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# Combining abilities for days to flowering and maturity periods among cowpea (*Vigna unguiculata*) lines

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**ABSTRACT**

10 parental lines of cowpea were crossed and evaluated to determine the genetic behaviour of days to flowering and maturity traits through a full diallel analysis. In all, there were 45 crosses, 45 reciprocals and 10 parents to make a total of 100 entries which were evaluated in two locations, Teaching and Research Farm, Ekiti State University, Ado Ekiti, and College of Education Demonstration Secondary School Farm in the early season of 2011 using a Randomized Complete Block Design with two replications. Data were collected on plant height, days to first flowering, days to 50% flowering, and days to 50% podding. Results showed that there were significant differences among the entries ($p<0.05$) for all traits studied. The mean for days to 50% flowering ranged between 50.07 and 51.73 days, days to pod maturity varied from 58.77 to 64.24 days. The hybrid lines exhibited the earliest flowering and pod maturity traits among the entries. General Combining Ability (GCA) for most of the traits were significant. Only days to pod maturity were not significant for Specific Combining Ability (SCA) among the traits. $P_1$, $P_4$, $P_5$ and $P_6$ are identified to be the best general combiners for most of the characters while $P_1$ x $P_4$, $P_1$ x $P_6$, $P_4$ x $P_2$ and $P_9$ x $P_5$ are excellent specific combiners for earliness traits. Mid-parents heterosis (%) was high (280.47%) among the crosses and reciprocals. The ratio of GCA to SCA ranged from less than 1 for flowering intervals to 48 for days to 50% flowering which underscores the importance of additive effect and suggesting that reasonable progress can be made using selection procedure.



## Introduction

Cowpea (*Vigna unguiculata (L).Walp*) belongs to the family leguminosae. It is a major grain legume, fodder, green pod and leafy vegetable crop grown majorly on 12.5 million ha in drought-prone regions of Africa and other Tropical and Subtropical region (Langyintuo *et al.* (2003) and Ogunwale,2013. FAOSTAT (2013) estimated that yield of cowpea ranges between 0.58 to 1.18 t $ha^{-1}$ in the last 5 years. Asiwe (2009) reported that the average land area planted per farmer ranged between 0.25 and 2.0 ha. Under small scale production, grain yield is reportedly low ranging between 0.25 and 2.0 ton/ha with an average of 0.5 ton/ha. Shiringani and Shimelis (2011) stated that the yield of cowpea varied from 2.6 to 4.0kg/ha.

Cowpea is a primary source of protein for many poor Africans. Cowpea is photosensitive-short day plant i.e. flowers when we have short days (September- December) Therefore, it is possible to cultivate cowpea three to four times per year when it is supplemented with irrigation. Early maturing cowpea varieties save cowpea farmers from long cultivating period and labour compared to late or medium maturing cowpea lines. It reduces the numbers of herbicide spray. Cowpea which flowers early tends to pod and mature early, therefore days to flowering can be used as an index for determining maturity period (Umar *et al*., 2010; Ogunwale, 2013).

Hall (2004) and Ogunwale (2013) opined that numbers of days to 50% flowering are affected more by additive than by dominance effects. However, additive gene action implying that significant improvement could be made in yield through selection of cowpea (Eid, 2009). A set of crosses produced by involving 'n' lines in all possible combinations is designated as diallel cross. This provides information on the nature and amount of genetic parameters and general and specific combining abilities of parents and their crosses, respectively. Therefore, the aim of this research is to determine the combining abilities for days to flowering traits among cowpea lines varying in maturity period. The objectives of this research are to determine the: general and specific combining abilities among the cowpea lines. reciprocal effects among the crosses., heterosis among the crosses., and potential hybrids among the crosses.

## Genetic Material

Ten Cowpea lines were collected from the International Institute of Tropical Agriculture (IITA) Ibadan gene bank. These ten cowpea lines were grouped into three, namely, two early maturing varieties (less than 60.00 days), six medium maturing varieties (greater than 60.00 days) and two late maturing varieties (greater than 70.00 days). Table 1 presents the characteristics of the cowpea lines used in the experiment.

