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Variability Studies for Quantitative Traits in F_3 Generation of Groundnut (*Arachis hypogaea* L.)

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A B S T R A C T

In the present investigation, estimates of genetic variability, heritability and genetic advance were assessed for nine different characters in the F_3 population derived from four groundnut crosses, viz., CO 7 × VRI Gn 6, TMV 2 × VRI Gn 6, TMV Gn 13 × VRI Gn 6 and VRI 2 × VRI Gn 6. Considering the mean performance, the cross derivative TMV Gn 13 × VRI Gn 6 registered superiority for the characters viz., 100-pod weight (g), 100-kernel weight (g) and sound mature kernel (%). Apart from these characters, the cross VRI 2 × VRI Gn 6 for shelling (%) and sound mature kernel (%), and CO 7 × VRI Gn 6 for the trait late leaf spot and rust score also showed higher mean performance. High percentage of PCV, GCV, heritability coupled with high GAM values were recorded by number of pods plant^{-1}, pod yield plant^{-1} (g), kernel yield plant^{-1} (g), late leaf spot score and rust score in varied crosses. Selection would be effective for these traits in respective crosses to obtain promising progenies. Regarding the population distribution, significant and negative skewness was observed in all the four crosses for shelling (%) and sound mature kernel (%). Leptokurtic/mesokurtic nature was noticed in most of the traits understudy. Thereby, directional selection will effectively improve the mean performance of these traits. Hence, based on mean and various genetic parameters, the cross CO 7 × VRI Gn 6 is considered as superior for late leaf spot and rust resistance in groundnut.

Introduction

Groundnut (*Arachis hypogaea* L.) is an important food and cash crop for resource-poor farmers in Asia and Africa and it can be consumed and utilized in diverse ways (Thirumala *et al.,* 2014). India is the second largest producer of groundnut after China (FAOSTAT, 2013). Groundnut is the largest oilseed crop in India in terms of production (Madhusudhana, 2013). Though India ranks first in production, its productivity is low due to two major foliar fungal diseases namely, late leaf spot (*Phaeoisariopsis personata*) and rust (*Puccinia arachidis*) which are economically very important foliar fungal diseases of cultivated groundnut and together they can reduce the yield about 50-70% (Subrahmanyam *et al.*, 1984). The regular incidence of these diseases warrants the development of resistant cultivars by which we can control not only these diseases but also improve the production and quality besides reducing the adverse effects of chemicals on our ecosystem (Shoba *et al.*, 2009). The yield is a complex character, which is highly influenced by environmental variations (John *et al.,* 2011).

Mean and genetic variability is the basic requirement for crop improvement as this provides wider scope for selection (Vishnuvardhan *et al.,* 2012). Mean serves as a basis for eliminating undesirable crosses (Shoba *et al.,* 2012). Information on extent of genetic variability and role of important yield determining traits are paramount importance for their skillful engineering of new ideotype. The presence of variability in crop is important for genetic studies and consequently used for improvement and selection (Govindaraj *et al.,* 2015). Thus, effectiveness of selection is dependent upon the nature, extent and magnitude of genetic variability present in material and the extent to which it is heritable. High GCV values indicate the greater extent of variability present in the character and can be improved through selection. A relative comparison of heritability estimates and expected GAM will give an idea about the nature of gene action governing a particular trait (Anusha and Savithramma, 2015). High value of heritability together with high genetic advance for any character indicates additive gene action and selection will be rewarding for improvement of such traits whereas, high heritability associated with low genetic advance might attribute to the presence of non-additive gene action which indicates dominance/epistasis and their response to selection would be poor (Bhargavi *et al.,* 2016).

An insight into the nature and degree of distribution present in population is of utmost importance as it forms the basis for selection in any crop improvement programme (Prabhu *et al.,* 2015b). Therefore, the present investigation was undertaken to study variability, heritability and genetic advance in four segregating F_3 populations of groundnut.

Materials and Methods

Study area

The present scientific investigation was carried out at Oilseeds Farm, Department of Oilseeds, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore, during *Kharif* (June-October) 2014.

Experimental material

Groundnut genotypes for the study consisted of four released/advanced breeding female parent *viz.,* CO 7, TMV 2, TMV Gn 13 and VRI 2 and a male parent, VRI Gn 6. The females are susceptible to foliar fungal diseases namely late leaf spot and rust. However, the male parent VRI Gn 6 is moderately resistant to these diseases. Four crosses *viz.,* CO 7 × VRI Gn 6, TMV 2 × VRI Gn 6, TMV Gn 13 × VRI Gn 6 and VRI 2 × VRI Gn 6 were made and utilised for the present study. Selection was done in F_2 generation for pod yield, kernel yield and foliar disease resistance. All the parents and F_3 progenies were evaluated in non-replicated trial. Recommended cultural practices were followed throughout the crop growing period. The spacing adopted was 30 × 10 cm.

