Genetic improvement for yield and its components in cowpea (*Vigna unguiculata* L.) via cycles of selection program

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Abstract: Selection is working to increase the genetic repetition in the desirable traits, as well as the improvement and development of new varieties of plant. The aims of this study were to determine genetic gain to flowering after three cycles of phenotypic selection in F_2 population (Dokki 331 × IT81D-1137). Significant differences among F_3 Families, F_4 Families and F_5 Families for days to flowering were found. Direct response to selection for early flowering date was – 6.76 – 5.68 and – 7.68 days and dry seed yield/ plant 4.92, 8.73 and 8.27 gram in the three cycles of selection, respectively. The genetic gains for early flowering date were 9.04% in the first cycle, 8.14% in the second cycle and 11.43% in the third cycle of selection and dry seed yield/ plant 8.69%, 14.69% and 12.8%, respectively.). Correlated response to selection was significant and positive for all studied traits in three cycles. Moderate – high broad-sense heritability (0.24 – 0.96%) indicated the presence of additive gene effects. Positive correlation was found between days to flowering and other character in three cycles. This result has been indicated before from the highest to indirect response before dry seed yield in three cycles. Generally, the observed response was greater than predicted response had indicated the presence of dominance gene action controlling the flowering date. The results indicated that the selection was effective in improving the traits of dry seed yield plant.

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1-Introduction

In a population under selection for a quantities character, genotypic frequencies and hence gene frequencies are altered and these changes are further modified by the mating system that may be employed to advance the selected individuals to the next generation (Chopra, 2000). Cowpea (*Vigna unguiculata* L. walp.) is produced worldwide under largely temperature but also under tropical and subtropical such as south valley region. Development of cultivars with early, acceptable grain quality, resistance to some important disease and pest has significantly increased the yield and cultivated area of cowpea (Ehlers and Hall, 1996). Selection of high yielding crops with wider adaptability shall not be only very useful but shall induce increasing productivity. Genetic improvement of seed yield, alone, is not possible through phenotypic selection through correlated response entailing several contributing factors which influence seed production both directly and indirectly shall be most appreciate. According to Rachio (1985) worldwide production levels may approach or exceed 25 million tons of dry seed every year on about 9 million hectares.

Cowpea is grown extensively in 16 African countries; Nigeria and Niger together produce 49.3% of the world crop. The third largest cowpea producing country is Brazil; where 26.4% of the world wide total is produced (Som and Hazara, 1993). Mehta (2000) compared selection procedure pedigree selection for early flowering (Ps (EF), pedigree selection for high yield (Ps (HY), mass selection (Ms), single seed descent (SSD) and random bulk (RB) populations, were initiated in the F_2 and compared in segregating F_3 and F_4 generations of four cowpea crosses. The widest phenotypic range and higher variances were exhibited by Ms for seed yield/plant in all the four crosses in both generations.

Sawarkar et al., (2000) studied the genetics of pod yield and its components in cowpea. The results indicated a major role of non-additive gene action in the inheritance of these characters and limited scope for improvement through straight forward selection. They estimated narrow-sense heritability as 12.99% (seeds/pod) and 45.51% (plant height). Sharama et al. (2000) estimated genetic variability for physiological parameters and their association with grain yield in cowpea. High heritability coupled with high value of genetic advance were reported during growth stages I and II. Tyagi et al., (2000) evaluated the coefficient of variability, heritability, genetic advance for days to 50% flowering, plant height, pod length, number of seeds/pod and weight of 100 seeds in 24 cowpea genotypes. Abd El-Hady (2003). It was found in the study of inheritance of yields and its components in some cowpea crosses that the responses to selection and heritability showed high values for the days to 50% flowering, plant height, pod length, number of seeds/pod, weight of 100 seeds and dry seed yield (Helmy 2003). Shahid Ahmed et al., (2005) reported that the magnitude of the phenotypic coefficient of variation (Pcv) was higher than that of the genotypic coefficient of variation (Gcv) for all the traits studied.

High Gcv and Pcv were recorded for plant height, number of pods/plant, seed yield/plot and weight of 100-seeds. High heritability coupled with high genetic gain was observed for plant height (96.39 and 90.78%), number of pods/plant (67.84 and 38.39%), seed yield/ plot (175.02 and 122.83%) and weight of 100 seeds (37.40 and 39.34%) indicating the preponderance of additive gene effects for these traits.

