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DISSECTING YIELD AND RELATED TRAITS THROUGH GENETIC VARIABILITY AND CHARACTER ASSOCIATION IN GROUNDNUT (*ARACHIS HYPOGAEA* L.)

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ABSTRACT

An evaluation of 25 groundnut (*Arachis hypogaea* L.) genotypes was conducted in the *kharif* season 2024 at the Rajasthan Agricultural Research Institute, Durgapura, to investigate genetic variability, correlation coefficient, and path analysis for 13 traits. ANOVA demonstrated strong statistical significance genotypic marked differences among all traits. PCV values slightly exceeded GCV values, indicating minimal environmental influence. High PCV and GCV were observed for the number of pods and branches per plant, while 100-seed weight, dry pod yield, kernel yield, and chlorophyll content showed moderate values. High heritability, alongside high genetic advance as a per cent of mean, for 100-seed weight, dry pod yield, number of pods, kernel yield, number of branches and chlorophyll content, suggested the prevalence of additive gene action and greater selection efficiency. Genotypes RG 632, RG 633, RG 624, RG 661 and RG 653 recorded superior pod yield, while RG 628, RG 615-3, and RG 636 were early maturing. Dry pod yield per plant showed strong positive associations with kernel yield per plant, number of branches per plant, number of pods per plant and 100-seed weight. Path analysis brought to light kernel yield per plant as the most pivotal trait, followed by number of branches per plant and number of pods per plant. These Outcomes identify promising traits and genotypes for yield improvement in groundnut.

Key words : Groundnut, Variability, Correlation coefficient, Path analysis, Pod yield.

Introduction

The word groundnut [*Arachis hypogaea* (L.)] derived from Greek language with *arachis* denotation a kind of leguminous plant and *hypogaea* meaning “below the earth,” emphasizing the characteristic underground pod development. This unusual biological phenomenon is in consistence with positive geotropism as pods are developed below the soil surface and weight of the groundnut is unpredictable (Suthar *et al.*, 2023). Its coordinated events of flowering, pegging, and pod development are awarded the title “wonder legume” (Yadav *et al.*, 2022). Commonly it is called as earthnut, peanut, monkey nut, goober, pinda and manila nut with a variety of local names and known as “King of Oilseeds” in view of its economic and nutritional importance (Kumari and Sasidharan, 2020).

Peanut (groundnut) is a major legume crop that is commonly cultivated on a large scale in the tropics and semi-arid tropics, and acts as a pivotal factor in vegetable protein and edible oil production in the world. The kernels are relatively high in food value, containing 47–53% oil and 25–36% protein. Cultivation is confined to the region between 40°N and 40°S of the equator. Groundnut is a highly selfed species and a very special type of reproductive system is observed that its flowers are above the soil and after pollination, fertilized ovary elongates into peg that penetrates in the soil and pods and seeds develop. In India, it is considered the premiere oilseed crop and it ranks as the third most significant source of plant-based protein. However, with its autogamous nature, groundnut has rather narrow genetic base requiring large variability in segregating populations for crop improvement.

Variability studies being the basic for evaluation of the genotypes for their quantitative and qualitative traits. For an effective breeding program targeted to desired improvement, a precise knowledge on the contextual proportions of genetic and non-genetic sources of variation is required. An understanding of the existing genetic variation that exists within a population, followed by an estimate of genetic parameters, such as heritability, is indispensable for initiating a successful crop improvement program. The genetic diversity is very important for any breeding program aimed at high productivity. This includes evaluation of various parameters such as variance components, genotypic coefficient and phenotypic coefficient of variation, heritability, and genetic advance (Younis *et al.*, 2008).

Correlation studies are essential in understanding the associations between yield traits and thereby helpful to plant breeders in selecting material for breeding programs. Positive correlations of the preferred characteristics is especially desirable in that it allows additional factors to be improved concurrently. Yield is a multigenic trait whose expression and interaction are highly impacted by the environment. Thus, it is necessary to break down the total deviation in the phenotype into genetic and non-genetic parts. Path coefficient analysis deepens the understanding one step further by decomposing the correlation coefficients into direct and indirect effects, thus illustrating of the interrelationships of traits. Such an analytical method is useful to spot the features that have the strongest direct impact on the productivity, thus giving the possibility of a more efficient selection. The use of path analysis has been extensively diversified over different crop species for numerous purposes and is still considered a practical tool by breeders for the optimization of selection strategies and achieving genetic gain (Dewey and Lu, 1959).

