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Genetic Associations under Aphids and Rosette Stress in Groundnut (*Arachis hypogaea* L.)

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Abstract Groundnut production is largely constrained by biotic stresses with groundnut rosette virus disease seriously contributing to losses in yield in Nigeria and sub Saharan Africa. This study was conducted to understand performances and correlations between aphid resistance, rosette resistance and other quantitative characters. Two aphid resistance, one rosette resistance, one aphid susceptible and one rosette susceptible lines were used as parents to develop F1s, F2s, BC1P1 and BC1P2. The seventeen generations obtained were evaluated along with three checks in three replications using randomized complete block design. The F_1 generations had higher mean performance compared to the parents suggesting heterosis. The segregating generations (F2s, BC1P1 and BC1P2) had mean values higher or lower than the parents due to transgressive genes. The genotypic correlation coefficients in contrasting magnitudes and directions exceeded those of the corresponding phenotypic correlation coefficients for most of the character pairs indicating that the correlations were more genetic than environmental in the three sets of crosses studied.

Keywords: *mean, performance, genotypic, phenotypic, correlations, heterosis, aphids, rosette, groundnut*

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1. Introduction

Groundnut is an oilseed crop in Nigeria appreciated for its abundance of dietary protein rich oil, carbohydrate and other essential mineral nutrients. It is mainly used for consumption, raw material in the confectionary industry and protein source in animal feed industry [1]. These multiple uses of groundnut make it an excellent cash crop for domestic and international trade [2]. As a legume, it has a soil fertilization quality through the activities of nitrogen fixing bacteria resident in the root nodules [3].

Despite the economic importance of groundnut, its production is constrained by several abiotic and biotic stresses among which is the groundnut rosette virus disease. Groundnut rosette virus disease (GRVD) has been recognized in all groundnut growing countries on the African continent, including its offshore islands such as Madagascar, but not anywhere outside Africa [4]. GRVD is responsible for an annual groundnut loss of worth US$ 150 million [3]. Nigeria alone lost about 0.7 million hectares of land to groundnut rosette virus epidemic which amounted to US$250million [5]. The disease results from the synergistic interaction of three viral components; groundnut rosette virus (GRV), its satellite RNA (Sat-RNA), and groundnut rosette assistor virus (GRAV) [6]. The disease is spread by groundnut aphid.

The most effective, economic and sustainable method of limiting both the spread of the aphid and rosette viruses is to develop high yielding varieties that are resistant to the vector and the disease. [7,8]. Although efforts have been made at the Institute for Agricultural Research, (I.A.R) Samaru, Nigeria to develop resistant varieties, there are often cases of break in resistance [9].

Correlation is a biometric tool that brings out the extent of association between two or more characters with the end to provide information that forms the bases for selection in a breeding program [9,10], Characters that show similarities in magnitude and direction as indicated by the correlation coefficients are simultaneously considered for selection for further resistance studies [11,12,13]. Therefore, the present study was carried out to study genotypic correlations, phenotypic correlations between aphid resistance, rosette resistance and other quantitative characters in groundnut based on these objectives;

1. To study the mean performances of aphid resistance, rosette resistance and other quantitative characters
2. To explain associations among aphid resistance, rosette resistance and other quantitative characters.

2. Materials and Methods

The field evaluations were conducted at the Institute of Agricultural Research (I.A.R), Samaru with an altitude of

686m above sea level, lat 11°11'N, long 07°38'E during the 2014 growing season in the Northern guinea savanna zone of Nigeria, with a mean annual rainfall of 1050 mm distributed within five months. The soil type is loamy.

The plant materials for this research consisted of four entries obtained from West and Central Africa groundnut improvement program, Mali (ICGX-SM00020/5/9, ICGVIS07899, ICGX-SM0017/5/P10/P1 and ICGX-SM0020/5/P4/P1), one local variety (MANIPENTA) and three checks (SAMNUT 22, SAMNUT 23, and SAMNUT 24). Lines ICGX-SM00020/5/9 and ICGX-SM0020/5/P4/P1 are resistant to groundnut aphid, line ICGVIS07899 is resistant to rosette while lines ICGX-SM0017/5/P10/P1and MANIPENTA are susceptible to both groundnut aphids and rosette. The genetic populations were developed through crossing of the resistant P_1 and susceptible P_2 parents to obtain the F_1s. The F_1s were advanced to obtain the F_2s. The F_1s were also crossed to the recurrent parents to obtain BC_1P_1 and BC_1P_2. The resulting generations (P_1, P_2, F_1, F_2, BC_1P_1 and BC_1P_2) were evaluated with the three checks. Table 1 gives information about the genotypes.