Indra Singh et al. (2006), reported that pooled analysis of variance for combining ability showed significant interaction of GCA variance and SCA variance with environment except seed per pod. The SCA components of variance were higher than GCA for yield component characters, indicating the predominance of non additive gene effects. F_4 lines derived from the highest 10% performing F_3 individuals were no higher yielding than F_3 lines derived from the remaining F_3 individuals. Padia and Ehlers (2008), indicating that early generation of selection for yield was effective. Selection for earliness, yield and its components in two populations of cowpea were studied by Abd El-Hady and Hussein (2008). They found that dry seed yield (Kg/Fed.) could be increased by selection for pod length and number of pods/plant.

Early flowering combined with delayed leaf senescence trait contribute to increased yield by mid- and terminal drought given that the resulting genotypes would be able to survive mid-season drought (Gwathmey and Hall, 1992). The additive and dominance variance components were estimated for each trait under stress or adequate soil moisture conditions (Alidu et al., 2013). Days to flowering, weight of hundred seeds and number of seeds per pod were conditioned mainly by additive genes, for biomass production, number of pods/plant and grain yield, dominance variance was higher than the additive variance component. The wide range in days to flowering in the Families indicates that significant variation and that progress could be made in selecting for different maturity groups in cowpeas. Differences in number of days to flowering was due sensitivity to photoperiod, thus indicating that the lines responded differently to photoperiod. The same findings of differences to flowering were reported by Adeyanju et al. (2007), they reported similar transgressive segregation for flowering days.

Seeds yield is a quantitative trait which is controlled via multi gene expression and function (Oseni 1994; Asins 2004). Selection on the basis of grain yield alone is usually not effective and efficient, whereas selection along with its component characters could be more efficient and reliable, consequently yield and yield components and among the component characters themselves can improve the efficiency of selection in plant breeding programs (Muhammed et al., 1994; Shimelis 2006; Mady et al 2012; Mady et al, 2013, and Helaly et al 2014).

Selection and breeding procedures of genetic important of cowpea is largely conditioned by the type of gene action and relative amount of genetic variance component in the population. This study was conducted (i) to determine genetic gain for days to flowering after three cycles of selection (ii) the indirect effects of the selection for dry seed yield/plant, number of pods/plant, pod length and number of seeds/pod (iii) estimate genetic correlations among and heritability of traits related to maturity such as seed yield and to develop early flowering advanced lines adopted to production systems.

2-Materials And Methods

The present genetic improvement study was carried out at the Experimental Farm of the Faculty of Agriculture, South Valley University, Qena, Governorate, Egypt and Horticulture Department, Faculty of Agriculture in Cairo, Al-Azhar University during the three summer season of 2012, 2013 and 2014. Selection studies were initiated in the F_2 generation of the cross (Dokki 331 × II81D-I137). The population was plant at the experimental farm of south valley university, Qena, Egypt and Horticulture department, Faculty of Agriculture in Cairo, Al-Azhar University. The name and source of the base population selection Dokki 331 genotype was obtained from Prof. Dr. A.M. Damarany, Hort. Dep., Faculty of Agric., Sohag Univ and II81D-I137 genotype was obtained from Local, Egyptian Agricultural, organization, Egypt.

In the summer season 2012, seeds of cowpea cultivars were sown on 20 April. Single plant were grown the ridge at 3m length 70 cm in width and plants spaced 20 cm between each other. Flowering date for individual plants was defined as the number of days from planting date until 50% of the plants had the first flower open in the plot. The 10 earliest plants were selected. From the other plants five plants were harvested from F_3 Bulk. Next season, the 10 F_3 selected and F_3 bulk families were planted on 20 April.

With regard to the second cycle of selection, the first of 2.22% of the plants to flowering date were ragged and selected. In the summer season of 2013, the 10 F_4 selected families and Bulk were planted on 20 April for the third cycle of selection within each family. One plant with first to flowering date (1/15) intensity selection was selected from F_5 selected families, seeds per plant for five random families harvested and bulked for each family.

With reference to the F_5 selected families and F_5 bulk families were planted on 20 April in 2014. The experimental design was randomized complete block design with three replications. The soil types as sandy soil, the normal practices of cultivation, irrigation, fertilization and pest control of cowpea were followed.

Data collection: Data were recorded for flowering date, dry seed yield gram/plant, number of pods/plant, pod length cm and number of seeds/pod.

Statistical procedure:

All response variables were subjected to analysis of variance (ANOVA) in the selection study (Snedecor and Cochran 1980). Genotypic and phenotypic correlation was computed according to (Miller et al. 1958). The predicted response to selection (Rx) was estimated as Rx = ih2σp (Falconer 1989), were i = standardized selection differential, h^2 = heritability, and σp = phenotypic standard deviation while, the indirect response to selection (cRx) was estimated as CRx = ih2σp rxy, Where rxy is the genetic correlation between the selected trait and unselected trait. The realized gains from selection (observed response) as a percentage deviation from the selected entries and bulk sample were estimated for the selection criteria and the correlated traits. Heritability = σ2q/σ2p where: σ2q the genetic variance and σ2p phenotypic variation (Mather and Jink, 1971).

