 | 0.0063 | 0.0418 | 0.1507 |
| 3. | Number of node at which first female flower appeared | 1.5489** | 0.8407** | 0.0362 | 0.0041 | 0.0276 | 0.1485 |
| 4. | Days to first female flower opening | 18.8996** | 13.3807** | 0.0815 | 0.0093 | 0.0621 | 0.1497 |
| 5. | Sex ratio | 0.0028** | 0.0018** | 0.00014 | 0.00002 | 0.00011 | 0.1818 |
| 6. | Number of fruits per vine | 0.2008** | 0.1736** | 0.0036 | 0.00042 | 0.00281 | 0.1495 |
| 7. | Fruit weight | 0.1121** | 0.0900** | 0.0022 | 0.00025 | 0.00164 | 0.1524 |
| 8. | Fruit length | 3.6360** | 53.2914** | 0.0408 | 0.00467 | 0.03110 | 0.1502 |
| 9. | Fruit girth | 0.7473** | 2.3752** | 0.0137 | 0.00157 | 0.01043 | 0.1505 |
| 10. | Yield per vine | 0.1759** | 0.7199** | 0.0089 | 0.00102 | 0.00681 | 0.1498 |
| 11. | Number of seeds per fruit | 3388.3377** | 3929.0403** | 84.0120 | 9.6014 | 64.0092 | 0.1500 |
| 12. | Hundred seed weight | 0.0305 | 0.4013** | 0.0806 | 0.00921 | 0.06142 | 0.1499 |

** Significant at P=0.01

**Table 2: Estimates of general combining ability effects of five parents for twelve characters in 5x5 half diallel of bottlegourd**

| Entry | Vine length | Number of branches per vine | Number of node at which first female flower appeared | Days to first female flower opening | Sex ratio | Number of fruits per vine | Fruit weight | Fruit length | Fruit girth | Yield per vine | Number of seeds per fruit | Hundred seed weight |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AB | 0.49 | -0.42 | 0.56* | 2.38** | 0.00 | -0.08 | 0.06 | -0.98** | 0.27 | -0.17 | 36.82** | 0.09 |
| PSPL | 0.78** | 0.64** | 0.46 | 1.04 | -0.02 | -0.24 | 0.19** | 0.66 | 0.42* | -0.11 | -21.00* | 0.04 |
| Pratik | -0.46 | 0.02 | -0.23 | -1.35 | -0.02 | 0.11 | -0.12 | 0.33 | -0.27 | -0.03 | 0.82 | -0.02 |
| IC-92330 | -0.87** | -0.95** | -0.43 | -1.24 | 0.02 | 0.19 | -0.09 | 0.54 | -0.15 | 0.23** | -7.78 | -0.02 |
| TPT-local | 0.06 | 0.71** | -0.36 | -0.82 | 0.02 | 0.02 | -0.04 | -0.54 | -0.28 | 0.08 | -8.86 | -0.08 |
| SE($g_i$) | 0.0588 | 0.0063 | 0.0643 | 0.0965 | 0.004 | 0.2028 | 0.0158 | 0.0683 | 0.0396 | 0.0318 | 3.0987 | 0.0959 |
| CD at P=0.05 | 0.1204 | 0.0129 | 0.1317 | 0.1976 | 0.0082 | 0.4153 | 0.0324 | 0.1398 | 0.0811 | 0.0651 | 6.3461 | 0.1964 |
| CD at P=0.01 | 0.1624 | 0.0174 | 0.1776 | 0.2666 | 0.0111 | 0.5603 | 0.0436 | 0.1887 | 0.2241 | 0.0878 | 8.5617 | 0.2649 |

* Significant at P=0.05
** Significant at P=0.01

**Table 3: Estimates of specific combining ability effects of ten F3 cross progenies for twelve characters in 5x5 half diallel of bottlegourd**

| Entry | Vine length | Number of branches per vine | Number of node at which first female flower appeared | Days to first female flower opening | Sex ratio | Number of fruits per vine | Fruit weight | Fruit length | Fruit girth | Yield per vine | Number of seeds per fruit | Hundred seed weight |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AB x PSPL | 5.50** | -0.48 | 1.89** | 9.24** | -0.03 | 0.18 | 0.48** | 2.53 | 2.90** | 0.12 | 115.57** | -0.06 |
| AB x Pratik | -0.22 | 2.64** | -0.69 | -2.64 | 0.03 | 0.12 | -0.01 | 5.06** | 0.37 | 0.05 | 8.75 | 0.37 |
| AB x IC-92330 | 0.45 | 3.40** | -0.55 | -1.85 | 0.00 | 0.54** | 0.33** | 5.48** | 1.02** | 1.29** | 48.34* | 0.43 |
| AB x TPT-local | 0.69 | 1.88 | -0.32 | -0.20 | 0.09** | 0.12 | 0.03 | 5.33** | -0.08 | 0.13 | 0.83 | 1.29 |
| PSPL x Pratik | 1.05 | 4.25** | -0.06 | -3.03** | 0.02 | 0.28 | 0.11 | 2.16 | 0.03 | 0.21 | 3.57 | 0.45 |
| PSPL x IC-92330 | -0.07 | 1.85 | -1.12** | -2.07 | 0.00 | 0.20 | -0.03 | 2.88 | 0.17 | 0.42 | 7.43 | -0.38 |
| PSPL x TPT-local | -0.07 | 0.19 | -0.36 | -0.63 | -0.02 | 0.08 | 0.11 | 6.63** | 0.64 | 0.32 | 14.31 | -0.12 |
| Pratik x IC-92330 | 0.17 | 0.86 | 0.70 | 2.38 | -0.05* | 0.08 | 0.11 | 5.21** | 0.43 | 0.13 | 35.31 | -0.45 |
| Pratik x TPT-local | 0.07 | 1.27 | -1.01* | -1.57 | 0.03 | 0.46** | 0.20** | 3.29 | 1.26** | 0.31 | 48.09* | -0.40 |
| IC-92330 x TPT-local | 0.15 | 0.77 | 0.23 | 0.06 | -0.01 | 0.18 | 0.14 | 2.55 | 0.57 | 0.10 | 17.72 | -0.30 |
| SE ($g_i$) | 0.1201 | 0.1769 | 0.1438 | 0.2158 | 0.0089 | 0.0454 | 0.0013 | 0.1527 | 0.0885 | 0.0713 | 6.9286 | 0.2146 |
| CD at P=0.05 | 0.2459 | 0.3623 | 0.2945 | 0.4419 | 0.0182 | 0.0929 | 0.0026 | 0.3127 | 0.1812 | 0.1460 | 14.1897 | 0.4395 |
| CD at P=0.01 | 0.3318 | 0.4887 | 0.3973 | 0.5962 | 0.0246 | 0.1254 | 0.0036 | 0.4219 | 0.2445 | 0.1970 | 19.1437 | 0.5929 |

* Significant at P=0.05
** Significant at P=0.01

## CONCLUSION

The analysis of variance for combining ability revealed that both gca and sca effects were significant for all the characters except hundred seed weight. Estimates of components of variances revealed that variance due to sca was greater than variance due to gca indicating the preponderance of non additive gene action for all the twelve characters studied. The estimates of gca effects indicated that AB was the best general combiner for number of seeds per fruit, hundred seed weight , PSPL for vine length, number of branches per vine , fruit girth and fruit weight,IC-92330 for yield per vine and TPT- local for number of branches per vine. The estimates of sca effects indicated that AB X IC -92330 and Pratik X TPT- local were the best specific $F_3$ crosses for fruit yield and its components and could be of promising for further yield improvement in bottlegourd through selective diallel mating programme.

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