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### Experimental Sites

### Generation of the crosses and the reciprocal crosses

Potted experiments was carried out in the screen house at Teaching and Research Farm, Ekiti State University during the dry Season of 2010. The cowpea lines were planted on 15th November, 2010. Each pot was filled with 35kg loamy soil obtained underneath the Teak Plantation. In all, 40 pots was used. In each pot four seeds were planted for each pure line and replicated four times. Planting of the seeds was done to ensure synchrony of flowering to allow for pollination in all possible ways i.e. the late maturing variety were planted about ten days early than the medium maturing variety.

Pollination was done a day after the emasculation of the male gamete. Pollens from desired flower are collected using a thin brush. Tagging of the pollinated flower was then done with the pollen donor parent written in the tag (i.e. female by male donor). The pollinated flowers are then carefully covered with mosquito net to prevent consternating of pollen from another parent. All possible crosses and reciprocal were generated among the 10 parental lines. In all, 45 crosses $F_1$, 45 reciprocal ($F_1$s) and 10 parents were generated for evaluation purposes.

To ensure sufficient seeds for evaluation at least 10 successful crosses was ensured. At maturity, the pods were carefully harvested, threshed and seeds were stored in envelop in preparation for evaluation.

### Results

The means of the agronomic traits of the evaluated cowpea genotypes are shown in (Table 2). Reciprocal had the highest values for all the characters except flowering interval for hybrid which were superior to those of parental lines in the following characters, days to last flowering, pod weight, grain yield and weight of 100 seeds, whilst the mean for parental lines where higher compare with that of the hybrids for plant height, days to first flowering, days to 50% flowering, days to pod maturity and pod length.

The mean value of hybrids for days to pod maturity mature earlier, (58.77) even earlier than the earliest parental line (63.15) and the reciprocal mean value showed that it exhihibited late maturing traits (64.24).

The pod traits mean value showed that the pod length. For reciprocal had the highest value of 18.72 cm and significant ($p < 0.05$) followed by parents and the hybrid lines.

The mean of the parents for days to 50% flowering ranged between 46.25 for $P_1$ to 67.25 days for $P_{10}$ given an interval of 20.00 days. Among the crosses, $P_2 \times P_4$ reached days to 50% flowering with 42.00 days which is the earliest among others, (Table 3). Furthermore, $P_1 \times P_3$ and $P_8 \times P_4$ (45.75 days) of the crosses attained 50% earlier than the earliest parent with less than 46.25 days. Most of the crosses and reciprocals attain 50% flowering at less than 63.25 days.

The mean of the parents for day to pod maturity shows that $P_1$ matured earliest among the parent lines (57.25 days). However, mean of the parent ranged between 57.25 for $P_1$ to 80.00 days for $P_{10}$ with 29.75 days interval. (Table 4). Among the crosses, mean of the crosses ranged from 53.75 for $P_1 \times P_6$ to 70.75 days for $P_1 \times P_9$ with 17.00 days interval. The reciprocals also ranged from 58.75 for $P_7 \times P_4$ to 72.00 days for $P_{10} \times P_6$ with 15.25 days interval. However, both crosses and reciprocals matured earlier than the parental lines, except parent, $P_1$ which matured earlier than the earliest among the reciprocal cross (i.e. 57.25 for $P_1$ and 58.75 days for $P_7 \times P_4$).

### Combining abilities for maturity traits and other agronomic characters of Cowpea

Mean Squares from analysis of variance (ANOVA) for general combining ability (GCA), specific combining ability (SCA), reciprocal (REC) and maternal effects (MAT), and other effects due to other sources of variation are presented in Table 5. The Mean Square values for GCA were highly significant ($P<0.01$) for days to first flowering, days to 50% flowering and days to pod maturity while only days to flowering interval was not significant.

The mean square values for SCA and REC were highly significant ($P<0.01$) for days to first flowering, days to 50% flowering, days to last flowering and flowering interval but not significant for days to pod maturity. The magnitude of SCA mean square was generally less than that of GCA for all the traits studied (Table 5). Mean Square for the MAT and Non-maternal effects (NMAT) were highly significant ($P<0.01$) for most of the traits except for days to flowering interval which was not significant in respect of variation due to MAT effects.