3-Results And Discussions

Selection is the retention of desired genotypes and elimination of undesirable ones is a major and important process in breeding for improvement of one ore more plant attributes. The means, observed and predicted response to selection for days to flowering in the three cycles of selection are presented in Table 1, while the analysis of variance are given in Table 2. In the first cycle of selection significant positive response to selection was obtained for days to flowering. Yet the observed response to selection for flowering dates 9.04% of the mean. Results showed that the F_3 selected families earlier than F_3 bulk by 6.66 days. In any event, the observed response to selection for flowering date greater than predicted response indicating the dominance gene effect involved in the inheritance of that trait. Regarding indirect response to selection, significant positive correlated to conventional selection were obtained in dry seed yield/plant (8.69%), number of pods/ plant (13.32%). The observed correlated response to selection for dry seed yield/ plant and number of pods/plant was greater than predicted response confirming the dominance gene effects play important role in the inheritance of these traits. These results are in agreement with those obtained by Abd El-Hady, (2003). In this direction, another study by Hussein and El-Dakak (2009) they found two new promising lines (c-46 and c-48) in F_6 generation are could be selected and characterized by high pods weight and dry seed yield with good earliness and quality traits and produced about (40-over 100%) pod and seed yield above the cheek cultivars cream 7 and/or Kaha-1.

Table 1: Mean performance, observed and predicted response to selection for flowering date, dry seed yield, number of pods/plant, pod length and number of seeds/pod in three cycles of selection.

Characters	Cycle	C1	C2	C3
Flowering date 50%	selected	67.51	64.02	59.48
	Bulk	74.27	69.70	67.169
	Ob%	9.04	8.14	11.43
	P%	0.65	1.07	0.88
Dry seed yield/ plant gram	selected	61.52	68.14	72.85
	Bulk	56.6	59.41	64.58
	Ob%	8.69	14.69	12.80
	P%	1.6	1.49	0.18
Number of pods/plant	selected	53.69	58.09	62.89
	Bulk	47.37	50.45	52.48
	Ob%	13.32	15.14	19.83
	P%	1.1	0.69	0.67
Pod length cm	selected	19.39	19.75	20.30
	Bulk	19.10	19.39	19.52
	Ob%	1.05	1.85	3.99
	P%	0.29	0.18	0.21
Number of seed/ pod	selected	14.74	15.00	15.42
	Bulk	14.46	14.64	14.71
	Ob%	1.93	3.73	4.82
	P%	0.03	0.07	0.25

The same result was in the second cycle of selection, significant positive response to selection for flowering date was obtained (Table 2). The observed response to selection was 8.14% of the mean. Results revealed that the F_4 selected earlier the F_4 bulk with 5.68 days. Greater progress for early flowering date was done in the second cycle of selection than in the first (Table 3). Our results were attributed greater response in the second (C2) versus first cycle (C1) to selection for major genes affecting flowering date in the second cycle of selection and for major genes in the first cycle. These results are in line with those reported by Backiyarani et al. (2000), Abd El-Hady (2003), Hussein (2004), Hussein and Abd El-Hady (2008), they found that the actual selection response showed value of -1.4 and 2.6 days in the F_4 and F_5 generation in population 1 and – 6.3, - 1.8 days in population 2, expected response was 1.81 in the F_4 and 2.09 days in the F_5 generation in population 1 and 1.84 days in the F_4 and 2.34 days in the F_5 generation in population 2.

As well as, greater response in the second cycle of selection in this study could simply reflect higher selection intensity. While selection intensity in the first cycle of selection was known to be 10% was estimated a selection intensity of 2.2% in the second cycle of selection.

The observed response to selection was greater than predicted response indicated that dominance gene effects were found.

Positive correlated response to selection for flowering date in dry seed yield/plant, number of pods/plant, pod length and number of seeds were positive and significant Table 2.

The observed correlated response to selection for dry seed and number of pods/plant were greater than predicted response promoted that these traits controlled by the type of dominance gene effects. These results are in line with those reported by Thiyagarajan (1989), Abd El-Hady (2003) and Hussein et al. (2004) whose found that the realized gain as percentage of mid parent was highly significant dry seed yield and number of pods/plant.

Also, analyze of genetic components revealed significant additive (D) and dominance (H) genetic variation for days to flowering, dry seed yield and number of pods/plant.

