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Assessment of physiological indices for growth and yield of groundnut (*Arachis hypogaea* L.)

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Abstract
The present study on the topic "Assessment of physiological indices for growth and yield of groundnut (*Arachis hypogaea* L.) was performed at AICRP on groundnut, M.P.K.V., Rahuri, (M.S.) during summer 2021.The experiment was laid out in Randomized Block Design with three replications includes sixteen genotypes. The observations on growth and morphological characters, dry matter accumulation and its distribution, phonological traits, physiological parameters, biochemical analysis i.e. protein, oil, chlorophyll content and correlation studies were recorded. The yield and yield attributes were recorded at harvest. The increased growth was higher between 60 DAS to 80 DAS. The groundnut genotypes with highest rate of photosynthesis and transpiration processes are higher in yielding. According to correlation studies, it was concluded that primary and secondary branches, number of mature pods per plant, 100 kernels weight (g), TDM (g) per plant, leaf area (dm^2) per plant showed maximum influence on dry pod yield (g/plant). The genotypes Phule Unnati, ICGV-15311 and ICGV-15303 showed higher yielding ability this may be due to the most promising yield contributing characters like number of mature pods per plant, hundred kernels weight (g), dry pod yield per plant and HI (%).

Keywords: Groundnut, morphological characters, physiological parameters, yield and yield attributes, biochemical studies

Introduction

Groundnut (*Arachis hypogaea* L.) is a tropical and subtropical oilseed and food legume. The *Arachis hypogaea* L. is a botanical name of groundnut. Where, *Arachis* and *hypogaea* are two Greek words with meaning legume and below ground, respectively, denotes geographical nature of pod formation. Groundnut has been dubbed "Nature's Masterpiece of Food Value" as it contains 36 to 54 percent oil, 24 to 26 percent protein and has an energy value 2,363 KJ per 100g Vitamin A, B1, B2, nicotinic acid, E and K are rich in kernels. (Woodroof, 1983) [14]. About 200g of groundnut can easily provide the FAO's recommended dietary allowance of minerals.

The partitioning of assimilates between vegetative and reproductive parts as well as the rate of fruit establishment causes most of the yield variation Past improvements in yield potential in most crop species including groundnut appear to have been derived primarily from increases in harvest index, when genetic enhancement is absent in photosynthesis and growth (Zhu *et al.*, 2010) [15]. Any morphological trait linked to higher seed yield or that contributes significantly to yielding ability could be beneficial in increasing grain yield. Basic research on the basis of morpho-physiological traits is required in order to overcome yield barriers within genotypes (Dharanguttikar and Borkar, 2014) [4].

A large variation in growth, yield and development was found among different genotypes with genotypic differences as a result of the interaction of external factors with physiological processes of the plant *viz*. photosynthesis, respiration, transpiration, stomatal conductance and so on. It is critical to identify plant characters that govern productivity in a breeding programme to improve pod yield in groundnut. For achieving genotype with desirable traits, it was necessary to investigate the interrelationships between different characters. Therefore, the present study was undertaken to assess the morphological, growth, physiological and biochemical parameters of groundnut genotypes as well as dry matter production, yield and yield attributes with a focus on pod yield.

Material and Methods

The field experiment was carried out in the summer of 2021 at the farm of AICRP on Groundnut, M.P.K.V., Rahuri.

The sixteenth genotypes of groundnut were sown on 20 February, 2021 with three replications by dibbling method and maintaining 30 cm × 10 cm spacing under irrigated condition. FYM @ 10 cartloads ha-1 was applied during land preparation and incorporated well with harrowing. The recommended dose of chemical fertilizer was 25 kg N and 50 kg P_2O_5 ha-1 in the form of urea and SSP was applied at the time of sowing. The weeding and hoeing were carried out as needed and field was kept weed free. The observations were recorded separately for all the genotypes on randomly selected five plants from each genotype in each replication. The observation on growth characters, morphological traits, phonological parameters, dry matter accumulation and it's partitioning were recorded at 20 days of interval. The yield and yield attributes were recorded at harvest. The rate of photosynthesis, transpiration and stomatal conductance were measured by using Portable Infrared Gas Analyzer (IRGA) at 50% flowering. Percentages of oil and protein content in kernels were estimated by using NIR spectrophotometer instrument. The chlorophyll content (a, b and total) of leaves was estimated at 10 days after flowering by spectrophotometer method describes by Arnon (1949) [1] on fresh weight basis and calculated by using formula suggested by Sadasivam S. and A. Manickam (1992).