Table 1. Genotype, description and source of materials used in this research

Parents	Genotypes	Description	Source
	Resistant lines		
P_1	ICGX-SM00020/5/9	Aphid Resistant, early maturing	ICRISAT
P_2	ICGX-SM0020/5/P4/P1	Aphid Resistant, early maturing	ICRISAT
P_3	ICGVIS07899	Rosette Resistant, early maturing	ICRISAT
	Susceptible lines		
P_4	ICGX-SM0017/5/P10/P1	Aphid Susceptible, early maturing	ICRISAT
P_5	MANIPENTA	Rosette Susceptible, late maturing	Local variety
	Checks		
P_6	SAMNUT26	Aphid Resistant, early maturing	IAR
P_7	SAMNUT23	Rosette Resistant, early maturing	IAR
P_8	SAMNUT24	Rosette Resistant, early maturing	IAR

ICRISAT-International Crops Research Institute for the Semi-Arid Tropics Patancheru, India. IAR-Institute for Agricultural Research, Samaru.

The five parents, three F_1s, three F_2s, six backcrosses along with the three checks making a total of twenty entries were evaluated at the Institute for Agricultural Research farm Samaru (lat 11°11'N, long 07°38'E). The experiment was laid out in a Randomized Complete Block Design (RCBD) in three replications with one row plot each of 5m in length and an inter row and intra row spacing of 0.75m by 0.25m. The rows containing the genotypes under test were flanked by two infector rows of MANIPENTA a highly susceptible cultivar. This technique, called infector-row technique was described by [14]. An alley of 1m separated one block from the other. MANIPENTA was sown two weeks earlier to allow buildup of infestation. *Aphis cracccivora* were collected from infested groundnut *Arachis hypogaea* and cowpea *Vigna unguiculata* plants in fields within Zaria and environs. These colonies were maintained on susceptible local groundnut genotype MANIPENTA. Three wingless (apterae) aphids were introduced on the tender leaves of 14 day-old seedlings of each of the twenty genotypes under trial. Each genotype was observed for the presence or absence of the aphids. Plants with no aphid were re-infested 7days after the first infestation. It is rare to find plants without aphids in choice test because the aphids were free to roam to find suitable plants within the field. No measure was taken to confine the aphids within the field. Data were collected from 40 plants for non-segregating populations (P_1, P_2, F_1) while 100 plants and 80 plants were considered for F_2 and BC_1 P_1 and BC_2 P_2 segregating populations respectively. Plant height, Days to 50% flowering, Days to maturity, Number of mature pods per plant, Number of seeds per pod were counted while Shelling percentage, pod yield per plant, and Hundred seed weight were measured using Mottler PM16-N weighing balance (ISC070501 Model).

2.1. Rosette Severity Index

The disease severity was recorded as the percentage of the amount of plant tissue that was diseased with green or chlorotic rosette. Reaction to rosette was scored based on the scale of 1 (No apparent rosette symptoms), 3 (10% - 20% rosette symptoms), 5 (20% -60% rosette symptoms) and 7 (60% -80% rosette symptoms). Disease severity index was then obtained using the formula described by [15]

2.2. Rosette Disease Incidence

This is the ratio of number of plants that showed green or chlorotic conditions to the total number of plants in the row expressed in percentage. The percent disease incidence was scored based on the scale recommended by ICRISAT [3]

2.3. Aphid Infestation Index

Aphid infestation index for each line was calculated by the formula and scale developed by [16,17].

2.4. Statistical Analysis

Data collected from different genetic populations were subjected to mean performance, genotypic correlations and phenotypic correlations. Mean separation was undertaken using Duncan's Multiple Range Test. Means with the same letter are not significantly different at 5% probability level. The Least significant difference was noted.

2.4.1. Correlations

Genotypic and phenotypic correlations were used to investigate the association among characters studied. Correlation coefficients were calculated from component of variance and covariance according to [18] the genotypic components were computed by equating the genotypic variances and covariance to the expected mean square and set products, and hence genotypic correlations were computed by this formula:

$$r_g = \frac{COV_{g12}}{\sqrt{\left(\sigma^2_{g1}\right)\left(\sigma^2_{g2}\right)}} \quad (1)$$

Where

$$r_g = genotypic\ correlation\ coefficient \quad (2)$$

$$COV_{g12} = estimate\ of\ the\ genotypic\ variance\ of\ character\ 1\ and\ 2 \quad (3)$$

$$\sigma^2_{g1} = estimate\ of\ the\ genotypic\ variance\ of\ 1 \quad (4)$$

$$\sigma^2_{g2} = estimate\ of\ the\ genotype\ variance\ of\ 2. \quad (5)$$

Phenotypic correlations were computed using the following formula:

$$r_p = \frac{COV_{ph12}}{\sqrt{\left(\sigma^2_{ph1}\right)\left(\sigma^2_{ph2}\right)}} \quad (6)$$

Where

$$r_p = phenotypic\ correlation\ coefficient \quad (7)$$

$$COV_{g12} = estimate\ of\ phenotypic\ covariance\ for\ characters\ 1\ and\ 2 \quad (8)$$

$$\sigma^2_{ph1} = estimate\ of\ phenotypic\ variance\ for\ character\ 1 \quad (9)$$

$$\sigma^2_{ph2} = estimate\ of\ phenotypic\ variance\ for\ character\ 2. \quad (10)$$

3. Result

3.1. Mean Performance

The mean performance of the parents, F_1s and the segregating generations (F_2, BC_1P_1, BC_1P_2) for days to fifty percent flowering, aphid infestation index, rosette disease incidence, rosette severity index, plant height, days to maturity, number of mature pods per plant, pod yield per plant, number of seeds per plant, shelling percentage and hundred seed weight are presented in Table 2.