Observations recorded

Observations were recorded and analyzed in terms of mean and variability parameters on nine characters *viz.,* number of pods plant^{-1}, 100-pod weight (g), 100-kernel weight (g), shelling (%), sound mature kernel (%), pod yield plant^{-1} (g), kernel yield plant^{-1} (g), late leaf spot (LLS) and rust disease scores. Nine point disease scale suggested by Subrahmanyam *et al.,* (1995) was used to screen the lines for source of resistance to late leaf spot and rust diseases.

Statistical analysis

Standard statistical procedures were adopted for calculating the mean and various genetic parameters like phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (h^2) in broad sense and genetic advance as % of mean (GAM). The range of coefficient of variation (CV) was categorized as per Sivasubramanian and Madhavamenon (1973): below 10% - Low coefficient of variation; 10-20% - Medium coefficient of variation; above 20% - High coefficient of variation. As suggested by Robinson *et al.,* (1949), the heritability range was classified as: less than 30% - Low heritability; 30%-60% - Moderate heritability; more than 60% - High heritability. Similarly, the range of genetic advance as per cent of mean (GAM) was grouped as: less than 10% - Low GAM; 10%-20% - Medium GAM; more than 20% - High GAM (Johnson *et al.,* 1955).

Results and Discussion

The results on the mean performance and various genetic parameters for nine yield and yield attributes of four segregating populations *viz.,* CO 7 × VRI Gn 6, TMV 2 × VRI Gn 6, TMV Gn 13 × VRI Gn 6 and VRI 2 × VRI Gn 6 are presented hereunder.

Mean performance

Mean performance of parents

In a breeding programme, mean performance is the foremost important criteria to select an individual. Among the parents, CO 7 and TMV 2 recorded superiority for number of pods plant^{-1} while, the parent VRI 2 possessed higher mean value for 100-pod weight (g), 100-kernel weight (g), sound mature kernel (%), pod yield plant^{-1} (g) and kernel yield plant^{-1} (g). VRI Gn 6 exhibited superior mean performance for late leaf spot and rust score. Thus, VRI 2 was considered as desirable parent for yield improvement and VRI Gn 6 for late leaf spot and rust resistance in groundnut (Table 1).

Mean performance of crosses

Among the crosses, TMV Gn 13 × VRI Gn 6 recorded superior mean performance for 100-pod weight (g), 100-kernel weight (g) and sound mature kernel (%). The cross VRI 2 × VRI Gn 6 exhibited higher mean value for shelling (%) and sound mature kernel (%) whereas, the cross CO 7 × VRI Gn 6 for late leaf spot and rust resistance. Hence, considering the mean performance, the cross CO 7 × VRI Gn 6 is considered superior for late leaf spot and rust resistance. No significance was observed for remaining traits in all the crosses.

Variability parameters

In the present study, the phenotypic and genotypic coefficient of variation exhibited wide range for all characters. All the four F_3 populations exhibited higher PCV values than the GCV values suggesting the influence of environmental factors for all the characters studied. Less difference observed between PCV and GCV in certain cases indicated greater role of genetic components and less influence by environment. Similar results were obtained by Shinde *et al.,* (2010) and Prabhu *et al.,* (2015a). The genetic parameters studied for various characters in F_3 generation (Table 2) are narrated below.

Number of pods plant^{-1}

The cross TMV Gn 13 × VRI Gn 6 alone exhibited high PCV, GCV, heritability coupled with high GAM for the trait number of pods plant^{-1}. Similar results have been reported by Savaliya *et al.,* (2009), Shinde *et al.,* (2010), Priyadharsini (2012), Anitha (2013), John *et al.,* (2013) and Prabhu *et al.,* (2015 a). The remaining crosses *viz.,* CO 7 ×

VRI Gn 6, TMV 2 × VRI Gn 6 and VRI 2 × VRI Gn 6 recorded high PCV, high GCV, moderate heritability and high GAM. This is similar to the findings of John *et al.*, (2013).

100-pod weight (g)

High/medium PCV, medium/low GCV, heritability and GAM values for 100-pod weight (g) were recorded by all the four crosses. Pradhan and Patra (2011), Zaman *et al.*, (2011), Anitha (2013) and John *et al.*, (2013) also reported medium values for the trait 100-pod weight (g) in groundnut. No such low values were reported earlier.