Results and Discussion

The vegetative phase is responsible for the plant's overall phenotypic expression and prepares it for the reproductive phase. The leaves stem, branches, roots are all components of the vegetative stage with a particular role. In the present investigation, it was observed that, the values of these growth parameters increased with advancement of crop age. The increased was higher between 60 DAS to 80 DAS and decreases thereafter to harvest. The data on growth and morphological parameters influenced by groundnut genotypes is presented in Table 1 revealed that, the genotypes ICGV-15287 (23.60 cm) and TAG-24 (24.07 cm) were dwarf, while ICGV-13027 (37.93 cm) and ICGV-13086 (36.47 cm) were tall genotypes. Plant height is genetically determined trait Mensah and Okpere (2000). Phule Unnati (13.53) and ICGV-15311 (10.79) recorded more no. of primary branches while, Phule Unnati (15.67), ICGV-10005 (8.00) and ICGV-10007 (6.80) had profuse secondary branching. Higher pegs and more canopy output are result of more number of branches produced Rahman (2001) [11]. The number of leaves and leaf area indicates plant ability for continuous photosynthesis activity and ultimate yield. In present investigation, Phule Unnati (480.00) and ICGV-10016 (388.80) recorded maximum number of leaves plant^{-1}. The genotypes ICGV-15303 (36.48 dm^2) had the largest leaf area per plant followed by genotypes ICGV-15311 (31.16 dm^2) and ICGV-10016 (30.61 dm^2). The results are in accordance with Rajmane (2001). The genotype ICGV-15290 (39.00 days) and ICGV-15303 (40.00 days) was early for 50% flowering and physiological maturity ICGV-15303 (124.00 days) and ICGV-15290 (125.00 days), while the genotype Phule Unnati (47.00 days) was late 50% flowering and physiological maturity (130.33 days) which had efficient dry matter partitioning during reproductive phase and it progresses towards the development of the plant's economic components and as a result, an increase in yield. These results were accordance with Jagtap *et al.* (2014) [7].

The data on groundnut genotypes in regard of photosynthetic rate, stomatal conductance and transpiration rate at 50 per cent flowering measured using Infra-red Gas Analyzer (IRGA; Model Portable Photosynthetic System LI 6400) presented in Table 2, revealed that the genotype ICGV-15311 (26.20 μ mol CO_2 $m^{-2} s^{-1}$) recorded highest photosynthetic rate, which was at par with genotypes ICGV-15303 (26.16 μ mol CO_2 m^{-2} s^{-1}) and ICGV-10007 (25.81 μ mol CO_2 m^{-2} s^{-1}); ICGV-15311 (0.39 m mol CO_2 m^{-2} s^{-1}), ICGV-15303 (0.38 m mol CO_2 m^{-2} s^{-1}) and ICGV-10007 (0.37 m mol CO_2 m^{-2} s^{-1}) recorded highest stomatal conductance and ICGV-15303 (3.16 m mol CO_2 m^{-2} s^{-1}), ICGV-15311 (3.07 m mol CO_2 m^{-2} s^{-1}) and ICGV-10007 (3.04 m mol CO_2 m^{-2} s^{-1}) recorded highest transpiration rate. The adaxial stomatal frequency was higher in ICGV-15303 (19.05) and ICGV-15311 (18.87) whereas, abaxial frequency was higher for ICGV-15311 (11.24), ICGV-10007 (10.87), ICGV-15303 (10.87) and Phule Unnati (10.85). The genotype ICGV-15311 and ICGV-15303 recorded higher rate of stomatal conductance, photosynthetic and transpiration rate produced higher grain yield. These findings support the results reported by Bhattacharya and Singh (1999) [2], Kalpana *et al.* (2003) [8] and Borkar and Dharanguttikar (2014) [4].