Table 2. Mean performance for aphid infestation index, rosette disease incidence, rosette severity index and other quantitative characters in the three sets of groundnut crosses evaluated at Samaru in 2014

Character (s)	Generation (s)	ICGX-SM00020/5/9x ICGX-SM0017/5/P10/P1	ICGX-SM0017/5/P10/P1x ICGX-SM0020/5/P4/P1	ICGVIS07899xManipenta
Days to fifty percent flowering	P1(R)	45.67a	41.00a	36.67cde
	P2(S)	38.67bc	38.00abcd	39.00b
	F1	32.00f	36.67cd	38.00bc
	F2	41.00b	40.33ab	42.33a
	BCP1	35.33de	39.33abc	36.00cdef
	9	37.67cd	40.00abc	34.33f
	LSD	2.44	3.4	2.23
	Range	32.00-45.67	36.67-41.00	34.33-42.33
Aphid Infestation Index (%)	P1(R)	5.13ab	5.13	2.16b
	P2(S)	5.27abb	2.19	57.50a
	F1	1.76b	2.31	4.55b
	F2	2.28ab	2.87	1.92b
	BCP1	2.63abb	3.82	2.08b
	BCP2	10..88a	2.03	4.05b
	LSD	8.85	3.25	28.49
	Range	1.78-10.88	2.03-5.13	1.92-57.50
Rosette disease incidence (%)	P1(R)	20.36cd	20.36bc	2.78bc
	P2(S)	32.54ab	11.48cd	42.50a
	F1	13.39d	16.98c	18.73abc
	F2	37.06a	31.11a	30.16ab
	BCP1	31.31ab	26.76ab	36.15a
	BCP2	26.48bc	31.11a	32.84a
	LSD	9.9	9.07	28.12
	Range	13.39-37.06	11.48-31.11	2.78-42.50
Rosette Severity Index (%)	P1(R)	26.71bc	26.71	0.93c
	P2(S)	38.89ab	10.31	50.83ab
	F1	11.81cd	16.99cd	25.08bc
	F2	45.95ab	51.85a	45.50ab
	BCP1	52.19a	40.44ab	60.25a
	BCP2	39.69ab	49.77a	54.73ab
	LSD	21.67	17.61	34.35
	Range	11.81-52.19	10.31-51.85	0.93-60.25

Character (s)	Generation (s)	ICGX-SM00020/5/9x ICGX-SM0017/5/P10/P1	ICGX-SM0017/5/P10/P1x ICGX-SM0020/5/P4/P1	ICGVIS07899xManipenta
Plant height (cm)	P1(R)	37.22ab	37.22	34.56cd
	P2(S)	36.00ab	43.78	31.56d
	F1	37.33ab	43.33	41.44a
	F2	37.56ab	36.56	38.11abc
	BCP1	32.67b	38.78	37.33bc
	BCP2	31.11b	37.57	35.33cd
	LSD	8.11	7.71	5.6
	Range	31.11-37.56	37.22-43.78	31.56-41.44
Days to Maturity	P1(R)	115.67a	115.67a	108.33a
	P2(S)	102.00c	108.33ab	98.67bc
	F1	99.00cde	107.00abc	104.33ab
	F2	109.00b	104.33bc	103.00abc
	BCP1	101.67cd	110.33ab	100.33abc
	BCP2	97.67de	115.00a	94.00c
	LSD	5.18	9.07	9.59
	Range	96.67-115.67	104.33-115.67	94.00-108.3
Number of matured pods per plant	P1(R)	8.56d	8.56c	35.00a
	P2(S)	33.44a	22.56ab	22.56abcd
	F1	32.11a	23.33ab	11.11d
	F2	17.89c	18.33b	16.44cd
	BCP1	28.44bc	24.56ab	33.78ab
	BCP2	22.44bc	23.00ab	33.67ab
	LSD	7.96	9.06	12.63
	Range	8.56-33.44	8.56-24.56	11.11-35.00
Pod yield per plant (g)	P1(R)	10.44e	10.44c	27.78a
	P2(S)	18.52cd	18.32b	17.59bcd
	F1	25.64ab	23.02ab	8.52d
	F2	20.10bcd	21.93ab	13.01cd
	BCP1	25.00abc	23.36ab	26.14ab
	BCP2	15.00de	21.00ab	20.07abc
	LSD	6.93	7.84	9.93
	Range	10.44-25.00	10.44-23.36	8.52-27.78
Number of seeds per plant	P1(R)	15.67ab	15.67c	15.44b
	P2(S)	15.33b	18.00ab	18.56a
	F1	18.22a	17.44abc	16.67ab
	F2	15.00b	15.67c	16.67ab
	BCP1	16.78ab	16.00c	17.33ab
	BCP2	16.89ab	15.44c	17.11ab
	LSD	2.87	2.25	2.18
	Range	15.00-18.22	15.44-18..00	15.44-18.56
Shelling percentage	P1(R)	66.94cd	66.94ab	69.05ab
	P2(S)	71.95abc	70.71ab	74.69a
	F1	71.85abc	63.33b	65.25bc
	F2	64.50d	68.93ab	61.08c
	BCP1	72.44ab	71.13ab	73.77a
	BCP2	71.79abc	65.24ab	70.17ab
	LSD	5.14	10.33	6.52
	Range	64.50-71.95	63.33-71.13	61.08-74.69
Hundred seed weight (g)	P1(R)	59.07ab	59.07ab	39.27cde
	P2(S)	30.73f	45.17cd	44.90bc
	F1	46.13cde	44.60cd	30.13g
	F2	59.87a	70.57a	32.10fg
	BCP1	44.40de	47.53bcd	41.80cd
	BCP2	31.60f	45.17cd	33.20efg
	LSD	8.36	13.06	6.7
	Range	81.60-59.87	45.17-70.57	30.13-44.90

