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Studies on genetic variability for water use efficiency and pod yield related traits in three F_2 populations of groundnut (*Arachis hypogaea* L.)

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Abstract
The present experiment was conducted to assess the variability, heritability and genetic advance as per cent of mean for ten characters in three F_2 populations of groundnut. The variability parameters revealed that the phenotypic coefficient of variation was higher than genotypic coefficient of variation for all the characters studied indicating the role of environmental variance in the total variance. Phenotypic coefficients of variance (PCV) and genotypic coefficients of variance (GCV) for important yield contributing characters such as pods per plant, pod yield per plant in all the three F_2 generations were higher in magnitude. Plant height, specific leaf area, pods per plant, SMK percentage, kernel yield and pod yield were displayed high heritability along with high GAM in all the three crosses. It suggests that all the six characters are conferred by additive gene action and these characters could be improved through simple selection in earlier generations.

Keywords: Groundnut, PCV, GCV, heritability, genetic advance

1. Introduction

Groundnut (*Arachis hypogaea* L.) is called as the 'King' of oilseeds and it is the fourth-largest oilseed crop in the world. Globally, it is cultivated in more than 100 countries, with the annual production of 45.95 million metric tonnes in an area of 28.5 m ha (FAOSTAT, 2018) [3]. Apart from being a rich source of edible oil (44-55%), protein (20-50%) and carbohydrates (10-20%), groundnut seeds are an important nutritional source of vitamin E, niacin, calcium, phosphorus, magnesium, zinc, iron, riboflavin, thiamine and potassium (Pandey *et al*. 2012) [15]. Analysis of genetic variability reveals its presence and is of paramount importance as it provides the basis for effective selection. The spectrum of variability is measured by the genotypic coefficient of variability (GCV) and phenotypic coefficient of variability (PCV) which provides information about the relative amount of variation in different characters. Hence, to obtain a comprehensive idea, it is necessary to assess quantitative traits. The information on heritability alone may not help in pinpointing characters enforcing selection. The genetic advance has an added edge over heritability as a guiding factor to breeders in the selection programme (Johnson *et al*., 1955) [9]. The objectives of the present investigation are to study the proportion of variability parameters such as genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) and selection parameters like broad-sense heritability and genetic Advance as percent of the mean (GAM) in three crosses of F_2 generation with respect to ten quantitative traits.

2. Material and Methods

The present investigation was carried out to know the mode of inheritance of pod yield and water use efficiency (WUE) related characters and along with variability estimation in F_2 generation of three crosses in groundnut. All the field experiments of the present study were conducted at K1 Block, Department of Genetics and Plant breeding, University of Agricultural Sciences, GKVK, Bangalore, located at an altitude of 899 MSL, and 13ºN latitude and 77º35' E longitude. For the present investigation, three crosses were effected *viz*., GKVK 4 × NRCG 12473, NRCG 12568 × NRCG 12326, and GKVK 4 × NRCG 12274. The crossed pods were harvested separately from each female plant during previous season was raised in individual rows as F_1s. For DNA isolation, young leaves were collected from 25 days old seedlings of each F_1 plant. DNA was isolated and true F_1s were identified using SSR marker GM 1991 in 2.5% agarose gel.

After the F_1 hybrid confirmation, three crosses were forwarded to F_2 generation.

Observations were recorded on ten characters *viz.*, days to first flowering, plant height, branches per plant, SCMR @ 60 DAS, SLA @ 60 DAS (cm^2/g), pods per plant, sound mature kernel (SMK) percentage, shelling percentage, kernel yield per plant and pod yield per plant in all the F_2 plants of three crosses *viz*., GKVK 4 × NRCG12473 (640 individual plants), NRCG 12568 × NRCG12326 (483 individual plants) and GKVK 4 × NRCG 12274 (182 individual plants). Phenotypic and genotypic coefficients of variation for all the characters were estimated using the formulae suggested by Burton and De Vane (1953) [2]. Broad sense heritability was estimated as the ratio of genotypic variance to the total variance and the extent of genetic advance expected through selection for all the characters also estimated as suggested by Johnson *et al*. (1955) [9].

3. Results and Discussion

Three F_2 populations derived from the crosses GKVK 4 × NRCG 12473, NRCG 12568 × NRCG 12326 and GKVK 4 × NRCG 12274 were evaluated to know the amount of variability, heritability and GAM for pod yield and WUE related traits in groundnut and it is furnished in Table 1. The variance indicated highly significant differences among three crosses for all the characters investigated.