Materials and Methods

Experimental site and location

The study was conducted at the experimental field of the *All India Coordinated Research Project (AICRP)* on Groundnut, located at the Rajasthan Agricultural Research Institute (RARI), Durgapura, Jaipur. Geographically, durgapura falls within the Semi-Arid Eastern Plain Zone, designated as Agro-climatic Zone

Table 1 : Name of Groundnut genotypes (along with their source).

S.No.	Genotype	Source	S.No.	Genotype	Source
1	RG 624	RARI, Durgapura	14	RG 653	RARI, Durgapura
2	RG 628	RARI, Durgapura	15	RG 656	RARI, Durgapura
3	RG 633	RARI, Durgapura	16	RG 657	RARI, Durgapura
4	RG 632	RARI, Durgapura	17	RG 658	RARI, Durgapura
5	RG 615-3	RARI, Durgapura	18	RG 659	RARI, Durgapura
6	RG 617	RARI, Durgapura	19	RG 660	RARI, Durgapura
7	RG 622	RARI, Durgapura	20	RG 661	RARI, Durgapura
8	RG 652	RARI, Durgapura	21	RG 662	RARI, Durgapura
9	RG 622-5	RARI, Durgapura	22	ICRICAT-44	ICRISAT, Hyderabad
10	RG 650	RARI, Durgapura	23	RG 638*	RARI, Durgapura
11	RG 622-1	RARI, Durgapura	24	RG 425*	RARI, Durgapura
12	RG 636	RARI, Durgapura	25	RG 559-3*	RARI, Durgapura
13	RG 646	RARI, Durgapura			

*Check

III-A of Rajasthan. The site is positioned at 26°51' North latitude and 75°47' East longitude, with an elevation of approximately 390 meters above mean sea level.

Climate and weather condition

In the 2024–25 crop season, the trial farm was watered with 1372.7 mm of rain in total. During the crop development stage, the highest and lowest temperatures were 31.9°C and 19.6°C, respectively. Relative humidity had a wide range of values with 93.6% as the maximum and 29.0% as the minimum, respectively.

Experimental materials

The original material for this research included 25 groundnut genotypes, with three check varieties, *i.e.*, the ones that have been used for comparison, which have been maintained under the *AICRP* on groundnut at the Rajasthan Agricultural Research Institute, Durgapura, Jaipur. Table 1 presents the complete set of genotypes along with the checks employed in the study.

Experimental details

To carry out the current study, the experimental material was made up of the 25 groundnut genotypes created at the Rajasthan Agricultural Research Institute (RARI), Durgapura, under Sri Karan Narendra Agriculture University, Jobner. The genotypes were sown on 20th June during the *Kharif* 2024 season. Each of the genotype was sown in five continuous rows within a plot measuring 5.0 × 2.25 m², maintaining an inter-row spacing of 45 cm and an intra-row spacing of 15 cm. The experimental layout followed a Randomized Complete Block Design (RCBD) with three replications per sowing date, conducted at RARI, Durgapura. A crop with all the necessary agronomic practices was used for the experiment.

Observations recorded

Observations were recorded on thirteen traits encompassing yield, physiological, and quality parameters. These included: days to 50% flowering, days to initiation of pegging, number of branches per plant, number of pods per plant, days to maturity, dry pod yield per plant (g), kernel yield per plant (g), sound mature kernel (%), shelling percentage (%), 100-seed weight (g), chlorophyll content (mg/g), protein content (%) and oil content (%). For each genotype, data on these traits were collected from five randomly selected plants per replication, except for the phenological traits namely, days to 50% flowering, days to initiation of pegging and days to maturity, which were recorded collectively for each plot.

Statistical analysis

Variance analysis (ANOVA) was performed following the methodology outlined by Panse and Sukhatme (1985). Phenotypic and genotypic coefficients of variation were computed using the formula proposed by Burton (1952). Broad-sense heritability (h^2_{bs}) was estimated in accordance with the procedure described by Burton and De Vane (1953), while genetic advance was calculated using the approach suggested by Johnson *et al.* (1955). Additionally, the predicted genetic advance, expressed as a percentage of the mean, was determined with reference to Johnson *et al.* (1955). Correlation coefficients were derived based on the method of Singh and Chaudhary (1979), and path coefficient analysis was conducted using the technique developed by Dewey and Lu (1959).