The growth and development of reproductive parts are referred to as reproductive growth. This phase is critical as sink is presents in the reproductive part i.e. pods. Hence detailed observations were made on various yield and yield contributing attributes. In present investigation, genotypic variations are statistically significant for all variables, indicating a large level of difference in yield and yield attributes between genotypes. The maximum number of total pods plant^{-1} was produced by Phule Unnati (47.90), ICGV-15311 (47.60), ICGV-10007 (47.47) and ICGV-15287 (47.40). The number of pods per plant is genetically controlled and one of the main yield contributing characters, Rasheed *et al.* (2015) reported the similar result. The genotypes ICGV-15303 (37.94 g/100 kernels), ICGV-10004 (34.38 g/100 kernels) and Phule Unnati (33.97g/100 kernels) were found bold seeded. The significantly highest dry pod yield (g) plant^{-1} was recorded by Phule Unnati (28.69 g) followed by ICGV-15311 (26.94 g). The groundnut genotypes studied shows large extent of variation in dry haulm yield (kg) per plot. The genotypes Phule Unnati (3.72 kg), ICGV-15311 (3.69 kg) and ICGV-10007 (3.64 kg) exhibited highest dry haulm yield (kg) per plot. The harvest index gives better understanding of assimilates translocation efficiency of the genotype. The highest harvest index was maintained by genotype Phule Unnati (66.58%) followed by ICGV-15311 (63.69%) and ICGV-15303 (63.03%) indicating the better translocation efficiency. It is measure of grain yield potential of genotype and considered as an important criterion for selection of high yielding genotypes. These results are similar with the findings of Bhargavi *et al.* (2015) [3] and Kamshette *et al.* (2015). The genotypes ICGV-15311 (3599.88 kg), ICGV-15303 (2909.38 kg) and Phule Unnati (2852.50 kg) recorded higher kernel yield (kg) per hectare (Table 3). The result about yielding parameters has been shown in figures below.

The correlation studies are necessary to finding out the degree and direction of association among two characters. Correlation studies would provide reliable information in nature of extent and the direction of the selection especially when the breeder needs to combine high yield potential with desirable traits. Correlation studies indicate that 100 kernels weight (0.914**), kernel yield (kg/ha) (0.899**), primary branches per plant (0.839**), secondary branches per plant (0.808**), total pods per plant (0.753**), mature pods per plant (0.753**), dry haulm yield (kg/ plot) (0.752**) and leaf area (dm^2/plant) (0.533*) showed maximum influence on dry pod yield (g/plant) (Table 4). Similar, results were also recorded by Rao *et al.* (2014) [13], Bhargavi *et al.* (2015) [3] and Hampannavar *et al.* (2018) [6].

Table 1: Growth and morphological parameters influenced by groundnut genotypes

Sr. No.	Genotypes	Plant height (cm)	Branches Plant^{-1}		Leaf area (dm^2)	Leaves Plant^{-1}	Days to 50% of flowering	Days to maturity
			primary	secondary				
1	ICGV-10001	32.00	6.87	1.53	20.82	291.87	43.00	127.00
2	ICGV-10004	27.73	10.13	6.47	15.53	196.93	42.33	126.67
3	ICGV-10005	26.13	10.14	8.00	20.22	343.20	42.00	126.33
4	ICGV-10007	29.60	10.04	6.80	20.16	364.40	43.00	126.00
5	ICGV-10008	35.80	7.50	1.80	22.92	264.53	42.33	126.33
6	ICGV-10016	30.80	9.05	3.60	30.61	388.80	44.67	126.33
7	ICGV-10021	29.53	8.40	4.00	25.16	323.47	40.67	125.67
8	ICGV-13027	37.93	8.00	5.00	25.80	313.47	42.00	126.00
9	ICGV-13086	36.47	7.20	2.73	24.48	209.07	40.67	125.67
10	ICGV-15284	26.67	6.20	1.47	21.33	304.00	42.67	126.00
11	ICGV-15287	23.60	9.60	3.87	22.93	388.27	46.67	130.00
12	ICGV-15290	28.43	7.33	2.47	18.46	261.07	39.00	125.00
13	ICGV-15303	33.00	8.59	6.33	36.48	263.33	40.00	124.00
14	ICGV-15311	30.47	10.79	6.60	31.16	279.07	44.33	127.33
15	TAG-24 (C)	24.07	9.87	5.40	24.20	336.33	43.00	126.00
16	Phule Unnati (C)	24.20	13.53	15.67	28.66	480.00	47.00	130.33
	Mean	29.78	8.95	5.11	24.31	312.99	42.71	126.54
	S.E.±	0.880	0.259	0.155	0.706	9.029	0.506	0.382
	C.D.at 5%	2.542	0.747	0.448	2.040	26.078	1.461	1.105