Also, the mean square value for analysis of variance for interaction showed that GCA ENV and SCA×ENV in respect of flowering traits were highly significant ($P<0.01$) except days to 50% flowering and days to flowering intervals for flowering interval in REC×ENV, and days to 50% flowering for MAT×ENV. GCA ×ENV and SCA × ENV respectively.

### Pearson correlation coefficient of different traits in the two environments

The relationships among the studied traits as revealed by Pearson Correlation Coefficients are shown in Table 8. Generally, there were significant correlations among many of the studied traits ($P \leq 0.01$ and $P \leq 0.05$). Days to first and 50% flowering, showed negative and significant correlation with the pod maturity (-0.04*‚-0.02*).Plant height also showed negative and significant correlation with days to pod maturity (-0.03*). First day to flowering is also significantly correlated to first day to maturity at (-0.04*). The days to flowering interval shown negative and significant correlation with days to pod maturity at -0.02*. Days to 50% flowering are not significantly correlated to flowering interval; therefore, there is no correlation between the days to 50% flowering and flowering interval of cowpea traits.

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### Discussion And Conclusion

The lower values of days to first flowering and days to first maturity in the hybrids compared to parental lines is an indication of the presence of dominance effect towards parent that flower earlier. These findings are similar to earlier reports by Adeyanju et al. (2007) and (Akande and Balogun, 2009). Francis (2006) in early generation selection for high yielding cowpea genotypes observed 45.2 days for days to 50% flowering in cowpea F2 generations similar to 45 days for days to 50% flowering reported Bhaskaraiah (1977) while in this study the days to 50% flowering in the F1 generations were lower at 42.00 days (Ogunwale, 2013). The wide range in days to flowering indicates that progress can be made in selecting for different maturity groups in cowpeas. This was also in agreement with the findings of Francis (2006) and Ogunwale, (2013) in early generation selection for high yielding cowpea genotypes and combining abilities for days to first flowering and yields of cowpea respectively.

High level variability was recorded for all the flowering traits such as days to first flowering, days to 50% flowering, flowering interval, days to pod maturity at harvest and other agronomic characters and indicating significant general combining abilities (GCA) and specific combining ability (SCA) effects. Significant GCA effect connotes importance of additive and additive x additive types of gene action while the SCA effect involves both dominant and epistasis type of gene action, all of which together constitute the non-additive genetic effects (Ogunwale, 2013). These are indications that both additive and non-additive gene effects played major roles in the inheritance of earliness and other agronomic traits of the cowpea lines as earlier observed by Hall (2004) and Asiwe (2009). This also showed that there is high potential for breeding early maturing cowpea cultivars in the agro-ecological zones where the experiments were conducted.

Even though appreciable levels of heterosis were recorded in some notable reciprocal crosses in terms of flowering study, the degree of specific combinations of the lines to form the reciprocal crosses was generally low. An indication to this was the low and non-significant SCA effects for the traits in many of the reciprocal crosses. This means that the lines specifically combined poorly for the traits, especially yield in the reciprocal crosses. This justifies the significant reciprocal effects earlier recorded for most of these traits. The implication of this is that it is not just enough to rely on the records of heterotic performance of the crosses but also the SCA records in cowpea hybrid production. This was the observation of Bhaskaraiah (1979), Bhaskaraiah et al. (1980) Pal-Alkish et al. (2007), Kabas et al. (2007) and Ogunwale (2013) for cowpea. Environment has no influence on Non Maternal-effect (NMAT) among the traits. The mean square attributed to flowering traits such as first day to flowering, days to 50% flowering and days to last flowering showed GCA and SCA except SCA×ENV and NMAT × ENV which are not significant in days to 50% flowering. The same trends were observed by Singh and Tarawali (1997) Francis, (2006) Olapade et al. (2002), Lopes et al. (2003) and Unal et al. (2006) in cowpea. The first day to pod maturity showed significant GCA for days to pod maturity; all traits were significant except SCA and reciprocal effects (REC). The implication of this is that the genes are additive and specific parents are not to be used as the seed parent (female plant) but the general parent can be used as the seed parent (paternal) while breeding for desirable traits in the cowpea genotypes as previously noted by Kabas et al. (2002) , Noubissie et al. (2011) and Ogunwale, (2013