Data in Table 2 showed significant positive response to selection for days to flowering. The genetic gain for days to flowering was 11.43% in third cycle. The F_5 selected families earlier than F_5 Bulk by 7.68%.

Retest progress for early flowering date was made in third cycle of second cycle of selection. Greatest response in the third cycle of selection in this study could simply reflect highest selection intensity. While selection intensity in the first cycle was 10% and the second cycle was 2.2% estimated a selection intensity of 0.06 in the third cycle of selection. Selection for days to flowering, also improved dry seed yield in tow population over the bulk sample by 176% and 28.49% for population I and 7.7% and 28.10% for population 2, respectively Abd El-Hady (2003).

Table 2: Analysis of variance in C1, C2 and C3 cycles of selection.

Item	Flowering date (50%)	Dry seed yield/plant gram	Number pods/plant	Pod length cm	Number of seed/pod
Among F_3 entries	3342**	21.25*-*	29.76**	0.04**	0.07**
F_3 selected	0.89**	5.76**	1.48**	0.03**	0.005**
F_3 Bulk	0.05 ^{NS}	0.81 ^{NS}	1.08**	0.001 ^{NS}	0.04**
Among F_4 entries	23.87**	56.91**	42.39**	0.11**	0.09*
F_4 selected	0.91**	2.99**	0.89**	0.03**	0.008**
F_4 Bulk	0.66**	0.07*	0.52**	0.003 ^{NS}	0.02*
Among F_5 entries	43.23**	49.88**	79.56**	0.49**	0.73 ^{NS}
F_5 selected	1.57**	0.89**	2.96**	0.09**	0.54 ^{NS}
F_5 Bulk	1.18 ^{NS}	1.47**	0.53**	0.001**	0.06**
Error	0.15	0.39	0.09	0.004	0.55

* Significant at 0.05 ** Significant at 0.01

High positive correlation was found between days to flowering and other characters in three cycles (Table 4). These results were in agreement with those obtained by Abd El-Hady (1998), Hazra et al (1999), Rashwan (2002), And Kwaye et al. (2008), who reported that significant positive phenotypic correlations were observed between seed yield with pod length (Pol) number of pods/plant (PON) and number f seeds/pod. Pol, Pod number/plant, SPD, and grain yield were identified as the best selection criteria that could be used in cowpea. Another study Muhammed et al. (2010), who found that high and positive rg exists between days to flowering and plant height (rg=0.9113), days to maturity and Fodder weight (rg=0.9301). Several workers have estimated the correlation between different yield attributing characters and their direct and indirect effects on yield in cowpea (Damarany (1994); Vikas et al., (1999); Tyagi et al., (2000); Padia et al. (2008); Hussein and El-Dakkak (2009); El-Shainy (2012) and Alidu et al. (2013).

Mean days to flowering was significantly earlier after one cycle of selection with gain of 3 days Table 4. After two cycles mean days to flowering was 8 days earlier than C1 cycle but was 7.88 days earlier than Bulk sample Table 1. These results agree with other studies reporting response to selection for early flowering date. Padia et al. (2008) reported that tow families including SARC2-72 and SARC2-27 recorded fines of 3 days over Marfo – Tuya. Contrary, in SARC3, the elite group of 13 families recorded mean gain of 3 days with individual families recording gains in the range of 1 to 4 days over Marfo-Ruya. Early Flowering lines generally tend to have a higher proportion of yield from the first harvest. However, some C1 advanced lines flowering on the same day but differed in dry seed yield by 1.67 gram. Also, some C3 advanced line flowering date in the same day (59.33 days) but differed in dry seed yield which ranged from 71.73 to 73.76 gram Table 5 flowering date entries gave higher dry seed yield than some earlier flowering gentries.

There were exceptions to the high correlation between flowering date dry seed yield calculated from all entries and cycles of selection.

Heritability estimates for flowering date ranged from 0.67 for C3 to 0.90 for C1 of selection (Table 6). While for dry seed yield heritability estimates ranged from 0.24 for third cycle C3 to 0.66 for first cycle C1. Overfed three cycles of selection were 0.24 for dry seed yield gram/plant in (C1) to 0.96 for pod length in (C3). The heritability values obtained in this study are within the values reported from several published studies in cowpea as Damarany, (1994); Umajaran et al (1997); Nakawaka and Adipala (1999), Ubi et al., (2001); Omoidui et al., (2006); Adeyanju and Ishiyaku (2007); Munbean, Makeen et al. (2007); and Adeniji et al. (2008); and Oyiga and Uguru (2011). According to Ubi et al. (2001), heritability advance are more useful in predicting the resultant effect for he selection of the best individual from a population. High broad sense heritability values indicated the predominance of additive gene action in the expression of these traits and can be improved through individual plant selection Abd El-Hady (1998), Makeen et al, (2007) and Rashwan (2010). High broad Sense heritability (63.16 – 96.74%) indicated the presence of additive gene effects (Manggoel et al. 2012).