100-kernel weight (g)

PCV, GCV, heritability and GAM values ranged from higher to lower for 100-kernel weight (g) in all the four crosses under study. Such estimates of PCV, GCV, heritability and genetic advance have already been indicated by John *et al.*, (2013).

Shelling (%)

High PCV, GCV, heritability and medium GAM values were recorded by the crosses *viz.*, TMV 2 × VRI Gn 6, TMV Gn 13 × VRI Gn 6 and VRI 2 × VRI Gn 6 for the trait shelling (%). Similar results were given by Anitha (2013) and John *et al.*, (2013). The cross, CO 7 × VRI Gn 6 exhibited medium PCV, GCV, high heritability and medium GAM values. These observations are in agreement with the findings of Zaman *et al.*, (2011).

Sound mature kernel (%)

For sound mature kernel (%), high PCV and GCV values were recorded in the cross CO 7 × VRI Gn 6. Similar findings were reported by Hiremath *et al.*, (2011) and Prabhu *et al.*, (2015 a) for sound mature kernel (%). High/medium PCV and medium/low GCV were observed in all the other crosses. Sound mature kernel (%) in all the four crosses exhibited high/medium heritability and low magnitudes of GAM values indicating the limited scope of selection for this trait. Concomitant results were obtained by Pradhan and Patra (2011) and Padmaja *et al.*, (2013 b).

Pod yield plant^{-1} (g)

Two of the four crosses *viz.*, TMV Gn 13 × VRI Gn 6 and VRI 2 × VRI Gn 6 recorded high PCV, GCV, heritability coupled with GAM for pod yield plant^{-1} (g). Higher values for pod yield plant^{-1} (g) were earlier reported by Shinde *et al.*, (2010), Narasimhulu *et al.*, (2012), Priyadharsini (2012), Anitha (2013), John *et al.*, (2013), Narasimhulu *et al.*, (2013), Thirumala *et al.*, (2014) and Prabhu *et al.*, (2015 a). The crosses, CO 7 × VRI Gn 6 and TMV 2 × VRI Gn 6 exhibited higher values for PCV, GCV and GAM while, moderate value for heritability. These findings were similar to the findings of Shoba *et al.*, (2009).

Kernel yield plant^{-1} (g)

High PCV and GCV values coupled with high heritability and GAM were exhibited by two cross derivatives *viz.*, TMV 2 × VRI Gn 6 and TMV Gn 13 × VRI Gn 6 for kernel yield plant^{-1} (g). Concomitant results have been reported by Savaliya *et al.*, (2009), Dolma *et al.*, (2010), Shinde *et al.*, (2010), Narasimhulu *et al.*, (2012), Priyadharsini (2012), Anitha (2013), John *et al.*, (2013), Narasimhulu *et al.*, (2013), Thirumala *et al.*, (2014) and Prabhu *et al.*, (2015 a) for the trait kernel yield plant^{-1} (g) in groundnut. Similarly, moderate heritability coupled with high GAM values were recorded by the cross CO 7 × VRI Gn 6. Shoba *et al.*, (2009) also reported similar kind of results. The other cross VRI 2 × VRI Gn 6 possessed high PCV, medium GCV, low heritability and high GAM. No such results were reported earlier.

Late leaf spot score

The cross derivative CO 7 × VRI Gn 6 showed high PCV, GCV, heritability coupled with high GAM values for late leaf spot score. Higher values for all the genetic parameters were noticed earlier by Narasimhulu *et al.*, (2013), Padmaja *et al.*, (2013 a) and Ashish *et al.*, (2014). The remaining crosses exhibited high/medium PCV, medium/low GCV, heritability and GAM values. This results are in accordance with Prabhu *et al.*, (2015 a).

Rust score

Rust score exhibited high PCV, GCV, heritability coupled with high GAM for all the four crosses in F_3 generation except TMV Gn 13 × VRI Gn 6. Similar results were reported by Narasimhulu *et al.*, (2013), Ashish *et al.*, (2014) and Prabhu *et al.*, (2015 a). In TMV Gn 13 × VRI Gn 6, the trait rust score registered medium PCV, GCV and heritability values while, the GAM recorded higher values for rust disease. Medium value results are in accordance with John *et al.*, (2008) and Vishnuvardhan *et al.*, (2012).