There was no paternal effect (non-additive) among the lines for days to first flowering in the estimate of GCA effects for the parental lines for different characters. P1 was highly significant and negative for days to 50% flowering and days to last flowering, Parent 6 was highly significant and negative for days to last flowering and flowering interval but positive for days to 50 % flowering .This is an indication that P1 and P6 had extra-early traits but the positive and significant effects indicated a delay in flowering effects. Similar reports were given by Pal-Alkish et al. (2007) and Kabas et al (2007) for cowpea

The SCA for different characters among the lines showed that the effects for first day to flowering, days to 50% flowering and flowering interval for hybrids and reciprocal effects which are highly significant and negative indicated extra early trait among the hybrid lines, but positive and significant ($P < 0.01$ and 0.05) are extra late and late traits. This result agrees with the views of Adeyanju et al. (2007), Noubissie (2007 and 2011) for cowpea and Arowosegbe (2010) for maize heterotic pattern. The flowering interval for hybrids and reciprocals which are highly significant and negative contributed to the low or moderate yield among the hybrid lines, but positive and significant for P1 × P6, P2 × P4 and P3 × P9 respectively. This indicates prolonged flowering and contributed to very high numbers of flowers in cowpea which resulted in very high yield.

The SCA for days to pod maturity for the hybrids and reciprocal effects which showed negative and significant effects correlated with high yield. The combining abilities for maturity traits and other cowpea agronomic characters on the average, the hybrids out-yielded the parental lines, through a worthwhile breeding effort indeed. The wide range of values recorded for all the studied traits of the parental lines and the crosses (hybrids and reciprocals) showed high level of variability among the cowpea genotypes. The means of the crosses were consistently lower than the parental lines for the days to flowering traits.

The diallel analysis showed significant GCA and SCA for flowering traits such as days to first flowering, days to 50% flowering, flowering interval, days to first maturity, and other agronomic characters. These are indications that both additive and non-additive gene effects played major roles in the inheritance of earliness and other agronomic traits of the cowpea genotypes. The results further show that there is potential for breeding early maturing cowpea cultivars in the zones in which the experiments were conducted. This result agrees with the views of Pal-Alkish et al. (2007), Kabas et al. (2007) and Ogunwale, (2013).

The relationships among the studied trait as measured by correlation coefficients are important in plant breeding because they measure the degree of association between two or more characters. This association is highlighted further through the coefficient of determination which gives the percentage contribution of one trait to the variation observed in the other trait(s). The cause of correlation could be genetic and or environmental.

The positive and significant correlations recorded between each of the flowering traits namely; first days to flowering (-0.17**), days to 50% flowering (0.28**) and flowering interval (-0.52**) in this study indicate that late flowering is associated with higher grain yield while earliness is associated with reduced grain yield. This had also been reported by Hall et al. (2003) Bolanos and Edmeades (1993), and (Pal-Akhilash et al., 2007, Ogunwale, 2013) in the development of cowpea cultivars. The results obtained in this study have demonstrated the importance of diallel analysis in the detection, the additive and dominance effects of hybrids, heterosis and identification of the cowpea parents with good general and specific combining abilities

The outstanding early-maturing and high-yielding materials identified in this work (P7 X P4, P1×P6 and P9 X P5) could be used as planting materials in areas where the duration of rainy season is short like the derived savannah areas and in the late season cropping under the forest ecological conditions in Nigeria.

**Table 1: The ten Cowpea lines used for the experiment**

| | Lines | Maturity/Breed | Testa Colour | Days to 50% Flowering |
|---|---|---|---|---|
| 1 | IT 04K 221-1 | Early | White | 57.25 |
| 2 | IT 06K 134 | Early | White | 59.75 |
| 3 | IT97K-499-35 | Medium | White | 61.00 |
| 4 | IT06K-124 | Medium | White | 63.75 |
| 5 | IT06K-835-45 | Medium, Prostrate | White | 60.50 |
| 6 | IT04K-321-2 | Medium | White | 61.50 |
| 7 | IT98K-503-1 | Medium, Erect | Cream White | 61.00 |
| 8 | IT06K-135 | Medium, Erect | White | 62.00 |
| 9 | IT06K-270 | Late Erect | Brown | 74.75 |
| 10 | IT97K-568-11 | Late, Erect | Brown | 80.00 |

