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GENETICS AND PLANT BREEDING

Estimates of genetic variability parameters for yield and yield attributes in groundnut (*Arachis hypogaea* L.)

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Abstract

Groundnut is an important oilseed crop grown under diverse climatic conditions. The productivity of the crop is considerably affected by foliar fungal diseases, especially late leaf spot and rust which occur together and cause severe yield loss. With an objective of upgrading yield integrated with disease resistance, two cross derivatives in BC_2F_1 generation were developed by crossing foliar disease susceptible variety CO 7 and two foliar disease resistant parents *viz.,* GPBD 4 and COG 0437 in groundnut. These backcrosses *viz.,* CO 7 × GPBD 4 and CO 7 × COG 0437 were used to study their mean performance, genetic variability, heritability and genetic advance as per cent of mean for yield and yield attributes. High percentage of PCV, GCV, heritability coupled with high GAM were recorded by both the backcrosses for kernel yield per plant, pod yield per plant, number of pods per plant and 100-pod weight. In addition, the characters *viz.,* 100-kernel weight, shell weight, sound mature kernel per cent, late leaf spot and rust score exhibited high/medium coefficient of variation accompanied with high/ moderate heritability and genetic advance as per cent of mean which indicated the presence of additive gene effect. Thus, upshot of the study clearly indicating that there is a presence of wide spectrum of genetic variation for almost all the characters in both the crosses, suggesting that they respond to selection with greater efficacy for amelioration of kernel and pod yield conjunction with foliar disease resistance in groundnut.

Highlights

- Late leaf spot and rust are most destructive, widely distributed and economically important foliar fungal diseases in groundnut
- Crosses were made to develop foliar fungal disease resistant groundnut lines with acceptable kernel yield and pod yield
- Two backcross derivatives were utilized to quantify the magnitude and extent of variability for yield and yield attributes in groundnut
- Study indicated the presence of wide spectrum of genetic variation for almost all the characters in both backcross populations of groundnut
- Suggesting that they respond to selection with greater efficacy for the improvement of kernel and pod yield coupled with resistance to foliar fungal diseases in groundnut

Keywords: Groundnut, *per se*, variability, pod yield, kernel yield, late leaf spot, rust

Groundnut (*Arachis hypogaea* L.) is an essential oilseed crop grown widely and its yield is constrained due to foliar fungal diseases in most areas of the world. Late leaf spot [*Phaeoisariopsis personata* (Berk. and Curt.) Deighton] and rust [*Puccinia arachidis* Speg.] are the most destructive, widely distributed and economically important foliar diseases of the groundnut causing severe damage to the crop (McDonald *et al.* 1985). As together they can reduce the yield by 50-70% (Subrahmanyam *et al.* 1984). Groundnut can be consumed and utilized in diverse ways due to its nutritional and medicinal values. Likewise, it is grown under diverse climatic conditions. So, the availability of wide genetic variability with broad genetic base is a pre-requisite for the development of improved varieties with wide adoption. There are three major sources of genetic variability *viz.,* already available hereditary differences among wild relatives or the cultivated species, genetic variability recombined through hybridization and the genetic differences created artificially by use of mutagens (Gregory, 1961). The occurrence of natural variability in the crop is negligible due to limited natural crossing. In such cases, creations of new variability through hybridization followed by selection will be the best option for the improvement of crop plants. With this framework, hybridization were at empted to develop two BC_2F_1 cross derivatives to estimate variability parameters for yield and yield at ributes, with an objective to establish suitable selection criteria for higher pod yield and kernel yield per plant coupled with foliar fungal disease resistance in groundnut.

Materials and Methods

Study area

The experiment was conducted at Oilseeds Farm, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore, during *Rabi* 2013-14.

Experimental material

The material for this study comprised of two crosses *viz.,* CO 7 × GPBD 4 and CO 7 × COG 0437. Crosses were made to develop a foliar fungal disease resistant groundnut lines by using a released popular variety CO 7 and two foliar disease resistant parents, GPBD 4 and COG 0437. The resultant F_1's and BC_1F_1's were backcrossed with the recurrent parent CO 7. The BC_2F_1 populations of two crosses *viz.,* CO 7 × GPBD 4 and CO 7 × COG 0437 were used to estimate the genetic parameters for yield and yield component characters. The BC_2F_1 crosses were evaluated along with parents in non replicated trial. The spacing adopted was 30 × 10 cm and the recommended agronomic practices were followed throughout the crop growing period.