Results and Discussion

Analysis of variance

Analysis of variance (ANOVA) for all the thirteen

characters studied among twenty-five genotypes of groundnut were showed that the mean sum of squares genotypes was markedly significant for all the characters and exhibited a wide range of genetic variation across genotypes. This suggesting that there is a substantial prospect for the selection of elite genotypes for improving the dry pods yield of groundnut. Alike results were mentioned by Narasimhulu *et al.* (2012), Chavadhari *et al.* (2017), Poojitha *et al.* (2024). Availability of pronounced variability in the material handled by the plant breeders is of immense crucial determinant of breeding programme efficacy (Table 2).

Mean performance

On the basis of mean performance values, several genotypes viz., RG 632 (32.35), RG 633 (32.04), RG 624 (31.15), RG 661 (30.49), and RG 653 (30.05) were give high dry pods yield per plant over the best check *i.e.*, RG 425 (29.84) indicating these genotypes can be further exploited for hybridization programme to achieve higher groundnut yield. RG 628 (27.00), RG 615-3 (27.00), RG 617 (27.00), RG 636 (27.00), RG 646 (27.00), RG 661 (27.00), RG 663 (27.00), RG 559-3 (27.00) found earliest in term of days to 50 per cent of flowering. As per their mean performance in genotypes RG 636 (32.00), RG 661 (32.00), RG 663 (32.00), RG 559-3 (32.00) found earliest in term of days to initiation of pegging. Whereas genotypes RG 622-5 (122.67), RG 650 (123.67), RG 658 (123.67), were found early maturing which can be used as donor in developing early maturity varieties. The genotypes having more number of branches per plant were RG 653 (15.27), RG 624 (13.20), RG 622-5 (11.73) more number of pods per plant were found RG 646 (27.40), RG 624 (24.40), RG 632 (26.00). Genotypes viz., RG 624 (23.29) followed by RG 661 (23.13), RG 633

Table 2 : Mean squares for various characters in 25 genotypes of groundnut at RARI, Durgapura during *Kharif* 2024.

RARI, Durgapura 2024								
Source	df	Days to 50 % flowering	Days to initiation of pegging	No. of branches per Plant	No. of pods per plant	Days to maturity	Drypod yield per plant	Kernel yield per plant (g)
Replication	2	0.17	0.25	1.93	18.34	0.57	10.74	7.92
Genotypes	24	1.78**	3.04**	8.92**	47.41**	6.79**	57.87**	21.78**
Error	48	0.09	0.13	2.33	7.72	1.68	8.86	4.11
Source	df	Sound mature kernel (%)	Shelling (%)	100-Seed weight (g)	Chlorophyll content (mg/g)	Protein content (%)	Oil content (%)	
Replication	2	4.86	2.19	50.30*	0.0003	0.61*	0.08	
Genotypes	24	26.23**	21.69**	190.69**	0.16**	3.15**	2.98**	
Error	48	11.87	9.62	18.03	0.0002	0.28	0.274	