Population distribution

Skewness and kurtosis reflects the nature of variability existing in a genetic population under study. The frequency distribution was studied for the quantitative traits under third and fourth order statistics *viz.*, skewness and kurtosis.

Skewness

Skewness, characterizes the degree of asymmetry in the population. A positively skewed distribution indicates that the individuals of the population bunched up towards the lower mean values whereas, negatively skewed distribution exhibits that the individuals are clustered towards higher mean values. In the present investigation, significant and negative skewness was observed in all the four crosses for shelling (%) and sound mature kernel (%), along with the trait 100-kernel weight (g) for the cross TMV Gn 13 × VRI Gn 6 alone. Similarly, significant and positive skewness were exhibited in the cross CO 7 × VRI Gn 6 for the traits pod yield plant^{-1} (g), kernel yield plant^{-1} (g) and rust score whereas, the cross VRI 2 × VRI Gn 6 possessed the same for number of pods plant^{-1}, pod yield plant^{-1} (g) and kernel yield plant^{-1} (g). No significant skewness was noticed for remaining traits in all the four crosses. The results are in accordance with Prabhu *et al.*, (2015 b).

Table.1 Mean performance of parents for various traits in F_3 generation of groundnut

Parent / Trait	Number of pods plant^{-1}	100-pod weight (g)	100 kernel weight (g)	Shelling (%)	Sound mature kernel (%)	Pod yield plant^{-1} (g)	Kernel yield plant^{-1} (g)	LLS score	Rust score
CO 7	23.38*	89.23	29.47	58.56	90.02	16.30	9.90	3.93	2.25
TMV 2	24.80*	81.93	28.58	60.13	90.78	17.91	10.68	5.02	2.50
TMV Gn 13	18.50	71.24	24.87	50.75	88.15	13.33	7.99	5.10	4.50
VRI 2	20.70	115.22*	38.10*	62.75	96.82*	20.71*	13.12*	5.80	3.20
VRI Gn 6	11.70	57.55	24.23	50.10	78.69	6.29	3.74	2.68*	2.00*
Grand mean	19.82	83.03	29.05	56.46	88.89	14.91	9.09	4.51	2.89
S.E .	1.96	9.15	2.25	6.90	2.41	2.27	1.29	0.53	0.37

* Significant @ p <0.05 level of probability

Table.2 Estimates of genetic variability parameters in F_3 populations of groundnut

Character	Cross	Mean	PCV (%)	GCV (%)	h^2 (BS) (%)	GAM (%)	Skewness	Kurtosis
Number of pods plant^{-1}	**C1**	20.80	46.64	27.91	59.85	40.47	0.58	0.34
	C2	14.90	50.70	28.20	55.62	54.67	0.15	-0.77
	C3	13.80	59.44	44.08	74.15	85.23	0.64	-0.38
	C4	19.60	50.22	29.22	58.18	43.36	0.70**	0.93*
100-pod weight (g)	**C1**	73.20	22.47	17.18	76.46	10.20	0.12	-0.61
	C2	75.80	28.24	4.97	17.59	2.54	0.17	-0.20
	C3	86.80*	23.13	12.92	55.86	6.38	-0.85	1.67
	C4	71.50	17.11	11.78	68.84	8.20	0.26	0.25
100-kernel weight (g)	**C1**	26.90	20.65	11.53	55.82	19.44	-0.15	-0.97
	C2	28.00	26.75	18.09	67.63	25.70	-0.80	0.49
	C3	34.00*	25.90	6.26	24.15	7.69	-1.79**	5.74**
	C4	27.20	17.09	8.20	48.00	15.00	0.12	0.40
Shelling (%)	**C1**	56.00	16.80	12.04	71.69	10.81	-1.85**	4.14**
	C2	54.50	37.50	27.67	73.78	17.06	-1.58**	1.50
	C3	57.40	29.01	26.60	91.66	17.73	-1.49**	1.53
	C4	66.30*	21.87	20.24	92.52	13.44	-2.88**	8.37**
Sound mature kernel (%)	**C1**	80.60	24.84	22.81	91.81	11.69	-0.98**	-0.07
	C2	87.00	26.67	8.10	30.37	3.72	-2.01**	2.99**
	C3	93.10*	19.49	16.06	82.41	8.05	-4.52**	22.93**
	C4	92.30*	11.99	8.14	67.89	5.25	-2.03**	6.28**
Pod yield plant^{-1} (g)	**C1**	13.10	53.12	29.74	55.99	63.97	0.76*	0.37
	C2	11.20	64.28	30.18	46.95	69.48	0.34	-1.26
	C3	11.30	60.04	45.82	76.31	108.12	0.55	-0.33
	C4	12.20	52.31	40.00	76.47	93.29	0.58*	0.16
Kernel yield plant^{-1} (g)	**C1**	7.70	60.24	20.00	33.00	68.20	0.90**	0.85
	C2	7.00	72.96	48.70	66.75	166.83	0.14	-1.53
	C3	7.20	68.62	54.58	79.53	187.49	0.47	-0.54
	C4	8.60	57.34	10.82	18.88	34.23	0.59**	0.26
LLS score	**C1**	3.00*	33.30	28.20	71.80	49.30	0.48	0.20
	C2	6.10	34.80	8.90	6.50	4.70	-0.18	0.49
	C3	5.60	15.10	-	-	-	0.13	-0.89
	C4	5.90	27.20	13.00	22.80	12.70	-0.33	-0.15
Rust score	**C1**	2.20*	28.90	25.80	79.30	47.30	1.94**	1.93**
	C2	2.70	36.50	33.70	85.00	63.90	0.31	-0.32
	C3	4.00	19.20	14.50	56.70	22.40	0.80	-0.29
	C4	4.70	25.00	21.70	75.50	38.90	-0.42	-0.63