Observations recorded

Observations were recorded on 12 characters *viz.,* plant height (cm), number of primary branches, number of pods per plant, 100-pod weight (g), 100-kernel weight (g), shell weight (g), shelling percentage, sound mature kernel (SMK) (%), pod yield per plant (g), kernel yield per plant (g), late leaf spot (LLS) score and rust score. To screen the lines for sources of resistance to late leaf spot and rust, nine point disease scale suggested by Subrahmanyam *et al.* (1995) was employed.

Statistical analysis

Standard statistical procedures were adopted for calculating the mean, range 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 per cent of mean (GAM). The range of coefficient of variation (CV) was categorized as per Sivasubramanian and Madhavamenon (1973): < 10% - Low coefficient of variation; 10-20% - Medium coefficient of variation; > 20% - High coefficient of variation. As suggested by Robinson *et al.* (1949), the heritability range was classified as: < 30% - Low heritability; 30%-60% - Moderate heritability; > 60% - High heritability. Similarly, the range of genetic advance as per cent of mean (GAM) was grouped as: < 10% - Low GAM; 10%-20% - Medium GAM; > 20% - High GAM (Johnson *et al.* 1955).

Results and Discussion

Genetic variability is the basic requirement for crop improvement as this exhibits wider scope for selection. The results on the mean, range, variability, heritability and genetic advance as per cent of mean for 12 characters in two backcross populations *viz.*, CO 7 × GPBD 4 and CO 7 × COG 0437 of groundnut are presented in Table 1 and 2, respectively.

Table 1. Estimates of genetic variability parameters in BC_2F_1 generation for the cross CO 7 × GPBD 4 in groundnut

S. No.	Character	Mean	SE	Minimum	Maximum	PCV (%)	GCV (%)	Heritability (BS) (%)	GAM (%)
1	Plant height (cm)	11.66*	0.50	5.00	19.00	25.56	24.37	90.88	47.86
2	Number of primary branches	5.31	0.17	3.00	8.00	19.24	9.59	24.84	9.84
3	Number of pods per plant	7.63	0.58	2.00	18.00	44.75	40.73	82.84	76.36
4	100-pod weight (g)	34.41*	3.31	4.20	81.50	56.83	55.68	95.98	112.37
5	100-kernel weight (g)	21.09*	0.94	0.00	30.33	26.41	21.94	69.04	37.56
6	Shell weight (g)	1.23	0.13	0.19	3.07	63.34	50.76	64.23	83.81
7	Shelling percentage	64.55*	0.95	54.33	73.08	8.67	8.43	94.61	16.90
8	SMK (%)	86.78*	3.84	0.00	100.00	26.19	26.18	99.91	53.91
9	Pod yield per plant (g)	3.50	0.35	0.42	9.26	59.58	51.11	73.57	90.30
10	Kernel yield per plant (g)	2.27	0.23	0.23	6.35	59.34	50.70	72.99	89.23
11	LLS score	4.60	0.17	3.00	7.00	22.49	19.84	77.76	36.03
12	Rust score	4.94	0.19	3.00	7.00	22.46	17.31	59.41	27.48

*Significant at 5% level of probability.

Table 2. Estimates of genetic variability parameters in BC_2F_1 generation for the cross CO 7 × COG 0437 in groundnut

S. No.	Character	Mean	SE	Minimum	Maximum	PCV (%)	GCV (%)	Heritability (BS) (%)	GAM (%)
1	Plant height (cm)	9.60	0.29	8.00	12.00	11.68	6.97	35.61	8.57
2	Number of primary branches	5.07	0.33	4.00	8.00	25.26	18.22	52.03	27.08
3	Number of pods per plant	6.13	1.01	2.00	17.00	63.71	59.39	86.90	114.04
4	100-pod weight (g)	24.30	4.41	7.70	64.50	70.26	68.38	94.72	137.08
5	100-kernel weight (g)	18.30*	1.17	10.75	27.14	24.76	18.07	53.23	27.15
6	Shell weight (g)	0.92	0.17	0.33	2.40	69.52	47.70	47.06	67.40
7	Shelling percentage	61.65*	1.53	51.28	75.56	9.61	9.37	95.19	18.84
8	SMK (%)	90.61*	3.73	57.14	100.00	15.95	15.93	99.78	32.79
9	Pod yield per plant (g)	2.46	0.46	0.77	6.90	72.56	58.02	63.93	95.57
10	Kernel yield per plant (g)	1.54	0.30	0.44	4.50	75.25	59.95	63.47	98.39
11	LLS score	4.07	0.30	3.00	6.00	28.60	25.96	82.39	48.54
12	Rust score	3.93	0.25	3.00	6.00	24.44	16.55	45.88	23.09

*Significant at 5% level of probability.