Table 2: Physiological parameters influenced by groundnut genotypes

Sr. No.	Genotypes	Photosynthesis Rate (μ molm^{-2}s^{-1})	Stomatal conductance (m molm^{-2}s^{-1})	Transpiration rate (m molm^{-2}s^{-1})	Stomatal frequency (mm^2/leaf area)	
					Adaxial	Abaxial
1	ICGV-10001	24.70	0.31	2.39	16.58	10.25
2	ICGV-10004	23.99	0.27	1.93	15.67	10.27
3	ICGV-10005	24.37	0.30	2.26	17.08	10.21
4	ICGV-10007	25.81	0.37	3.04	18.53	10.87
5	ICGV-10008	24.84	0.31	2.49	17.08	10.27
6	ICGV-10016	25.06	0.32	2.75	17.37	10.65
7	ICGV-10021	25.36	0.35	2.81	17.55	10.82
8	ICGV-13027	25.32	0.33	2.82	17.88	10.77
9	ICGV-13086	24.36	0.28	2.14	16.01	10.11
10	ICGV-15284	24.61	0.31	2.40	18.53	10.23
11	ICGV-15287	25.02	0.32	2.44	16.98	10.54
12	ICGV-15290	23.88	0.25	2.08	14.24	09.42
13	ICGV-15303	26.16	0.38	3.16	19.05	10.87
14	ICGV-15311	26.20	0.39	3.07	18.87	11.24
15	TAG-24 (C)	25.05	0.31	2.54	17.24	10.64
16	Phule Unnati (C)	25.76	0.36	2.44	18.11	10.85
	Mean	25.03	0.32	2.55	17.30	10.50
	S.E.±	0.146	0.010	0.056	0.178	0.140
	C.D. at 5%	0.423	0.029	0.162	0.514	0.406

Table 3: Yield and yield contributing attributes as influenced by groundnut genotypes

Sr. No.	Genotypes	Total pods per plant	Mature pods per plant	100 kernels weight (g) (HKW)	Haulm Yield (kg/plot)	Kernel yield (kg/ha)	Dry pod yield (g /plant)	Harvest index (%)
1	ICGV-10001	30.00	27.47	22.47	3.05	1437.06	12.78	39.81
2	ICGV-10004	45.15	37.53	34.38	2.82	2423.38	17.00	57.50
3	ICGV-10005	42.73	36.73	24.43	3.07	2449.77	17.88	55.49
4	ICGV-10007	47.47	41.47	33.94	3.64	2533.33	19.55	51.04
5	ICGV-10008	38.53	35.33	33.81	3.03	1625.12	16.51	51.72
6	ICGV-10016	32.67	28.47	29.73	3.26	1737.27	16.30	47.50
7	ICGV-10021	34.40	29.80	26.04	3.40	1900.00	14.06	39.27
8	ICGV-13027	41.13	37.33	27.72	3.13	2256.25	15.51	47.09
9	ICGV-13086	40.80	36.33	32.63	2.98	1627.31	14.29	45.62
10	ICGV-15284	26.20	22.93	20.28	2.07	1040.16	8.62	39.54