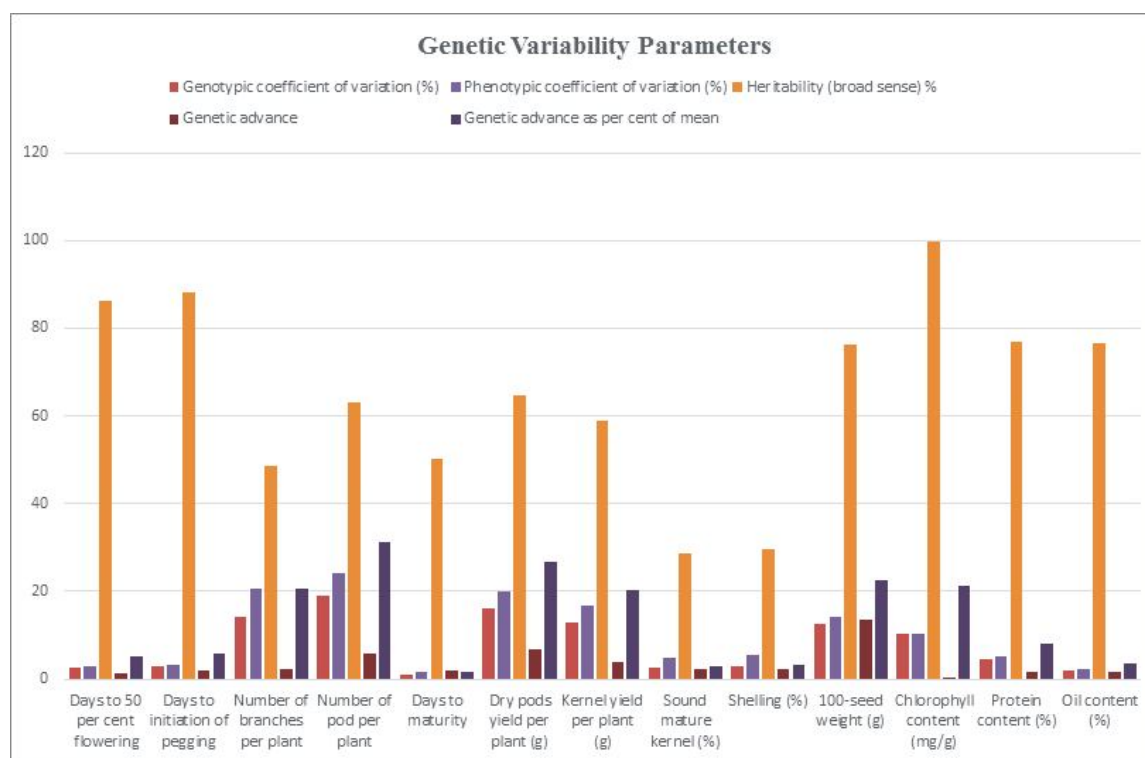


Fig. 1 : Graphical representation of Genetic variability parameters of twenty-five groundnut genotypes.

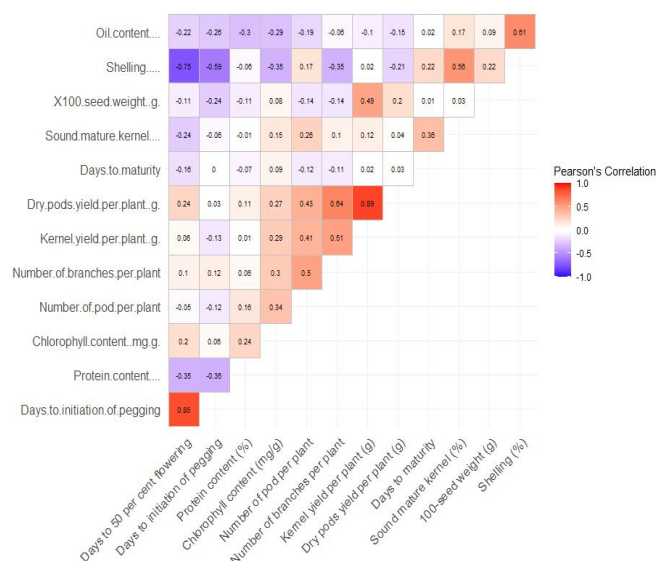


Fig. 2 : Heatmap showing genotypic correlation coefficients among yield and associated traits in groundnut.

(22.48) were found maximum kernel yield per plant. Maximum number of sound mature kernel was observed in genotypes RG 659 (93.24) followed by RG 638 (90.23), RG 624 (90.12). Genotypes viz., RG 659 (74.50) followed by RG 638 (72.87), ICRISAT 44 (71.31) were found maximum shelling. Genotypes such as RG 656 (75.12) followed by RG 650 (73.89), ICRISAT 44 (72.53) showed significantly higher mean value of 100-seed weight. Highest 100-seed weight is important and desirable traits for seed yield enhancement.

Maximum per cent of chlorophyll content was observed in genotypes RG 632 (2.74), RG 624 (2.74), RG 628 (2.69). Genotypes viz., RG 632 (23.66) followed by RG 425 (23.49), RG 646 (23.40) were found maximum protein content. Maximum oil content was observed in genotypes RG 660 (51.98) followed by RG 657 (51.14), ICRISAT 44 (51.02) (Table 3).

Genetic variability parameters

Phenotypic coefficient of variation (PCV)