Mean performance

Mean performance is one of the basic selection criteria for categorizing of superior performing progenies and eliminating undesirable genotypes/crosses. Considering the BC_2F_1 generation, the cross CO 7 × GPBD 4 exhibited higher mean for plant height, 100-pod weight, 100-kernel weight, shelling percentage and sound mature kernel per cent whereas, the cross CO 7 × COG 0437 showed higher mean performance for 100-kernel weight, shelling percentage and sound mature kernel per cent over the recurrent parent CO 7. No significance was observed for remaining traits in both the crosses.

Variability parameters

Studies on genetic parameters such as phenotypic variance, genotypic variance, PCV, GCV, heritability and GAM provide basic fact regarding the genetic properties of the population, based on which breeding methods are formulated for further improvement of the crop. Current study revealed the presence of wide range of phenotypic and genotypic coefficient of variation for all the characters studied. The estimates of GCV and PCV indicated that the values of PCV were always higher than GCV suggesting the influence of environmental factors. Less difference observed between PCV and GCV in certain cases indicated greater role of genetic components and less influence by environment. Similar kind of results were obtained by Ladole *et al.* (2009), Shinde *et al.* (2010), Sunil (2014) and Sunil *et al.* (2015).

Plant height (cm)

The cross CO 7 × GPBD 4 recorded high PCV, GCV values coupled with high heritability and high genetic advance as per cent of mean (GAM) for the trait plant height. High PCV, GCV, heritability and GAM values for plant height were earlier reported by Dandu *et al.* (2012), John *et al.* (2013), Terkimbi and Terkula (2014) and Thirumala *et al.* (2014). Whereas, the cross CO 7 × COG 0437 showed medium PCV, low GCV, moderate heritability and low GAM values. Similar results have been reported by Mothilal (2003), Zaman *et al.* (2011), Vishnuvardhan *et al.* (2012) and Mukesh *et al.* (2014) for medium PCV, Ashutosh and Prashant (2014) for low GCV, Shoba *et al.* (2009) and Vishnuvardhan *et al.* (2012) for moderate heritability and Thakur *et al.* (2011) for low GAM values.

Number of primary branches

Medium PCV and low GCV values were recorded by the cross CO 7 × GPBD 4. The cross CO 7 × COG 0437 had high PCV and medium GCV values. Higher coefficient of variation for number of primary branches were reported by Ashutosh and Prashant (2014), Terkimbi and Terkula (2014), medium values by Vishnuvardhan *et al.* (2012), Anitha (2013), John *et al.* (2013) and low values by John *et al.* (2008) and Mukesh *et al.* (2014). Low heritability and low GAM were noticed in the cross CO 7 × GPBD 4 whereas; the cross CO 7 × COG 0437 exhibited moderate heritability and high GAM values. John *et al.* (2013) earlier possessed moderate heritability and high GAM for the trait number of primary branches.

Number of pods per plant

The PCV and GCV values were found to be high for number of pods per plant in both the crosses, suggesting wide spectrum of genotypic variation for this trait. High PCV and GCV values for number of pods per plant were reported by Shinde *et al.* (2010), Priyadharsini (2012), Anitha (2013) and Makinde and Ariyo (2013). These crosses *viz.*, CO 7 × GPBD 4 and CO 7 × COG 0437 also exhibited high heritability and high GAM. High heritability with high GAM values for number of pods per plant was reported by Savaliya *et al.* (2009), Zaman *et al.* (2011), Priyadharsini (2012), Anitha (2013) and Padmaja *et al.* (2013 a).

100-pod weight (g)

High PCV, GCV, heritability and GAM values were noticed in both the backcross populations for 100-pod weight. Ali *et al.* (2000) and Ladole *et al.* (2009) also expressed the same for the trait 100-pod weight.