11	ICGV-15287	47.40	40.53	30.04	3.40	2295.83	17.89	50.07
12	ICGV-15290	32.73	27.53	25.44	3.00	1748.26	12.58	40.06
13	ICGV-15303	36.87	30.80	37.94	3.04	2909.38	21.90	63.03
14	ICGV-15311	47.60	42.20	31.19	3.69	3599.88	26.94	63.69
15	TAG-24 (C)	33.87	28.73	28.10	2.93	1825.23	14.41	46.72
16	Phule Unnati (C)	47.90	42.57	33.97	3.72	2852.20	28.69	66.58
	Mean	39.09	34.11	29.51	3.14	2141.28	17.18	50.30
	S.E.±	2.057	2.024	0.870	0.092	144.850	1.021	3.008
	C.D. at 5%	5.940	5.846	2.513	0.264	418.357	2.948	8.686

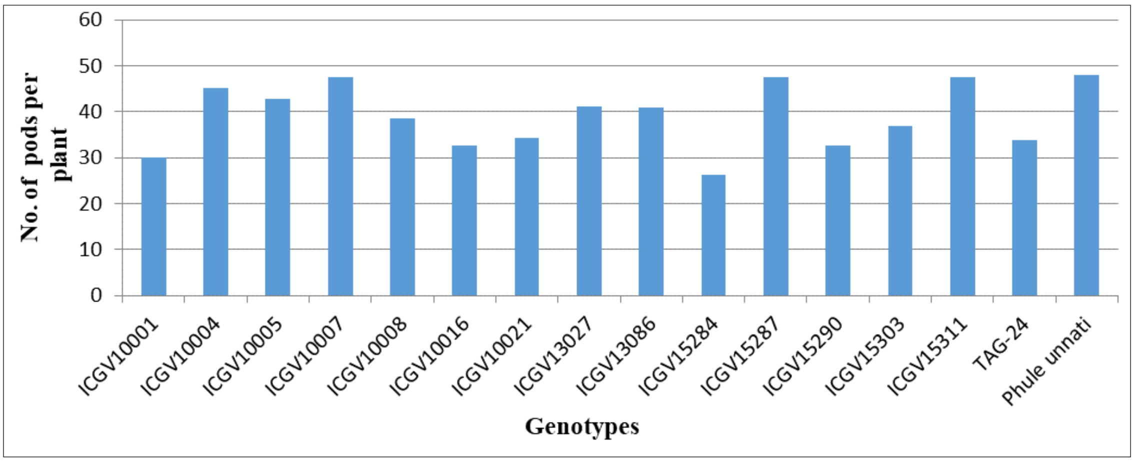

Fig 1: Groundnut genotypes performance in terms of total number of pods per plant

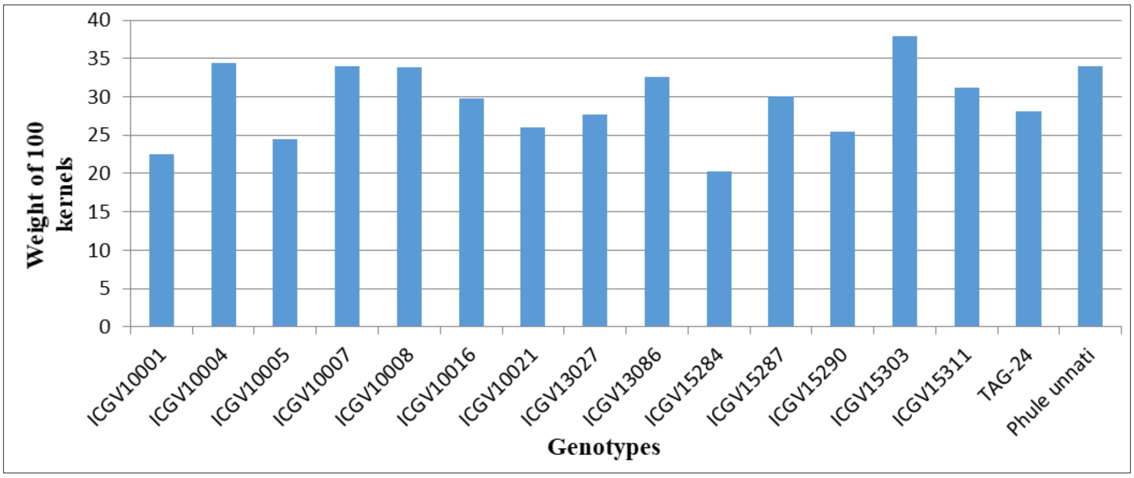

Fig 2: Groundnut genotypes performance in terms of 100 kernels weight (g) per plant