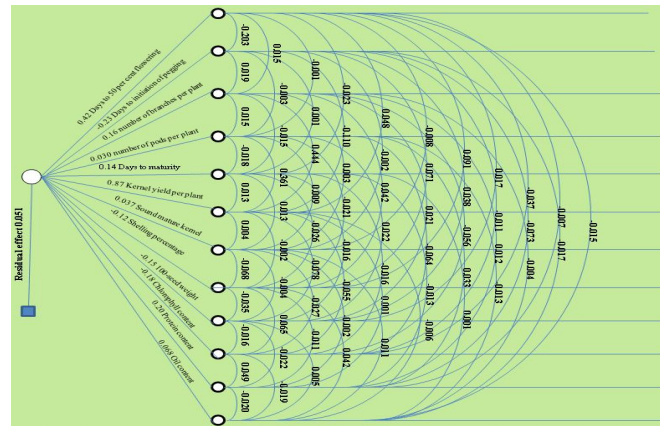
In this investigation, the magnitude of PCV was slightly higher than the GCV values which indicating the minor effect of the environmental factors on the characters articulation (Table 4). High phenotypic coefficient of variation (PCV) was observed for number of pods per plant (24.11%) and number of branches per plant (20.53%), which aligns well with the elevated variability Stated by Mane *et al.* (2024) and Varghese *et al.* (2024), who recorded PCV for dry pod yield per plant and number of pods per plant. Moderate PCV values for dry pod yield per plant (19.93%), kernel yield per plant (16.78%), 100 kernel weight (14.29%), and chlorophyll content (10.29%) correspond with findings by Savaliya *et al.* (2009) and Nagaveni K and Khan (2019) which noted by moderate PCV for these yield-contributing traits in groundnut. Finally, low PCV observed for shelling (5.34%), oil content (2.19%), days to 50 per cent flowering (2.90%) and days to maturity (1.47%). Sravanti *et al.* (2024) reported low PCV for days to 50 per cent

Tables 3 : Mean table of all 13 character of groundnut genotypes.

Genotypes	Days to 50 per cent flowering	Days to initiation of pegging	Number of branches /plant	Number of pod/plant	Days to maturity	Drypod yield/plant	Kernel yield/plant (g)	Sound mature kernel (%)	Shelling (%)	100-Seed weight (g)	Chlorophyll content (mg/g)	Protein (%)	Oil (%)
RG 624	29.00	34.33	13.20	24.40	124.00	31.15	23.29	90.12	71.05	61.01	2.74	22.32	49.31
RG 628	27.00	32.33	10.80	20.47	124.33	21.93	19.41	87.04	67.63	64.27	2.69	23.31	49.02
RG 633	29.00	35.00	11.20	22.40	128.33	32.04	22.48	86.30	63.83	68.25	2.68	20.69	47.71
RG 632	28.33	33.00	11.67	26.00	124.00	32.35	21.08	85.66	68.56	63.10	2.74	23.66	49.31
RG 615-3	27.00	33.33	11.87	15.53	126.33	20.17	15.46	84.24	69.01	51.61	2.29	22.13	49.48
RG 617	27.00	33.00	9.93	17.20	126.00	24.37	18.47	87.87	69.60	57.04	2.20	22.69	47.83
RG 622	28.00	34.33	11.00	17.33	125.00	24.66	19.31	88.23	69.88	63.76	2.24	22.48	49.22
RG 652	30.00	36.00	8.13	12.40	124.67	19.61	13.05	82.65	63.02	45.61	2.23	22.56	48.22
RG 622-5	28.33	34.33	11.73	22.47	122.67	28.29	20.68	85.47	69.57	63.05	1.66	20.92	49.36
RG 650	28.00	33.00	9.07	17.03	123.67	16.75	15.78	85.41	68.16	73.89	2.22	20.66	49.36
RG 622-1	28.00	33.00	10.60	22.13	124.00	26.31	19.55	77.79	65.92	53.40	2.23	22.32	49.47
RG 636	27.00	32.00	11.33	17.87	124.67	28.94	20.96	83.87	67.46	66.10	2.21	23.14	49.77
RG 646	27.00	33.00	10.73	27.40	126.33	20.43	15.17	88.43	70.71	53.44	2.21	23.40	50.14
RG 653	28.33	34.33	15.27	18.20	125.00	30.05	19.09	86.38	64.75	53.67	2.20	22.38	50.50
RG 656	28.00	34.00	7.47	12.87	125.33	22.48	18.77	82.70	70.14	75.12	2.19	23.26	50.18
RG 657	28.00	34.00	8.73	14.87	127.00	20.41	15.90	85.73	70.85	53.54	2.19	20.46	51.14
RG 658	28.00	33.00	8.87	14.33	123.67	22.96	16.84	88.92	68.53	57.63	2.20	22.68	49.91
RG 659	27.33	33.33	9.73	19.93	127.67	24.79	19.68	93.24	74.50	60.03	2.18	22.61	50.55
RG 660	28.00	33.00	9.73	18.40	125.00	27.08	20.38	86.61	71.00	59.88	2.17	20.74	51.98
RG 661	27.00	32.00	10.80	21.00	125.33	30.49	23.13	87.03	70.54	67.44	2.17	22.54	49.80
RG 663	27.00	32.00	7.80	19.67	125.33	19.79	14.83	85.33	70.85	47.98	2.16	22.50	49.81
ICRISAT-44	28.00	33.00	10.00	14.93	127.67	24.22	19.06	86.40	71.31	72.53	2.16	20.82	51.02
RG 638	28.00	34.00	9.60	21.80	124.00	24.96	19.09	90.23	72.87	59.72	2.16	21.08	49.14
RG 425	28.00	33.00	11.00	21.13	128.00	29.84	21.76	87.14	69.97	57.20	2.15	23.49	48.31
RG 559-3	27.00	32.00	8.87	14.93	125.67	25.69	18.19	85.89	71.23	71.77	2.14	23.21	49.46
Mean	27.85	33.37	10.37	18.99	125.35	25.19	18.86	86.35	69.24	60.84	2.26	22.24	49.60
S.E.m. ±	0.17	0.21	0.88	1.60	0.75	1.72	1.17	1.99	1.79	2.45	0.01	0.31	0.30
CD at 5%	0.49	0.59	2.51	4.56	2.13	4.89	3.33	5.66	5.09	6.97	0.02	0.88	0.86
CD at 1%	0.66	0.78	3.34	6.09	2.84	6.52	4.44	7.55	6.79	9.30	0.03	1.17	1.15
CV (%)	1.08	1.07	14.73	14.64	1.04	11.82	10.76	3.99	4.48	6.98	0.63	2.40	1.06