P2=Parent 2, P1=Parent 1, F1=First filial generation, F2=Second Filial generation, BC1P1=Backset to parent 1, BC1P2=Backset to parent 2. R=resistance, S=susceptible. LSD= Least significant difference. Means with the same letter are not significantly different at 0.05 probability level.

There were significant differences between the parents for all the traits measured in the three sets of crosses. Among the sets, ICGVIS07899 was the best performer in terms of days to fifty percent flowering (36.67days), aphid infestation index (2.16%), rosette disease incidence (2.78%) and rosette severity (0.93%) followed by ICGX-SM0020/5/P4/P1. The tallest (43.78cm) and the shortest (31.56cm) plants were ICGX-SM0020/5/P4/P1 and Manipenta. The earliest maturing (98.67days) was Manipenta followed by ICGX-SM0017/5/P10/P1. The latest was ICGX-SM0020/5/9. ICGVIS07899 exhibited superiority in terms of numbers of matured pods per plant (35pods) and pod yield per plant (27.78pods) with ICGX-SM0017/5/P10/P1 ranking second. With regards to number of seeds per plant (18.56seeds) and shelling percentage (74.69%), Manipeta was also the highest. The heaviest in terms of hundred seed weight (59.07g) was recorded in ICGX-SM00020/5/9 and ICGX-SM0017/5/P10.

Among the F_1 hybrids, ICGX-SM0020/5/9 x ICGX-SM0017/P10/P1 ranked best in the characters studied except in plant height (37.33cm) where it ranked last. ICGX-SM0017/5/P10/P1xICGX-SM0020/5/P4/P1 ranked second in most of the characters performing best in plant height (43.33cm) and last in days to maturity (104.33days) and shelling percentage (63.33%). ICGVIS07899 x Manipenta was the least in performance but ranked second in plant height (41.44cm), days to maturity (104.33days) and shelling percentage (65.25%).

The mean performances of the segregating generations for the characters studied showed that among the F_2s, ICGVIS07899 x Manpenta was outstanding in performance for aphid infestation index (1.92%), rosette disease incidence (30.16%), rosette disease severity (45.50%), plant height (38.11cm), days to maturity (103days) and number of seeds per plant (16.67seeds) with ICGX-SM0017/5/P10/P1xICGX-SM0020/5/P4/P1 ranking second. However, ICGX-SM0017/5/P10/P1xICGX-SM0020/5/P4/P1 ranked first in performance for days to fifty percent flowering (42.33days), number of matured pods per plant (18,33pods), pod yield per plant (21.93g) and hundred seed weight (70.57g). ICGX-SM0020/5/9 x ICGX-SM0017/P10/P1 performed least among the sets of crosses although ranking second for number of matured pods per plant (17.89pods), shelling percentage (64.50%) and hundred seed weight (70.57g).