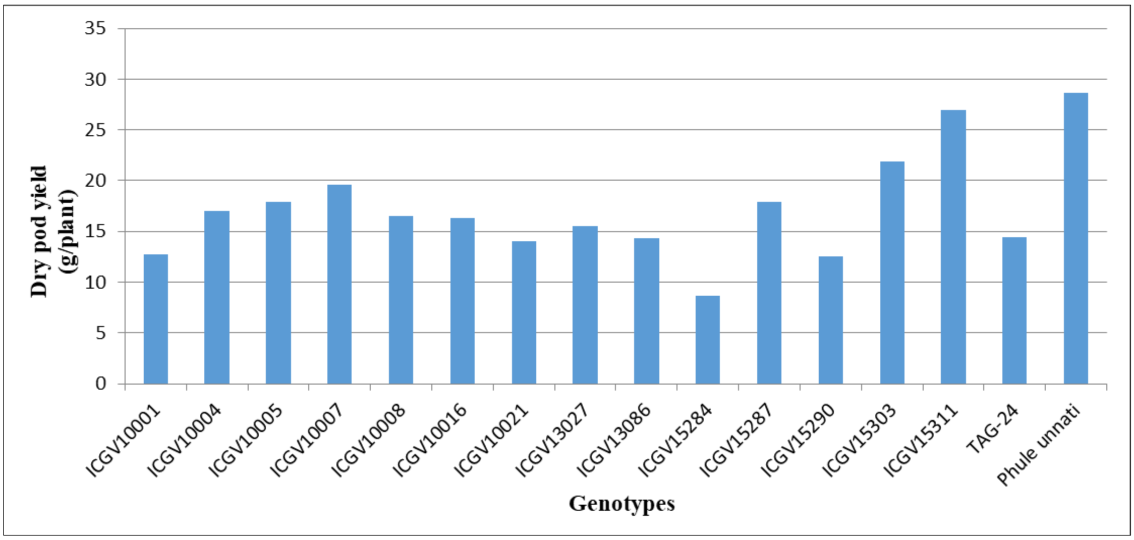

Fig 3: Groundnut genotypes performance in terms of dry pod yield (g) per plant

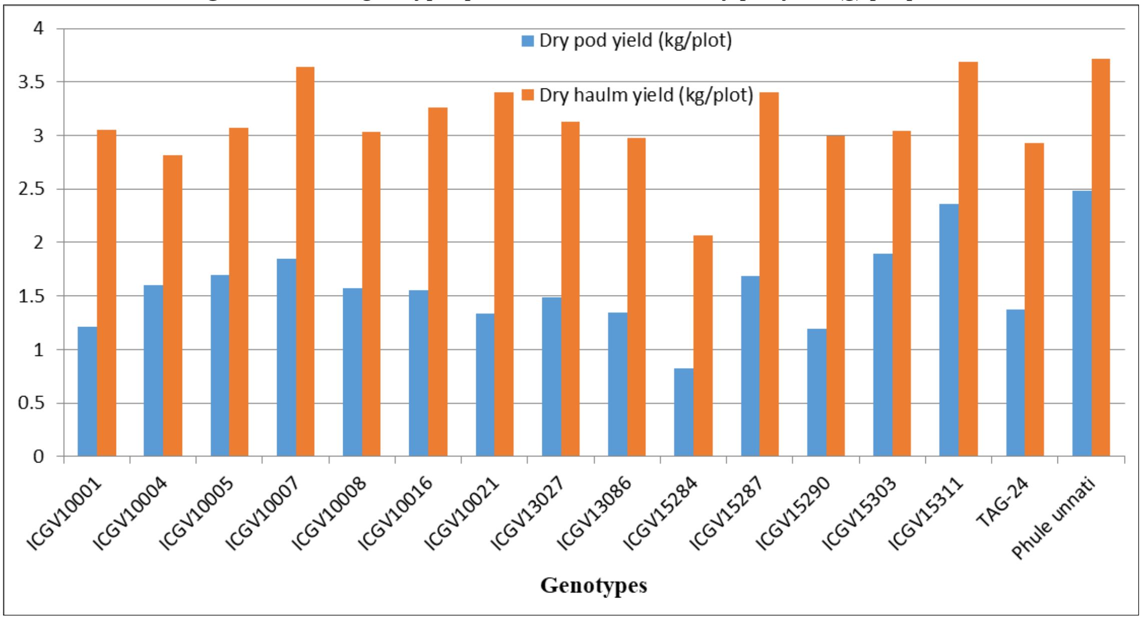

Fig 4: Groundnut genotypes performance in terms of dry pod yield (kg/plot) and dry haulm yield (kg/plot).