Table 4 : Genetic variability parameters for dry pod yield and its contributing characters in groundnut genotypes.

S. no.	Characters	Range		Mean	Genotypic coefficient of variation (%)	Phenotypic coefficient of variation (%)	Heritability (broad sense) %	Genetic advance	Genetic advance as per cent of mean
		Min.	Max						
1.	Days to 50 per cent flowering	27	30	27.85	2.69	2.90	86.22	1.44	5.15
2.	Days to initiation of pegging	32	36	33.37	2.95	3.14	88.31	1.91	5.71
3.	Number of branches per plant	7.47	15.27	10.37	14.30	20.53	48.52	2.12	20.52
4.	Number of pod per plant	12.40	27.40	18.99	19.15	24.11	63.14	5.95	31.35
5.	Days to maturity	122.67	128.33	125.35	1.04	1.47	50.26	1.91	1.52
6.	Dry pods yield per plant (g)	16.75	32.35	25.19	16.04	19.93	64.83	6.70	26.61
7.	Kernel yield per plant (g)	13.05	23.29	18.86	12.87	16.78	58.85	3.83	20.34
8.	Sound mature kernel (%)	77.79	93.24	86.35	2.53	4.73	28.72	2.41	2.80
9.	Shelling (%)	63.02	74.50	69.24	2.90	5.34	29.47	2.24	3.24
10.	100-seed weight (g)	45.61	75.12	60.84	12.47	14.29	76.13	13.63	22.40
11.	Chlorophyll content (mg/g)	1.66	2.74	2.20	10.27	10.29	99.63	0.48	21.12
12.	Protein content (%)	20.46	23.66	22.24	4.39	5.01	77.03	1.77	7.94
13.	Oil content (%)	47.71	51.98	49.60	1.92	2.19	76.67	1.71	3.46

**Fig. 3 :** Path diagram of showing direct and indirect effects of 12 characters on dry pod yield per plant.

flowering, maturity, shelling (%) and sound mature kernel. Savaliya *et al.* (2009) similarly reported low PCV for phenological and quality traits, including oil content, and days to maturity.

Genotypic coefficient of variation (GCV)

A moderate genotypic coefficient of variation (GCV) was recorded for number of pods per plant (19.15%), dry pod yield per plant (16.04%), number of branches per plant (14.30%), kernel yield per plant (12.87%), 100-kernel weight (12.47%) and chlorophyll content (10.27%), similar result finds Mane *et al.* (2024), who reported moderate GCV for pods, kernel yield, branches, and 100-seed weight. In contrast, lower GCV was noted for protein content (4.39%), days to initiation of pegging (2.95%), shelling percentage (2.90%), days to 50 per cent flowering (2.69%), sound mature kernel (2.53%), oil content (1.92%) and days to maturity (1.04%), Sravanti *et al.* (2024) indicated by low GCV for days to flowering, maturity, shelling percentage, and sound mature kernel. Savaliya *et al.* (2009) similarly reported low PCV for phenological and quality traits, including oil content, and days to maturity.