Table 1: Variability parameters for morpho-physiological and yield related traits in F_2 generation of three crosses in groundnut

Trait	Cross	Mean ± SE	Range		GCV	PCV	h^2 (bs)	GAM
			Min.	Max.	(%)	(%)	(%)	(%)
Days to first flowering	Cross 1	36.63 ± 0.10	29.00	44.00	6.07	6.61	84.33	11.49
	Cross 2	36.37 ± 0.10	32.00	43.00	5.24	5.86	79.79	9.64
	Cross 3	34.37 ± 0.28	30.00	39.00	10.66	11.01	93.59	21.23
Plant height (cm)	Cross 1	31.45 ± 0.23	19.00	52.00	17.22	18.54	86.25	32.94
	Cross 2	27.32 ± 0.28	12.00	47.00	21.04	22.69	85.99	40.20
	Cross 3	27.81 ± 0.37	17.00	43.00	16.13	18.16	78.89	29.51
Branches per plant	Cross 1	4.50 ± 0.04	3.00	6.00	16.78	20.16	69.29	28.78
	Cross 2	4.46 ± 0.04	3.00	6.00	12.04	20.74	33.69	14.39
	Cross 3	4.91 ± 0.09	3.00	6.00	20.33	24.68	61.36	31.19
SCMR @ 60 DAS	Cross 1	45.65 ± 0.15	30.40	54.30	7.21	8.35	74.61	12.84
	Cross 2	44.25 ± 0.14	39.09	51.98	6.04	6.93	75.86	10.83
	Cross 3	44.49 ± 0.35	39.68	49.18	10.21	10.70	91.11	20.08
SLA @ 60 DAS (cm^2/g)	Cross 1	115.50 ± 0.65	61.77	191.40	12.87	14.18	82.33	24.05
	Cross 2	124.41 ± 0.93	82.57	214.95	14.78	16.48	80.40	27.29
	Cross 3	137.97 ± 1.92	80.84	214.95	17.54	18.73	87.66	33.82
Pods per plant	Cross 1	46.43 ± 0.56	22.00	101.00	29.75	30.37	95.97	60.05
	Cross 2	24.03 ± 0.42	10.00	78.00	35.86	38.52	86.66	68.77
	Cross 3	28.79 ± 1.07	5.00	80.00	48.69	50.08	94.50	97.50
SMK percentage	Cross 1	61.67 ± 0.40	32.18	84.68	14.93	16.32	83.67	28.13
	Cross 2	61.12 ± 0.49	23.22	76.72	15.30	17.63	75.26	27.34
	Cross 3	60.71 ± 0.81	25.64	79.61	15.60	17.92	75.73	27.96
Shelling percentage	Cross 1	63.18 ± 0.41	20.21	78.49	14.12	16.43	73.93	25.02
	Cross 2	60.16 ± 0.32	33.69	78.85	10.34	11.55	80.16	19.08
	Cross 3	57.06 ± 0.56	37.42	72.88	12.06	13.22	83.16	22.65
Kernel yield per plant (g)	Cross 1	35.12 ± 0.43	18.99	70.32	29.96	31.15	92.53	59.38
	Cross 2	18.13 ± 0.22	11.00	36.74	21.08	27.15	60.29	33.72
	Cross 3	13.52 ± 0.55	4.82	46.50	50.39	55.37	82.82	94.46
Pod yield per plant (g)	Cross 1	56.49 ± 0.69	29.85	121.61	30.28	30.78	96.82	61.38
	Cross 2	30.18 ± 0.33	18.75	60.97	20.83	23.87	76.18	37.45
	Cross 3	23.01 ± 0.78	9.35	74.57	43.36	45.97	88.96	84.24

Cross 1 : GKVK 4 × NRCG 12473
Cross 2 : NRCG 12568 × NRCG 12326
Cross 3 : GKVK 4 × NRCG 12274

3.1 Variability parameters

Days to first flowering exerted low GCV and PCV in the crosses GKVK 4 × NRCG 12473 and NRCG 12568 × NRCG 12326, moderate in the other cross GKVK 4 × NRCG 12274. This result is in harmony with the findings of the low magnitude of GCV in groundnut for days to first flowering recorded by Padmaja *et al*. (2013) [14] but in converse with the findings of high GCV reported by Yadlapalli (2014) [33]. High GCV and PCV was noticed in one cross NRCG 12568 × NRCG 12326 for plant height, whereas in the other two crosses GKVK 4 × NRCG 12473 and GKVK 4 × NRCG 12274 documented moderate GCV and PCV. Injeti *et al*. (2008) [5] and Savaliya *et al*. (2009) [20] registered moderate GCV and PCV in groundnut for plant height, thus it supports the outcome of the present study. Two crosses GKVK 4 × NRCG 12473 and NRCG 12568 × NRCG 12326 registered moderate to high GCV and PCV for branches per plant. The cross GKVK 4 × NRCG 12274 exhibited high variability at both genotypic and phenotypic level. A similar finding was registered in groundnut by Nandini *et al*. (2011) [13], Vishnuvardhan *et al*. (2012) [32] and Yadlapalli (2014) [33] registered moderate to high GCV and PCV for branches per plant.