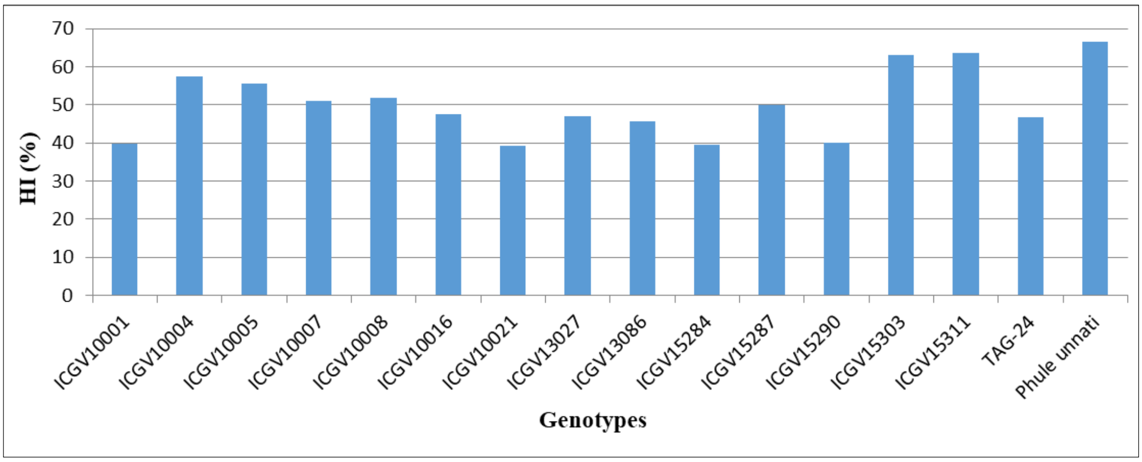

Fig 5: Groundnut genotypes performance in terms of harvest index (%)

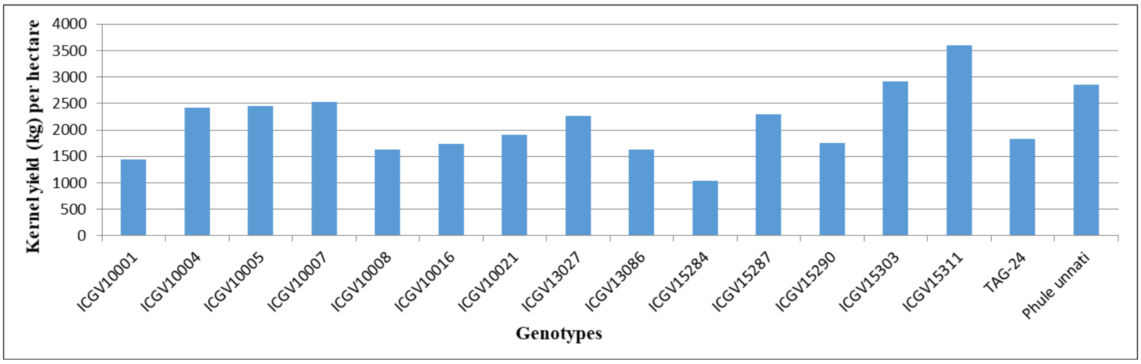

Fig 6: Groundnut genotypes performance in terms of kernel yield (kg/ha)