Among the backcross generations, BC_1P_2 of ICGVIS07899 x Manpenta performed best for days to fifty percent flowering (34.33days) and days to maturity (94days). BC_1P_1 of ICGVIS07899 x Manpenta performed best for number of matured pods per plant (33.78 pods), pod yield per plant (26.14g) and number of seeds per plant (17.33seeds) while BC_1P_2 of ICGVIS07899 x Manpenta and BC_1P_1 of ICGX-SM00020/5/9xICGX-SM0017/5/P10/P1 ranked second for number of matured pods and pod yield per plant(g) respectively. BC_1P_2 of ICGX-SM0017/5/P10/P1xICGX-SM0020/5/P4/P1 was outstanding for aphid infestation index. BC_1P_2 of ICGX-SM00020/5/9xICGX-SM0017/5/P10/P1 ranked first for rosette disease incidence (26.48%) and BC_1P_1 of ICGVIS07899 x Manpenta for shelling percentage (73.77%). BC_1P_1 of ICGX-SM0017/5/P10/P1xICGX-SM0020/5/P4/P1 took the lead for plant height (38.78cm) and hundred seed weight (47.53g). For rosette severity index, BC_1P_2 of ICGX-SM00020/5/9xICGX-SM0017/5/P10/P1 is the best performer with a severity of 39.69%.

3.2. Genotypic and Phenotypic Correlations

The genotypic (upper matrix) and phenotypic (lower matrix) correlation coefficients at 5% and 1% levels of significance among the characters in the three sets of groundnut crosses are given in Table 3.

Table 3. Genotypic and Phenotypic Correlations for Aphid Infestation Index, Rosette Disease Incidence, Rosette Disease Severity and other quantitative characters in Cross 1 (ICGX-SM00020/5/9 x ICGX- SM0017/5/P10/P1), Cross 2 (ICGX-SM0017/5/P10/P1xICGX-SM0020/5/P4/P1) and Cross 3 (ICGVIS07899xManipenta) evaluated at Samaru in 2014

Character(s)	Crosses	Aphid Infestation Index (%)	Rosette Disease incidence (%)	Rosette severity index (%)	Days to fifty flowering (%)	Plant Height (cm)	Days to maturity	No of Matured pods/plant	Pod yield/plant (g)	No of Seeds/plants	Shelling percentage	Hundred seed weight (g)
Aphid Infestation Index (%)	Cross 1		1.00**	-0.50*	1.00**	-0.70**	0.88**	-1.00**	-1.00**	-1.00**	-1.00**	1.00**
	Cross 2		0.02	-0.26	1.00**	-1.00**	1.00**	-1.00**	-1.00**	-1.00**	0.42	1.00**
	Cross 3		0.24	1.00**	-0.03	0.35	1.00**	-0.57*	-0.67**	-0.68**	-0.09	-0.41
Rosette Disease incidence (%)	Cross 1	-0.07		0.02	-1.00**	1.00**	-0.02	0.33	1.00**	-1.00**	-1.00**	0.04
	Cross 2	0.26		1.00**	0.87**	-1.00**	0.65**	0.2	0.56*	-1.00**	-1.00**	0.64**
	Cross 3	0.13		-0.005	0.18	-0.38	1.00**	1.00**	1.00**	-0.32	0.07	0.06
Rosette severity index (%)	Cross 1	0.14	0.37		0.05	-0.63**	0.08	0.08	0.26	-0.1	-0.2	-0.33
	Cross 2	0.45	0.93**		1.00**	-1.00**	0.53*	0.11	0.45	-1.00**	-1.00**	0.64**
	Cross 3	0.16	0.81**		-1.00**	-0.42	-0.24	1.00**	0.01	-0.33	0.01	0.003
Days to fifty flowering (%)	Cross 1	-0.21	-0.19	0.25		0.38	0.82**	-0.90**	-1.00**	-1.00**	-0.82**	0.52*
	Cross 2	0.05	0.41	0.36		-1.00**	0.11	-0.85**	-0.54*	-1.00**	-1.00**	0.88**
	Cross 3	-0.08	-0.27	-0.45		0.27	1.00**	-0.89**	-0.90**	-0.28	-0.84**	-0.37
Plant height (cm)	Cross 1	-0.21	0.09	-0.15	0.42		0.94**	-0.17	-0.44	-1.00**	-1.00**	0.17
	Cross 2	0.01	-0.08	-0.21	-0.15		-1.00**	1.00**	0.51*	1.00**	1.00**	-1.00**
	Cross 3	-0.82**	0.16	0.2	-0.32		0.73**	-0.70**	-0.69**	0.22	-0.74**	-0.79**