100-kernel weight (g)

The values of PCV and GCV were higher for 100-kernel weight in the cross CO 7 × GPBD 4 whereas, high PCV and medium GCV were exhibited in other cross. These results are in accordance with Makinde and Ariyo (2013), Padmaja *et al.* (2013 a), Padmaja *et al.* (2013 b) and Thirumala *et al.* (2014) for high PCV and GCV values. Zaman *et al.* (2011), Anitha (2013) and Ashutosh and Prashant (2014) also possessed medium GCV for this trait. Both the crosses recorded higher heritability and GAM except the cross CO 7 × COG 0437 which had moderate heritability. Higher estimates of heritability with high GAM values for hundred kernel weight was reported earlier by Zaman *et al.* (2011), Padmaja *et al.* (2013 a), Padmaja *et al.* (2013 b), Ashutosh and Prashant (2014) and Thirumala *et al.* (2014).

Shell weight (g)

High PCV and GCV values were recorded by both the cross derivatives. The cross CO 7 × GPBD 4 expressed high heritability whereas, the other cross CO 7 × COG 0437 possessed moderate heritability for the trait shell weight. Both the crosses exhibited higher GAM for shell weight. Anitha (2013) reported high PCV, GCV, heritability and GAM values for this trait.

Shelling percentage

Shelling percentage in both crosses exhibited low magnitudes of PCV and GCV indicating the limited scope of selection for this trait. These observations are in agreement with the findings of John *et al.* (2013), Narasimhulu *et al.* (2013), Padmaja *et al.* (2013 b) and Ashutosh and Prashant (2014). The crosses *viz.*, CO 7 × GPBD 4 and CO 7 × COG 0437 also exhibited high heritability coupled with medium GAM. Similar results were also obtained by Zaman *et al.* (2011), Anitha (2013) and John *et al.* (2013).

Sound mature kernel (%)

For sound mature kernel per cent, high PCV and GCV values were recorded by the cross CO 7 × GPBD 4 which are in accordance with the findings of Hiremath *et al.* (2011). Medium PCV and GCV were observed in cross CO 7 × COG 0437. Similar reports were given by John *et al.* (2013). The crosses *viz.*, CO 7 × GPBD 4 and CO 7 × COG 0437 had high heritability and high GAM for sound mature kernel per cent. High heritability and high GAM for sound mature kernel per cent were earlier reported by Hiremath *et al.* (2011).

Pod yield per plant (g)

Both the cross derivatives exhibited higher PCV and GCV values coupled with high heritability and GAM for pod yield per plant. High PCV, GCV, heritability and GAM values for pod yield per plant were earlier observed by Shinde *et al.* (2010), Dandu *et al.* (2012), Narasimhulu *et al.* (2012), Priyadharsini (2012), Anitha (2013), John *et al.* (2013), Narasimhulu *et al.* (2013), Mukesh *et al.* (2014) and Thirumala *et al.* (2014).

Kernel yield per plant (g)

High PCV and GCV values coupled with high heritability and GAM were exhibited by both the cross derivatives for kernel yield per plant. These findings were similar to the findings of Savaliya *et al.* (2009), Dolma *et al.* (2010), Shinde *et al.* (2010), Dandu *et al.* (2012), Narasimhulu *et al.* (2012), Priyadharsini (2012), Anitha (2013), John *et al.* (2013), Narasimhulu *et al.* (2013), Mukesh *et al.* (2014) and Thirumala *et al.* (2014) for the trait kernel yield per plant.

Late leaf spot score

Both the cross derivatives showed higher PCV and GCV values except CO 7 × GPBD 4 which possessed medium GCV for late leaf spot. High PCV, GCV values were noticed earlier by Khedikar *et al.* (2009), Venkataravana and Injeti (2008), Narasimhulu *et al.* (2013), Padmaja *et al.* (2013 a), Ashish *et al.* (2014) and medium GCV values by Vishnuvardhan *et al.* (2012) and Padmaja *et al.* (2013 b). High heritability coupled with high GAM for the trait late leaf spot were recorded in both the backcross combinations. Venkataravana and Injeti (2008), Khedikar *et al.* (2009), Vishnuvardhan *et al.* (2012), Narasimhulu

Table 3. Information on nature, magnitude and extent of variations present in two backcross derivatives of groundnut