Table 4: Correlation coefficient between different morphological, growth, phenological, physiological and yield and yield attributes of groundnut genotypes

Characters	Plant height (cm)	Number of primary branches	Number of secondary branches	Leaf area (dm^2)	Days to 50% of flowering	Days to maturity	Total number of pods	Number of mature pods	100 kernels weight (g)	Dry haulm yield (kg/plot)	Kernel yield (kg/ha)	Protein content (%)	Oil Content (%)	Dry pod yield per plant
Plant height (cm)	1.000	-0.519	-0.399	0.233	-0.525	-0.576	-0.111	-0.016	0.207	-0.045	-0.115	-0.303	-0.419	-0.138
Number of	-0.519	1.000	0.916**	0.223	0.596*	0.572*	0.730**	0.691**	0.463	0.673**	0.747**	0.405	0.658*	0.839**

primary branches													*	
Number of secondary branches	-0.399	0.916**	1.000	0.265	0.439	0.464	0.635**	0.611*	0.427	0.545*	0.695**	0.354	0.677**	0.808**
Leaf area	0.223	0.223	0.265	1.000	0.101	-0.114	0.040	0.064	0.405	0.348	0.443	0.242	0.273	0.533*
Days to 50% of flowering	-0.525	0.596*	0.439	0.101	1.000	0.899**	0.358	0.379	0.086	0.345	0.162	0.168	0.267	0.391
Days to maturity	-0.576	0.572*	0.464	-0.114	0.899**	1.000	0.416	0.430	0.024	0.337	0.106	0.158	0.248	0.332
Total number of pods	-0.111	0.730**	0.635**	0.040	0.358	0.416	1.000	0.985**	0.619*	0.679**	0.773**	0.141	0.269	0.753**
Number of mature pods	-0.016	0.691**	0.611*	0.064	0.379	0.430	0.985**	1.000	0.589*	0.702**	0.735**	0.117	0.195	0.753**
100 kernels weight (g)	0.207	0.463	0.427	0.405	0.086	0.024	0.619*	0.589*	1.000	0.453	0.579*	0.376	0.535**	0.654**
Dry haulm yield (kg/plot)	-0.045	0.673**	0.545*	0.348	0.345	0.337	0.679**	0.702**	0.453	1.000	0.680**	0.229	0.330*	0.752**
Kernel yield (kg/ha)	-0.115	0.747**	0.695**	0.443	0.162	0.106	0.773**	0.735**	0.579*	0.680**	1.000	0.138	0.333	0.899**
Protein (%)	-0.303	0.405	0.354	0.242	0.168	0.158	0.141	0.117	0.376	0.229	0.138	**1.000**	0.714**	0.314
Oil (%)	-0.419	0.658**	0.677**	0.273	0.267	0.248	0.269	0.195	0.535**	0.330*	0.333	0.714**	**1.000**	0.452
Dry pod yield (g/plant)	-0.138	0.839**	0.808**	0.533*	0.391	0.332	0.753**	0.753**	0.654**	0.752**	0.899**	0.314	0.452	**1.000**

* Significance at P = 5 and ** significance at p = 1 level of significant

Conclusion

In current research, the morphological characters *viz*., plant height (cm), number of primary branches and secondary branches plant^{-1}, number of leaves plant^{-1}, leaf area (dm^2) plant^{-1} are mainly responsible for growth in groundnut

The genotype Phule unnati, ICGV- 15303 and ICGV-15311 recorded highest dry pod yield may be due to highest number of primary and secondary branches per plant, higher total dry matter (g) per plant, pod dry matter partitioning percent, mature pods per plant, 100 kernels weight and harvest index (%).

The genotypes ICGV-15311 and ICGV-15303 recorded highest rate of physiological processes is higher yielding.

It is observed in the present study, that genotypes, ICGV-15311 and ICGV-15303 showed better performance in all parameters after Phule unnati therefore, these may employ for heterosis in further breeding programme

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