**Table 2: Mean and Standard deviation for all the agronomic characters of the parental inbred lines, their hybrids and reciprocal**

| S/N | Agronomic Characters | Parents 10 | Hybrids 45 | Reciprocals 45 |
|---|---|---|---|---|
| 1. | Plant Height (cm) | 54.26± 27.51 | 53.34± 29.94 | 54.37± 25.03 |
| 2. | Days to first flowering | 44.95± 5.70 | 42.47± 5.77 | 45.23± 4.91 |
| 3. | Daysto50% flowering | 50.98± 6.47 | 50.07± 6.17 | 51.73± 5.62 |
| 4. | Days to Last Flowering | 76.85± 5.96 | 77.53± 6.24 | 78.63± 6.21 |
| 5. | Flowering Interval | 33.02± 5.11 | 34.12± 7.57 | 33.44± 6.75 |
| 6. | Days to Pod Maturity | 63.15± 7.12 | 58.77± 8.56 | 64.24± 5.89 |
| 7. | Pod Length (cm) | 17.29± 2.24 | 17.15± 2.20 | 18.72± 3.99 |

**Table 3: Mean of the parents (underlined), crosses (upper diagonal) and the reciprocals (lower diagonal) for days to 50% flowering**

| Parents Inbredlines | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 | P10 |
|---|---|---|---|---|---|---|---|---|---|---|
| (P1) | <u>46.25</u> | 49.25 | 45.75 | 50.25 | 48.25 | 44.25 | 47.50 | 49.00 | 57.25 | 49.25 |
| (P2) | 52.50 | <u>50.00</u> | 49.50 | 42.00 | 49.75 | 51.50 | 49.25 | 51.00 | 50.50 | 53.67 |
| (P3) | 52.50 | 48.50 | <u>47.75</u> | 47.75 | 46.25 | 51.00 | 53.00 | 53.75 | 49.25 | 50.00 |
| (P4) | 52.50 | 52.50 | 49.50 | <u>48.25</u> | 49.25 | 53.00 | 53.25 | 49.00 | 47.25 | 51.00 |
| (P5) | 46.25 | 50.50 | 49.25 | 49.25 | <u>48.25</u> | 48.25 | 44.25 | 48.25 | 51.00 | 51.50 |
| (P6) | 50.50 | 54.25 | 52.50 | 50.50 | ____ | <u>51.50</u> | 51.00 | 52.00 | 55.75 | 52.00 |
| (P7) | 51.25 | 52.00 | 49.00 | 53.00 | 49.25 | 47.75 | <u>52.00</u> | 50.50 | 46.25 | 55.25 |
| (P8) | 49.25 | 46.25 | 51.50 | 45.75 | 52.75 | 55.75 | 47.50 | <u>48.75</u> | 54.75 | 53.50 |
| (P9) | 48.25 | 50.00 | 50.50 | 50.25 | 52.50 | 52.00 | 52.50 | 53.00 | <u>58.50</u> | 60.25 |
| (P10) | 53.75 | 53.50 | 54.50 | 55.25 | 55.25 | 58.25 | 60.25 | 60.25 | 53.50 | <u>67.25</u> |

**Table 4: Mean of the parents (underlined), crosses (upper diagonal) and the reciprocals (lower diagonal) for days to Pod Maturity**