Character(s)	Crosses	Aphid Infestation Index (%)	Rosette Disease incidence (%)	Rosette severity index (%)	Days to fifty flowering (%)	Plant Height (cm)	Days to maturity	No of Matured pods/plant	Pod yield/plant (g)	No of Seeds/plants	Shelling percentage	Hundred seed weight (g)
	Cross 1	-0.04	-0.4	-0.03	0.18	0.35		-0.71**	-0.48**	-0.96**	-1.00**	0.86**
Days to maturity	Cross 2	-0.2	0.65**	0.66**	0.58*	-0.23		0.70**	0.23	-1.00**	0.01	-1.00**
	Cross 3	0.75**	0.28	0.24	-0.002	-0.58*		-0.76**	-0.42	-0.12	-0.46	-0.04
	Cross 1	0.1	0.47	-0.02	-0.23	0.38	-0.17		0.77**	0.65**	0.98**	-0.74**
No of matured pods/plants	Cross 2	0.33	-0.43	-0.24	-0.43	-0.12	-0.32		0.95**	0.52*	-1.00**	-0.85**
	Cross 3	-0.28	-0.26	-0.01	0.23	0.02	-0.48*		0.96**	0.51*	1.00**	0.86**
	Cross 1	0.01	0.54	0.04	-0.13	0.22	-0.11	0.72**		1.00**	0.64**	-0.15
Pod yield/plant (g)	Cross 2	0.1	-0.29	-0.17	-0.49*	0.06	-0.11	0.79**		0.19	-1.00**	0.50**
	Cross 3	-0.32	-0.36	-0.18	0.3	0.05	-0.4	0.89**		0.69**	1.00**	0.86**
	Cross 1	0.49	0.19	0.33	-0.12	0.06	-0.2	-0.07	-0.16		0.11	-0.16
Number of Seeds/plants	Cross 2	0.77**	0.33	0.52*	-0.12	-0.08	-0.04	0.2	0.07		0.004	-0.54*
	Cross 3	-0.84**	-0.04	0.06	-0.51*	0.81**	-0.58*	0.32	0.34		0.3	0.4
	Cross 1	0.37	0.09	0.18	-0.09	0.39	0.15	-0.01	-0.18	0.79**		-1.00**
Shelling percentage	Cross 2	0.2	0.21	0.31	0.32	-0.93**	0.22	0.29	0.06	0.22		0.15
	Cross 3	-0.63**	0.05	0.14	-0.47*	0.54*	-0.39	0.15	0.29	0.68**		0.94**
	Cross 1	-0.36	-0.25	0.33	-0.24	-0.37	0.37	-0.26	-0.07	-0.48	-0.27	
Hundred seed weight (g)	Cross 2	-0.32	-0.21	-0.17	0.45	-0.02	0.35	0.05	0.32	-0.49*	0.13	
	Cross 3	-0.64**	-0.39	-0.38	0.32	0.25	-0.14	0.13	0.33	0.48*	0.3	

The coefficients indicated that genotypic correlations were larger than the phenotypic correlations for most of the character pairs. There were also some similarities in magnitude and directions (signs) in genotypic and phenotypic correlation coefficients for the three sets of groundnut crosses for the character pairs studied.

Based on these similarities in magnitude and direction of the estimates of genotypic correlations, aphid infestation index (%) was highly positively correlated with days to maturity (0.88**, 1.00**, 1.00**) but highly negatively correlated to number of matured pods per plant (-1.00**, --1.00**, -1.00**) and pod yield per plant (-1.00**, -1.00**. -0.68**) for the three sets of groundnut crosses studied. Similarly, Aphid infestation index had low positive correlations (1.00**, 0.02, 0.24) with rosette disease incidence.

Rosette disease incidence (%) had consistent positive correlations with number of matured pods per plant (0.33, 0.20, 1.00**), pod yield per plant (1.00**, 0.56*, 1.00**) and hundred seed weight (0.04, 0.65**, 0.06). However, there was negative correlations between rosette disease incidence with number of seeds per plant (-1.00**, -1.00** and -0.32) for the three sets of groundnut crosses tested.

Furthermore, there was positive correlations between rosette severity index with number of matured pods per plant (0.08, 0.11, 1.00**) and pod yield per plant (0.26, 0.45, 0.01) and negative correlations with number of seed per plant (-0.10, -1.00**, -0.03).

Again, days to fifty percent flowering had highly negative correlations with number of matured pods per plant (-0.90**, -0.85**, -0.89**), pod yield per plant (-1.00**, -0.54*, -0.90**), number of seeds per plant (-1.00**, -1.00**, -0.28) and shelling percentage (-0.82**, -1.00**, -0.84**). While positive correlations were recorded between days to fifty percent flowering and days to maturity (0.82**, 0.11, 1.00**) for the three sets of groundnut crosses.

Number of matured pods per plant showed positive correlations with pod yield per plant (0.77**, 0.95**, 0.96**) and number of seeds per plant (0.65**, 0.52**, 0.51*). The same trends were observed in the correlations (1.00**, 0.19, 0.69**) between pod yield per plant and number of seeds per plant, and also in the correlations (0.11, 0.004, 0.30) between number of seeds with shelling percentage respectively.