Heritability

High heritability demonstrates trait stability and inheritance from parent to offspring. High heritability was observed for traits such as chlorophyll content (99.63%), days to initiation of pegging (88.31%), days to 50 per cent flowering (86.22%), oil content (76.67%), 100-seed weight (76.13%), dry pods yield per plant (64.83%), and number of pods per plant (63.14%). This evidence indicate that these traits are less influenced by the environment and more controlled by genetic factors, making them reliable for selection. Similar high heritability values for 100-seed weight, oil content, and days to 50 per cent flowering traits were reported by Killi and Beycioglu (2022) and moderate heritability was observed for traits

Table 6 : Genotypic path coefficient analysis showing direct and indirect effects of 12 characters on dry pod yield per plant Genotypic.

Characters	Days to 50 percent flowering	Days to initiation of pegging	Number of branches per plant	Number of pod per plant	Days to maturity	Kernel yield per plant (g)	Sound mature kernel (%)	Shelling (%)	100-seed weight (g)	Chlorophyll content (mg/g)	Protein content (%)	Oil content (%)	Correlation with Dry pods yield /plant (g)
Days to 50 per cent flowering	0.4257	-0.2037	0.0153	-0.0013	-0.0231	0.0483	-0.0089	0.0917	0.0179	-0.0377	-0.0705	-0.0152	0.2386
Days to initiation of pegging	0.3620	-0.2396	0.0194	-0.0037	0.0004	-0.1101	-0.0021	0.0719	0.0383	-0.0117	-0.0731	-0.0178	0.0337
Number of branches per plant	0.0408	-0.0291	0.1603	0.0153	-0.0159	0.4441	0.0036	0.0425	0.0215	-0.0564	0.0123	-0.0042	0.635 **
Number of pod per plant	-0.0191	0.0290	0.0794	0.0309	-0.0182	0.3618	0.0097	-0.0211	0.0228	-0.0643	0.0335	-0.0134	0.4309*
Days to maturity	-0.0660	-0.0007	-0.0171	-0.0037	0.1490	0.0138	0.0135	-0.0265	-0.0016	-0.0169	-0.0136	0.0015	0.0314
Kernel yield per plant (g)	0.0234	0.0301	0.0813	0.0127	0.0023	0.8761	0.0043	-0.0029	-0.0783	-0.0550	0.0013	-0.0068	0.8887**
Sound mature kernel (%)	-0.1016	0.0136	0.0155	0.0080	0.0536	0.1016	0.0375	-0.0689	-0.0044	-0.0275	-0.0029	0.0116	0.0361
Shelling (%)	-0.3187	0.1405	-0.0557	0.0053	0.0322	0.0213	0.0210	-0.1226	-0.0351	0.0658	-0.0114	0.0423	-0.2149
100-seed weight (g)	-0.0482	0.0578	-0.0217	-0.0044	0.0015	0.4324	0.0010	-0.0271	-0.1586	-0.0160	-0.0226	0.0059	0.1999
Chlorophyll content (mg/g)	0.0847	-0.0149	0.0478	0.0104	0.0133	0.2543	0.0054	0.0425	-0.0134	-0.1895	0.0494	-0.0199	0.2705
Protein content (%)	-0.1473	0.0859	0.0097	0.0050	-0.0099	0.0057	-0.0005	0.0069	0.0176	-0.0459	0.2039	-0.0209	0.1102
Oil content (%)	-0.0939	0.0621	-0.0097	-0.0060	0.0033	-0.0864	0.0063	-0.0753	-0.0137	0.0547	-0.0620	0.0689	-0.1517

Residual effect = 0.0513

like, kernel yield per plant (58.85%) and days to maturity (50.26%), number of branches per plant (48.52%), which are moderately influenced by the environment similar moderate heritability values found was observed by Kannappan *et al.* (2022). Traits such as shelling (29.72%), and sound mature kernel (28.72%) showed relatively lower heritability, indicating more environmental influence on their expression being similar low heritability values were observed found in Korale *et al.* (2021).

Genetic advance and Genetic advance as per cent mean

Genetic advance was used to measure the expected gain and find the truly associated traits for yield improvement through selection. Genetic advance as per cent of mean expresses the genetic advance relative to the mean value of the traits.