Table 3: Direct and correlated response to selection for early flowering date in three cycles of selection.

Cycle	Flowering date (50%)	Dry seed yield/plant g.	Number pods/plant	Pod length cm	Number of seed/pod
C_1	67.51 [a]	61.52 [a]	53.68 [a]	19.30 [a]	14.74 [a]
C_2	46.02 [b]	68.14 [b]	58.09 [b]	19.75 [b]	15.00 [b]
C_3	59.48 [c]	72.85 [c]	62.89 [c]	20.30 [c]	15.42 [c]

Table 4: correlation between flowering date, dry seed yield, number of pods/plant, pod length and number of seed/pod in three cycles selection.

Cycle	Dry seed yield/plant	Number pods/plant	Pod length cm	Number of seed/pod
C_1	+0.96	+0.81	+0.90	+0.98
C_2	+0.99	+0.96	+0.92	+0.87
C_3	+0.98	+0.97	+0.99	+0.98

Table 5: Mean performance and standard errors (S.E) of flowering date effective dry seed yield, number of pods, pod length and number of seeds/pod.

	Entry	Flowering date (50%)	Dry seed yield/plant gram	Number pods/plant	Pod length cm	Number of seed/pod
C_1	1	67.33	62.53	53.80	19.44	14.76
	2	67.60	59.80	54.40	19.15	14.72
	3	68.16	61.00	53.46	19.28	14.71
	4	66.66	61.63	54.40	19.20	14.67
	5	67.23	62.00	53.250	19.31	14.78
	6	68.26	61.26	53.53	19.35	14.76
	7	67.26	59.20	54.60	19.19	14.75

	Entry	Flowering date (50%)	Dry seed yield/plant gram	Number pods/plant	Pod length cm	Number of seed/pod
	8	67.33	64.20	53.46	19.30	14.71
	9	68.20	61.86	53.80	19.21	14.81
	10	67.00	61.73	52.20	19.45	14.75
	S.E	0.76	0.53	0.16	0.03	0.03
C_2	1	64.53	68.00	58.26	19.81	15.02
	2	63.53	69.40	57.53	19.62	14.95
	3	64.53	67.93	58.40	19.80	14.96
	4	63.53	69.06	57.26	19.71	14.97
	5	64.73	66.60	59.03	19.70	15.13
	6	63.66	68.80	57.83	19.70	15.03
	7	64.20	66.86	57.86	19.59	14.96
	8	63.60	67.60	58.46	19.85	14.98
	9	64.60	69.40	57.70	19.87	15.02
	10	63.26	67.73	58.60	19.85	14.99
	S.E	0.14	0.52	0.36	0.03	0.03
C_3	1	59.43	73.26	64.13	20.34	15.23
	2	60.06	72.53	61.06	20.32	15.20
	3	59.20	73.20	62.33	20.47	16.61
	4	60.20	72.66	62.13	20.40	15.45
	5	58.33	72.53	63.60	20.96	15.24
	6	60.60	73.20	63.40	20.14	15.28
	7	59.33	71.73	62.56	20.44	15.25
	8	59.33	73.76	63.13	20.50	15.36
	9	58.36	72.43	64.26	20.13	15.21
	10	59.93	7.40	62.33	20.31	15.41
	S.E	0.38	0.55	0.30	0.23	0.74

Table 6: Broad sense heritability, genetic variance for traits in three cycles of selection.

Traits	C_1	C_2	C_3	C_1	C_2	C_3
Flowering date (50%)	0.73	0.90	0.67	0.26	0.29	0.45
Dry seed yield/plant gram	0.66	0.67	0.24	0.85	0.86	0.15
Number pods/plant	0.91	0.56	0.66	0.48	0.26	0.28
Pod length cm	0.96	0.84	0.36	0.03	0.009	0.09
Number of seed/pod	0.65	0.69	0.25	0.001	0.002	0.28

H^2 = Heritability in broad sense; $\sigma^2 g$= genetic variance

Conclusion

Through the results obtained in this research, it can be concluded the some advanced lines in third cycle C3 in F6- generation with earliest in days to flowering and high dry seed such as selected entries 1, 3, 8 and 10 used in breeding program and increased breeding emphasis. The results of this study could be useful in breeding programs for improving cowpea production in Egypt.

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