Moderate GCV and PCV was observed for SCMR in the cross GKVK 4 × NRCG 12274. On the other side, two crosses showed low GCV and PCV for the same trait. Our findings are in contrast to Upadhyaya (2005) [29], who reported large variation for this trait. SCMR possesses considerable genetic variation in groundnut as proposed by earlier workers Shashidhar (2002) [22], Serraj *et al*. (2004) [21], Lal *et al*. (2006) [10] and Sheshshayee *et al*. (2006) 23[]. Specific leaf area exhibited moderate GCV and PCV in all the three crosses of groundnut. In accordance with our findings of moderate GCV and PCV was reported in groundnut by Lal *et al*. (2006) [10] and Sheshshayee *et al*. (2006) [23]. But other reports are Shashidhar (2002) [22], Serraj *et al*. (2004) [21] and Talwar *et al*. (2004) [27] observed a substantial quantum of variation for specific leaf area in groundnut.

All the three crosses of groundnut in the present study had shown moderate GCV and PCV for SMK percentage. The present result is in agreement with the findings of Nandini *et al*. (2011) [13] noticed moderate GCV and PCV for SMK percentage. But Sumathi *et al*. (2009) [26] recorded high GCV and PCV and Vishnuvardhan *et al.* (2012) [32] recorded low GCV and PCV for this trait. Thus, these conclusions are a contradiction to our present experimental results. Shelling percentage showed moderate GCV and PCV in all the three crosses from our investigation. Concurrent findings of moderate GCV and PCV reported by Injeti *et al*. (2008) [5], Savaliya *et al*. (2009) [20] and Nandini *et al*. (2011) [13] for shelling percentage in groundnut. The present investigation noticed high GCV and PCV for pods per plant, pod yield per plant and kernel yield per plant in all the three crosses of groundnut. This finding is in conformity with earlier reports of Parameshwarappa *et al*. (2005) [16] for kernel yield; John *et al*. (2006) [6] and Blummel *et al*. (2012) [1] for pod yield; Shoba *et al*. (2010) [24] for pods per plant, pod yield per plant and kernel yield per plant; Nandini *et al*. (2011) [13], Yadlapalli (2014) [33] and Shukla and Rai (2014) [25] for kernel yield and pod yield per plant and Thirumala Rao *et al*. (2014) for pods per plant, pod yield and kernel yield per plant.

3.2 Selection parameters

Heritability estimates facilitate in deciding the relative measure of heritable portion from the total variation. Heritability value itself does not reveal the number of best individual while exploring the genetic variability because the constraints of estimating the broad sense heritability as it comprise both additive and non-additive gene effects. Heritability estimates appear to be more significant when accompanied by estimates of genetic advance as percent of the mean (GAM).

3.2.1 Heritability and genetic advance as per cent of mean

Plant height, specific leaf area, pods per plant, SMK percentage, pod yield per plant and kernel yield per plant exerted high broad-sense heritability with high GAM in all the three crosses *viz*., GKVK 4 × NRCG 12473, NRCG 12568 × NRCG 12326 and GKVK 4 × NRCG 12274.

For plant height, Hamasselbe *et al*. (2011) [4], Shukla and Rai (2014) [25] and Yadlapalli (2014) [33]; for SLA Jayalakshmi *et al*. (1999) [6], Serraj *et al*. (2004) [21], Puangbut *et al.* (2011) [19]; for pods per plant, Savaliya *et al*. (2009) [20], Nandini *et al*. (2011) [13]; for pod yield Hamasselbe *et al*. (2011) [4], Patidar *et al*. (2014) [17]; for kernel yield, Sumathi *et al*. (2009) [26], Patidar *et al*. (2014) [17] and for SMK percentage, Parameshwarappa *et al*. (2005) [16], Sumathi *et al*. (2009) [26], Nandini *et al*. (2011) [13] noticed high heritability together with high expected GAM. Vishnuvardhan *et al.* (2012) [32] observed low heritability along with low GAM for SMK percentage indicates the greater part of non-additive gene action. High heritability concurred with high expected GAM registered for these characters indicate the lesser influence of environment on the expression of these characters. These characters are directed by additive gene effect, hence, ample scope for exercising selection to improve these morpho-physiological and productive related traits.