The highest genetic advance was observed for 100 seed weight (13.63%), indicating strong potential for improvement in this trait. High genetic advance as per cent mean was also noted for number of pods per plant (31.35%), dry pods yield per plant (26.61%), chlorophyll content (21.12%), number of branches per plant (20.52%) and kernel yield per plant (20.34%), following closely suggesting effective selection opportunities these findings are coherent with those reported by Kumar *et al.* (2024). Traits exhibiting moderate genetic advance included protein content (7.94%), days to initiation of pegging (5.71%), days to 50 per cent flowering (5.15%), and oil content (3.46%). Low genetic advance was collected for shelling (3.24%), sound mature kernel (2.80%), and days to maturity (1.52%), implying limited scope for improvement through selection similar results found in Nagaveni K and Khan (2019).

Correlation coefficient analysis

Dry pods yield per plant is an intricate trait that is formidable to improve by selecting specific genotypes to enhance yield; correlation helps to identify traits that are related to yield enhancement. In plant breeding, correlation coefficient exposes the magnitude of linear association between different plant traits and identifies the whole network associated traits that can be contributed genetically boost dry pods yield per plant.

Dry pod yield per plant showed strong, highly significant genotypic correlations with kernel yield per plant ($rg = 0.8887^{**}$), number of branches per plant ($rg = 0.6350^{**}$), and number of pods per plant ($rg = 0.4309^{*}$). These associations mirror findings reported by Mahesh *et al.* (2018) and Rao (2016), who observed similar positive and significant correlations between dry pod yield per plant, kernel yield per plant, number of pods per plant.

Non-significant positive correlations with chlorophyll content ($rg = 0.2705$), 100-seed weight ($rg = 0.1999$), sound mature kernel ($rg = 0.0361$), days to maturity ($rg = 0.0314$), days to initiation of pegging ($rg = 0.0337$), days to 50 per cent flowering ($rg = 0.2386$) and protein content ($rg = 0.1102$), alongside negative correlations with shelling ($rg = -0.2149$) and oil content ($rg = -0.1517$), align with patterns noted by Shendekar *et al.* (2023) (Table 5).

Path coefficient analysis

The correlation analysis reveals solely nature and degree of association existing between pairs of characters. Dry pods yield per plant is dependent on many jointly connected components characters and a change in any one component is likely to propagate through the full chain of causality. Path coefficient analysis is an effective statistical methodology that stratification the observed correlation coefficient into direct and indirect effects of pods yield components which offers more reliable estimates of cause of association between polygenic dependent traits such as yield and its associated independent traits. If any traits exhibit a positive direct effect on dry pod yield, indirect selection for such a trait would be reliable. Along with direct effect, if a high significant correlation is observed for a trait, then it indicates a true relationship and selection for such a trait would enhance yield.

In this study at genotypic level, kernel yield per plant (0.8761) exhibited maximum direct effect on dry pods yield per plant followed by days to 50 per cent flowering (0.4257), protein content (0.2039), number of branches per plant (0.1603), days to maturity (0.1490), oil content (0.0689), sound mature kernel (0.037), number of pods per plant (0.0309), which also had significant and positive correlation with dry pods yield per plant apart from days to 50 per cent flowering, protein content, days to maturity, oil content, sound mature kernel. These results were in consistent with earlier findings of kernel yield per plant, Hampannavar *et al.* (2018), Mahesh *et al.* (2018), days to 50 per cent flowering, sound mature kernel, Sravanti *et al.* (2024), Mahalakshmi *et al.* (2020), number of pods per plant, sound mature kernel, Ajith *et al.* (2023), John and Reddy (2018), oil content, Meena and Singh (2021) days to maturity, number of branches per plant (Choudhary *et al.*, 2013) (Table 6).

Conclusion

The results highlighted significant genetic variability for all traits. High genotypic variation for the number of pods per plant, dry pod yield, and number of branches per plant suggests strong genetic control. Most traits exhibiting high heritability alongside substantial genetic

advance particularly number of pods per plant, dry pod yield, 100-seed weight, kernel yield per plant, number of branches per plant and chlorophyll content offer considerable prospect for genetic improvement through selection. Kernel yield per plant, number of branches per plant, number of pods per plant, and 100-seed weight were positively and significantly associated with dry pod yield. Path coefficient analysis highlighted kernel yield per plant as the most influential characters, exerting the peak direct effect on dry pod yield, with additional indirect contributions from protein content, number of branches per plant, days to maturity, chlorophyll content, and number of pods per plant. These traits should be prioritized in selection strategies aimed at yield enhancement in groundnut breeding programs.

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