Based on similarities in magnitude and direction of phenotypic coefficient of correlations, there were low positive correlations (0.14, 0.45, 0.16) between Aphid infestation index with Rosette severity index but negative correlations (-0.36, -0.32, -0.64**) with hundred seed weight across the table for the three set of groundnut crosses studied. In the same vein, rosette disease incidence was positively correlated with rosette severity index (0.37, 0.93**, 0.81**) and shelling percentage (0.09, 0.21, 0,05) but negatively correlated with hundred seed weight (-0.36, -0.32, -0.64**) across the table for the three sets of groundnut crosses. Rosette severity index had consistent positive correlations with number of seeds per plant (0.33, 0.52**, 0.06) and shelling percentage (0.18, 0.31, 0.14).

Days to fifty percent flowering showed negative correlations (-0.12, -0.12, -0.51*) with number of seeds per plant. The correlation coefficient estimates (0.22, 0.06, 0.05) observed between plant height and pod yield per plant were positive but low. A consistent negative correlations were recorded for days to maturity with number of matured pods per plant (-0.17, -0.32, -0.48*), pod yield per plant (-0.11, -0.11, -0.40) and number of seeds (-0.20, -0.04, -0.58*) across the table for the three set of groundnut crosses studied. The correlations between number of matured pods

per plant and pod yield per plant was high (0.72**, 0.79**, 0.89**) and in the positive direction. There were positive correlations (0.79**, 0.22, 0.68**) between number of seeds per plant and shelling percentage.

4. Discussion

4.1. Mean Performance

Significant differences in performance among the parents, F_1s, F_2s and backcrosses studied suggest that there was sufficient variability across the generations for the characters studied. The F_1 generations had mean values higher than those of their parental lines suggesting the presence of heterosis. The mean values of the segregating generations were higher or lower than those of the parental lines suggesting the presence of transgressive segregation. Heterosis may result from over dominance of gene pair, depression of the dominant increasing alleles in the parental lines or both while transgressive segregation may result from recombination of additive alleles and epistasis.

4.2. Genotypic and Phenotypic Correlations

Succinctly, the genotypic correlation coefficients exceeded those of the corresponding phenotypic correlation coefficients for most of the character combinations in the three sets of crosses studied. These phenomena can be seen in correlations between aphid infestation index with number of matured pods per plant and pod yield per plant. Correlations between rosette disease incidence and plant height, pod yield per plant and number of seeds per plant, and between rosette disease severity and plant height indicating strong genetic associations between characters studied whose phenotypic expressions where influenced by the environment. Similar results were obtained by [19,20,21,22,23].

In the three sets of groundnut crosses, aphid infestation index showed positive genotypic and phenotypic correlations with rosette disease incidence but positive phenotypic correlations with days to maturity. Rosette disease incidence had consistent positive genotypic correlations with matured pods per plant, pod yield per plant and hundred seed weight but positive phenotypic correlations with rosette severity index and shelling percentage. Any pair of two mutually and directly correlated characters that are heritable can be considered together during selection.

Similarly, days to 50 percent flowering had highly negative genotypic correlations with number of matured pods per plant, pod yield per plant, number of seeds per plant and shelling percentage. It also had negative phenotypic correlations with number of seeds per plant illustrating that increase in the number of days to fifty percent flowering has a converse effect on the expression of these characters. These findings were in agreement with those of [9,24,25]. Phenological characters such as days to first flowering and days to fifty percent flowering have converse effect on the expression of yield and yield attributing characters.

Days to maturity showed consistent negative phenotypic associations with number of matured pods per plant, pod yield per plant and number of seeds per plant in the three sets of groundnut crosses. These result were in agreement with those reported by [24]. Positive estimates of phenotypic correlations where observed between pod yield per plant and number of matured pods per plant. These findings were at par with those reported by [10].

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References

[1] Echekwu, C. A., Emeka, I. Groundnut, Endoowing, The Groundnut /Rediscovery progrmme in Nigeria. Opah Mission Abuja. 2005, 18.

[2] Manish, K. P., Emmanuel, M., Peggy, O., Xuanquiang, L., Patricia, G., Shyan, N. N., Hari, D. U., Pasupuleti, J., Xinyou, Z., Baozhu, G., Douglas, R. C., David, J. B., Richard, M., Rajeev, K. V. Advances in Arachis Genomics for Peanuts Improvement. *Biotechnology Advances*, 2012, 30(3): 639-65.

[3] Waliyar, F., Kumar, P. L., Monyo, E., Nigam, S. N., Reddy, A. S., Osiru, M., Diallo, A. T. (2007). *A Century of Research on Groundnut Rosette Disease and its Management*. Technical Report. International Crops Research Institute fo rSemi-Arid Tropics (ICRISAT), Patancheru, Andhra Pradesh, India. 2007, 75: 1-44.

[4] Nigam, S. N. Strides in Groundnut Crop Improvement and New Challenges. Third International Conference of the Peanut Research Community on Advances in Arachis through Genomics and Biotechnology(AAG-2008) 4-8 November 2008, ICRISAT, Hydrerabad, Andhra Pradesh, India. 2008.