C1 - CO 7 × VRI Gn 6 **C2** - TMV 2 × VRI Gn 6 **C3** - TMV Gn 13 × VRI Gn 6 **C4** - VRI 2 × VRI Gn 6

*,** Significant @ p <0.05 and p <0.01 level of probability, respectively.

Kurtosis

Similarly, kurtosis characterizes the relative peak size and flatness of a population distribution compared to normal distribution (Balanda and MacGillivray, 1988). Positive kurtosis indicates leptokurtic distribution, negative kurtosis indicates platykurtic distribution and zero value indicates normal or mesokurtic distribution (Pearson, 1929). Leptokurtosis were registered in the cross CO 7 × VRI Gn 6 for the trait shelling (%) and rust score whereas, the cross TMV 2 × VRI Gn 6 exhibited the same for sound mature kernel (%). Similarly, the cross TMV Gn 13 × VRI Gn 6, recorded leptokurtic nature for the traits *viz.*, 100-kernel weight (g) and sound mature kernel (%) while, the cross VRI 2 × VRI Gn 6 possessed the same for number of pods plant^{-1}, shelling (%) and sound mature kernel (%) indicating the presence of narrow variability for the particular trait. Hence selection cannot be made for these traits (Anitha, 2013). Mesokurtic nature of distribution was observed for the remaining traits in all the four crosses. Hence, directional selection will effectively improve the mean performance of these traits.

Considering the mean performance, the cross derivative TMV Gn 13 × VRI Gn 6 registered superiority for the characters *viz.*, 100-pod weight (g), 100-kernel weight (g) and sound mature kernel (%). Apart from these characters, the cross VRI 2 × VRI Gn 6 (shelling (%) and sound mature kernel (%)) and CO 7 × VRI Gn 6 (late leaf spot and rust score) also showed higher mean performance. High percentage of PCV, GCV, heritability coupled with high GAM values were recorded by number of pods plant^{-1} (TMV Gn 13 × VRI Gn 6), pod yield plant^{-1} (g) (TMV Gn 13 × VRI Gn 6 and VRI 2 × VRI Gn 6), kernel yield plant^{-1} (g) (TMV 2 × VRI Gn 6 and TMV Gn 13 × VRI Gn 6), late leaf spot score (CO 7 × VRI Gn 6) and rust score (CO 7 × VRI Gn 6, TMV 2 × VRI Gn 6 and VRI 2 × VRI Gn 6). Hence, selection would be effective for these traits in respective crosses to obtain promising progenies.

Regarding the population distribution, significant and negative skewness was observed in all the four crosses for shelling (%) and sound mature kernel (%). The trait 100-kernel weight (g) also recorded negative skewness for the cross TMV Gn 13 × VRI Gn 6. Similarly, leptokurtic/mesokurtic nature was noticed in most of the traits understudy. Thereby, directional selection will effectively improve the mean performance of these traits.

In conclusion, the various crosses registered superiority for varied characters understudy. High percentage of PCV, GCV, heritability coupled with high GAM values were recorded by number of pods plant^{-1}, pod yield plant^{-1} (g), kernel yield plant^{-1} (g), late leaf spot score and rust score in varied crosses. Hence, based on mean performance and various genetic parameters, the cross CO 7 × VRI Gn 6 is considered as superior for late leaf spot and rust resistance in groundnut.

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