| Parents Inbredlines | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 | P10 |
|---|---|---|---|---|---|---|---|---|---|---|
| (P1) | <u>57.25</u> | 65.25 | 58.25 | 62.25 | 58.75 | 53.75 | 57.25 | 57.25 | 70.75 | 61.50 |
| (P2) | 66.75 | <u>59.75</u> | 63.25 | 55.75 | 67.25 | 62.00 | 61.00 | 63.50 | 64.00 | 62.00 |
| (P3) | 68.25 | 63.00 | <u>61.00</u> | 60.50 | 59.25 | 65.75 | 62.50 | 63.75 | 60.50 | 63.50 |
| (P4) | 63.50 | 65.75 | 60.50 | <u>63.75</u> | 64.25 | 66.75 | 65.25 | 60.00 | 60.75 | 62.00 |
| (P5) | 58.75 | 62.50 | 59.25 | 64.25 | <u>60.50</u> | 61.00 | 57.75 | 54.75 | 61.50 | 66.75 |
| (P6) | 59.25 | 64.75 | 68.25 | 58.75 | _____ | <u>61.50</u> | 65.75 | 64.75 | 65.25 | 62.00 |
| (P7) | 62.50 | 65.50 | 63.00 | 58.75 | 63.50 | 62.00 | <u>61.00</u> | 67.75 | 57.25 | 65.50 |
| (P8) | 59.25 | 61.75 | 67.75 | 61.50 | 63.75 | 67.75 | 59.75 | <u>62.00</u> | 59.75 | 64.25 |
| (P9) | 65.25 | 62.00 | 63.50 | 64.75 | 66.75 | 64.75 | 66.75 | 65.25 | <u>74.75</u> | 68.25 |
| (P10) | 64.50 | 63.50 | 70.25 | 66.75 | 69.25 | 72.00 | 66.25 | 67.75 | 65.25 | <u>80.00</u> |

**Table 7: Mean Square values attributed to general combining ability (GCA), specific combining ability (SCA), and reciprocal (REC) and other observed squares of the parental inbred line**

| Source of variation | Degree of freedom | DTFF | 50% Flowering | DTLF | Flower Inter | DTFM |
|---|---|---|---|---|---|---|
| GCA | 9 | 28.96** | 56.23** | 30.83* | 8.12 | 6.80** |
| SCA | 45 | 7.47** | 7.77** | 11.57* | 9.60** | 3.86 |
| REC | 36 | 10.04** | 9.42** | 13.12* | 77.58** | 3.55 |
| MAT | 9 | 15.14** | 15.07** | 14.96* | 11.62 | 6.50** |
| N MAT | 36 | 8.76** | 8.01** | 12.66* | 5.94** | 2.92** |
| GCA X ENV | 9 | 3.72** | 6.93 | 9.89** | 3.40** | 0.07** |
| SCA X ENV | 45 | 8.73** | 7.68** | 5.33** | 3.48 | 1.15** |
| REC X ENV | 45 | 6.09** | 10.03** | 6.38** | 3.54 | 0.86** |
| MAT X ENV | 9 | 3.86** | 10.37 | 10.86 | 3.97** | 0.54** |
| NMATX ENV | 36 | 6.65** | 9.95** | 5.26 | 3.43** | 1.15** |
| ERROR | 120 | 4.10 | 3.69 | 4.67 | 10.96 | 19.09 |

DTFF: Days to first flowering, DTLF: Days to Last Flowering, DTFM: Days to First Maturity, 50% Flowering: Days to 50% Flowering

**Table 8: Pearson Correlation Coefficient of different traits in the two Environments**

| S.N | Traits | | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|
| 1 | Plant Height | 1 | __ | -0.10** | -0.39** | -0.08 | -0.46** | -0.35** |
| 2 | Days to first flowering | 2 | __ | __ | -0.51** | 0.45** | -0.42** | -0.40** |
| 3 | Days to50% flowering | 3 | __ | __ | __ | -0.33** | -0.53** | 0.42* |
| 4 | Days to last flowering | 4 | __ | __ | __ | __ | 0.29** | -0.52** |
| 5 | Flowering Interval | 5 | __ | __ | __ | __ | __ | -0.28** |
| 6 | Days to Pod Maturity | 6 | __ | __ | __ | __ | __ | __ |

These results strongly support the view that earliness in cowpea can be achieved through incorporation of genes for earliness in cowpea genotypes which is easily done through diallel analysis (Ogunwale, 2013). Additive gene action predominated in all the characters studied which could be effectively exploited using the simple recurrent selection methods.

The four parental lines (P1, P6, P7 and P9) were good general combiners for earliness and could therefore be used as sources of genes for earliness in the production of cowpea composite cultivars. Crosses P1 X P4, P1 X P6, P4 X P2 and P9 X P5 identified to be the best specific combiners for earliness-determining traits.

Some parental lines showed heterotic responses for earliness determining traits and grain yield upon crossing even though they were poor specific combiners. There is therefore, need to always investigate both the general combining ability and the specific combining ability of cowpea parental lines whenever earliness and yield is the objective of a cowpea breeding programme.

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