[5] Yayock, J. Y. Rossel, H. W., Harkness, C. A Review of the 1975 Rosette Epidemic in Nigeria. Paper presented at African Groundnut Council Symposium on pest of Groundnut and Millet in the field. Kaolock-Senegal. 1976, 12.

[6] Taliansky, M. E. Robinson, D. J., Murant A. F. Groundnut Rosette Disease Virus Complex: Biology and Molecular Biology. *Adv. Virus Res*. 2000, 55: 357-400.

[7] Feakin, S. D. (Ed). Pest Control in Groundnuts. 3rd Edn. *Centre for Overseas Pest Research.* PANS Manual, London, UK. 1973, 2: 123.

[8] Padgham, D. E. Kimmins, F.M., Ranga Rao, G. V. Resistance in groundnut *(Arachis hypogaea L.)* to *Aphis craccivora Kock*. *Annals of Applied Biology*. 1990, 117: 285-294.

[9] Vange, T., Maga, T. J. Genetic characteristics and path coefficient analysis in ten groundnut varieties (*Arachis hypogaea* L.) evaluated in the Guinea Savannah agro-ecological zone. *Afri. J. Agric. Res.* 2014, 3(25):1932-1937.

[10] Alam, M. K. Genetic Correlation and Path Coefficient Analysis in Groundnut (*Arachis hypogaea* L.) SAAC J. Agric. 2014, 12(1), 96-105.

[11] Khan. M. I., Ryan, A., Rahim, M., Tahir, M. Genetic variability and criterion for the selection of high yielding peanut genotypes. Pakistan J. Agric. Res. 2000, 16(1): 9-12.

[12] Mahalakshmi, P., Manivannan, N., Muralidharan, V. Variability and correlation studies in groundnut (*Arachis hypogaea* L.). Legume Res. 2005, 28(3): 194-197.

[13] Zaman M. A., Tuhina-Khatun, M, Ullah, M. Z., Moniruzzamn, M., Alam, K. H. Genetic Variability and Path Analysis of Groundnut (*Arachis hypogaea* L.). Agric. 2011, 9 (1-2): 29-36.

[14] Olorunju, P. E., Ntare, B. R. Combating viruses and virus disease of groundnut through the use of resistant varieties: A case study of Nigeria. *Plant virology in Sub-Saharan Africa*. 2001, 189-202.

[15] Sherwood, R. T., Hagedron, D. J. Determining the common root rot potential of pea fields. *Wis. Agric. Exp. Stn. Bull*. 1958, 531:12.

[16] Mensah, C., DiFonzo, C., Wang, D. C. Inheritance of Soybean Aphid Resistance in PI567541B and PI567598B. *Crop Sci.* 2008, 48: 1759-1763.

[17] Mensah, C., DiFonzo, C., Nelson, R. L., Wang, D. C. (2005). Resistance to Soybean Aphids in Early Maturing Soybean Germplasm. *Crop Sci*. 45: 2228-2233.

[18] Shivaji, P., Gritton, E. T. Genotypic and phenotypic variance and correlation in Peas. *Crop Sci.* 1975, 15(3): 353-355.

[19] Abdelmula, A. A., Abdalla, A. H., Salih, F. A. Phenotypic and genotypic correlations of some characters of the Faba bean (*Vicia faba* L.). *Uni. Khartoum J. Agric. Sci.* 1993, 1(1): 20-31.

[20] Brindha, S., Ponnuswami, V., Thamburaj, S. Correction studies in cluster bean (*Cyamopsis tetragonoloba* (L.) Tamb). *South Indian Hortic.* 1997, 45(1-2): 59-60.

[21] Gasim, S. M., Khidir, M. O. Correlation and path coefficient analysis of some characters in roselle (*Hibiscus sabdariffa* var sabdariffa) *U. K. J. Agric. Sci.* 1998, 6(1): 35-49.

[22] Ibrahim, E. B. Evaluation of some roselle (*Hibiscus sabdariffa* var sabdafiffa) genotypes for yield and its components. M. Sc. Thesis. Faculty of Agriculture, Unversity of Kartoum. Sudan. 2001

[23] Ibrahim, E. A. Abdalla, A. W. H., Rahman, M. E. A. Genotypic and phenotypic correlations between yield and yield components in some guar (*Cyamopsis tetragonoloba* L.) genotypes under rainfed condition. *African Journal of Agricultural Research*. 2013, 8(18): 1864-1871.

[24] John., K., Raghava Reddy, P. Studies on Characters Association and Path Coefficient Analysis for Yield and Water Use Efficiency Traits in Groundnut (*Arachis hypogaea* L.). *Int. J. Curr. Res. Biosci. Plant Biol*. 2016, 3(10): 128-135.

[25] Meta, H. R. and Monpara, B. A. Genetic variation and trait relationships in summer groundnut, *Arachis hypogaea* L. *J. Oilseed Res.*, 2010, 26: 186-18.