S. No.	Characters	Backcross Derivatives										Selection Remarks
		CO 7 × GPBD 4					CO 7 × COG 0437					
		PCV	GCV	h^2	GAM	Gene Effect	PCV	GCV	h^2	GAM	Gene Effect	
1	Plant height (cm)	High	High	High	High	Additive	Medium	Low	Moderate	Low	Non additive	×
2	Number of primary branches	Medium	Low	Low	Low	Non additive	High	Medium	Moderate	High	Additive	×
3	Number of pods per plant	High	High	High	High	Additive	High	High	High	High	Additive	✓
4	100-pod weight (g)	High	High	High	High	Additive	High	High	High	High	Additive	✓
5	100-kernel weight (g)	High	High	High	High	Additive	High	Medium	Moderate	High	Additive	✓
6	Shell weight (g)	High	High	High	High	Additive	High	High	Moderate	High	Additive	✓
7	Shelling percentage	Low	Low	High	Medium	Additive	Low	Low	High	Medium	Additive	×
8	Sound mature kernel (%)	High	High	High	High	Additive	Medium	Medium	High	High	Additive	✓
9	Pod yield per plant (g)	High	High	High	High	Additive	High	High	High	High	Additive	✓
10	Kernel yield per plant (g)	High	High	High	High	Additive	High	High	High	High	Additive	✓
11	Late leaf spot score	High	Medium	High	High	Additive	High	High	High	High	Additive	✓
12	Rust score	High	Medium	Moderate	High	Additive	High	Medium	Moderate	High	Additive	✓

PCV - Phenotypic coefficient of variation, **GCV** - Genotypic coefficient of variation, $\mathbf{h^2}$ - Heritability in broad sense, **GAM** - Genetic advance as per cent of mean
✓ - Enough scope for selection of particular trait due to additive gene effect in both the backcross derivatives for yield improvement in groundnut
× - Selection may not be rewarding due to the presence of low genetic variation / non additive gene effect in any one of the backcross derivatives

et al. (2013), Padmaja *et al.* (2013 a), Padmaja *et al.* (2013 b) and Ashish *et al.* (2014) reported the same for late leaf spot score.

Rust score

High PCV and medium GCV for rust were recorded by both the cross derivatives *viz.,* CO 7 × GPBD 4 and CO 7 × COG 0437. High PCV values were earlier reported by Venkataravana and Injeti (2008), Narasimhulu *et al.* (2013), Ashish *et al.* (2014), Shridevi *et al.* (2014) and medium GCV values by Vishnuvardhan *et al.* (2012) for the trait rust disease score. The same crosses registered medium heritability and high GAM values for this trait. High GAM results are in accordance with John *et al.* (2008), Venkataravana and Injeti (2008), Vishnuvardhan *et al.* (2012), Narasimhulu *et al.* (2013), Ashish *et al.* (2014) and Shridevi *et al.* (2014).

Considering the variability parameters, both the backcross populations *viz.,* CO 7 × GPBD 4 and CO 7 × COG 0437 recorded high PCV and GCV values for kernel yield per plant, pod yield per plant, number of pods per plant, 100-pod weight and shell weight. High PCV and medium GCV values were exhibited by both the crosses for late leaf spot and rust disease scores except the cross CO 7 × COG 0437 which possessed high PCV and GCV values only for late leaf spot. Apart from these characters, the cross CO 7 × GPBD 4 also showed high PCV and GCV values for plant height, 100-kernel weight and sound mature kernel per cent. This revealed that the variation for these characters contributed markedly to the total variability and selection for these characters would be effective only on lesser environmental impact over the character. Hence, there is enough scope for selection based on these characters.

Regarding the heritability and genetic advance as per cent of mean (GAM), both the backcross derivatives recorded higher values for kernel yield per plant, pod yield per plant, number of pods per plant, 100-pod weight, sound mature kernel per cent and late leaf spot. Moderate heritability and high GAM values were exhibited by both the crosses for rust disease score. The characters *viz.,* plant height, 100-kernel weight and shell weight also showed higher values for the cross CO 7 × GPBD 4. To express, these characters are mainly controlled by additive genes and selection of such traits might be effective for the improvement of groundnut (Table 3).

Conclusion

Taken as a whole, high percentage of PCV, GCV, heritability coupled with high GAM were recorded by both the backcrosses for kernel yield per plant, pod yield per plant, number of pods per plant and 100-pod weight indicated the presence of additive gene effect and these traits are expected to respond to selection with greater efficiency. In addition, the characters *viz.,* 100-kernel weight, shell weight, sound mature kernel per cent, late leaf spot and rust score exhibited high/medium coefficient of variation accompanied with high/moderate heritability and high/moderate genetic advance as per cent of mean which implies the existence of additive gene effect in both the backcross derivatives can also be taken into consideration for selection. As an concluding remark, the upshot of the study clearly indicating that there is a presence of wide spectrum of genetic variation for almost all the characters in both the crosses, suggesting that they respond to selection with greater efficacy for amelioration of kernel and pod yield conjunction with foliar disease resistance in groundnut.

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