Days to first flowering displayed high heritability with high expected GAM for the cross GKVK 4 × NRCG 12274 but it registered high heritability with moderate expected GAM in the cross GKVK 4 × NRCG 12473 and high heritability with low GAM in the cross NRCG 12568 × NRCG 12326. High heritability with high expected GAM indicates the lesser influence of environment and trait under additive genetic control but moderate heritability and GAM indicates both additive and non-additive genetic effect on the trait. John *et al*. (2011) [8] and Padmaja *et al.* (2013) [14] observed moderate to low heritability and low GAM, Patil *et al.* (2014) [18] registered moderate to high heritability and GAM for days to 50% flowering in groundnut. Shukla and Rai (2014) [25] and Vange and Maga (2014) [30] who reported high heritability and high GAM; Yadlapalli (2014) [33] found high heritability along with low genetic advance. These findings are in accordance with our results. For days to first flowering, simple selection could be effective for the cross GKVK 4 × NRCG 12274 but the selection should be postponed to advanced generation for the crosses NRCG 12568 × NRCG 12326 and GKVK 4 × NRCG 12473.

For branches per plant and shelling percentage, two crosses *viz*., GKVK 4 × NRCG 12473 and GKVK 4 × NRCG 12274 was showed high heritability and high GAM. Another cross NRCG 12568 × NRCG 12326 exhibited moderate heritability with moderate GAM for branches per plant and high heritability along with moderate GAM for shelling percentage. These results are in compact with findings of Nandini *et al.* (2011) [13], Shukla and Rai (2014) [25], Vange and Maga (2014) [30] and Yadlapalli (2014) [33] reported high heritability with high GAM for branches per plant in groundnut. For shelling percentage, high heritability with high GAM reported by Lal *et al.* (2007) [11], Injeti *et al.* (2008) [5] and Savaliya *et al*. (2009) [20], Sumathi *et al*. (2009) [26], Shoba *et al*. (2010) [24], Patil *et al*. (2014) [18] and Shukla and Rai (2014) [25]; moderate heritability with low GAM by Mukri *et al*. (2014) [12] in groundnut. Simple selection could be operated to improve these characters in two crosses, GKVK 4 × NRCG 12473 and GKVK 4 × NRCG 12274 but because of additive and non-additive gene action, selection could be done in later generations in the cross NRCG 12568 × NRCG 12326.

For SCMR, two crosses GKVK 4 × NRCG 12473 and NRCG 12568 × NRCG 12326 exhibited high heritability with moderate GAM, so it indicates the influence of both additive and non-additive gene actions on SCMR. Hence, selection could be performed in later generations. But in the cross, GKVK 4 × NRCG 12274 had high heritability accompanied by high GAM thereby selection could be done in early generations to improve this character. Serraj *et al.* (2004) [21], Vasanthi *et al.* (2005) [31] and Puangbut *et al.* (2011) [19] reported high heritability for SCMR in groundnut. John *et al*. (2006) [7] recorded high heritability together with high GAM for SCMR. These earlier reports are in line with present results for the cross GKVK 4 × NRCG 12274 but it is contrary to other two crosses. Six out of ten characters *viz*., plant height, specific leaf area, pods per plant, SMK percentage, kernel yield and pod yield were displayed high heritability along with high GAM in all the three crosses studied. It indicates additive gene action conferring all the six characters, hence less influenced by environment and these characters were improved through simple selection in early generations.

4. Conclusion

Phenotypic coefficients of variance (PCV) and genotypic coefficients of variance (GCV) for important yield contributing characters such as pods per plant, pod yield per plant in all the three F_2 generations were higher in magnitude. Except for days to first flowering and SCMR @ 60 DAS in two crosses showed low PCV and GCV, remaining characters were displayed moderate to high PCV and GCV in all the three crosses. This denotes that presence of ample variation for majority of the characters studied in all the three F_2 populations. High heritability and GAM for plant height, specific leaf area, pods per plant, SMK percentage, kernel yield and pod yield per plant were noticed in all the three F_2 populations. It indicates additive gene action conferring all the six characters, hence less influenced by environment and these characters were improved through simple selection in early generations.

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