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Research Article

Physiological Analysis of Growth and Yield Variation in Groundnut (*Arachis hypogaea* L.)

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Abstract
The experiment was conducted during *Summer* 2016 at experimented field of Oilseed Research Unit, Dr. PDKV, on twenty four different groundnut genotypes of different habit group (Spanish, Virginia and Valencia). The experiment was laid out in Randomized Block Design in three replications. The physiological and growth parameter like leaf area, total dry matter production, RWC% and total chlorophyll content was recorded periodically. The yield and yield attributes were recorded at harvest replication and treatment wise. The significant differences among the genotypes was observed for total dry matter production, crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR) and absolute growth rate (AGR) at various stages of growth played an important role in yield determining processes. The values of these growth parameter increased between 60 and 80 DAS and declined thereafter towards maturity. The genotype AK 303 recorded highest CGR. The genotype TAG 24 recorded significantly higher and genotype JL 776 recorded lower RGR. The genotype AK 350 recorded maximum and genotype Chico recorded lower AGR. The genotype TAG 24 and AK 335 recorded highest NAR at reproductive stage and also higher in yield production. The genotype TAG 24 and AK 335 recorded highest no. of pod per plant and genotype AK 303 recorded lowest no. of pod per plant. The genotype AK 303 recorded highest 100-kernel weight. The highest dry pod yield was recorded by the genotypes TAG 24 and AK 335. These studies will be helpful in determination of physiological traits responsible for yield of groundnut.

Key words
Groundnut, growth parameters, physiological parameters

Introduction

Groundnut (*Arachis hypogaea* L.) is one of the important oilseed crop originated in Brazil. The botanical name of groundnut *Arachis hypogaea* L. is derived from two Greek words *Arachis* and *hypogaea*, *Arachis* means a legume and *hypogaea* means below ground referring to the geographic nature of pod formation. It has been described as nature master piece of food values containing 36 to 54 per cent oil with 24-26 per cent protein and has an energy value of 2,363 KJ/100g.

The partitioning of photosynthesis to fruit during pod filling stage is the most influential physiological factor in yield determining of groundnut. The high yield is associated with rapid increase in pod number and near cessation of vegetative growth during pod filling. The yield depends on number of mature pods and 100 kernel weight, thus yield is the summation of the rate of fill for each fruit multiplied by the duration of its filling period. Most of the yield variation are due to difference in three physiological processes; the partitioning of assimilate between vegetative and reproductive parts, the length of the filling period, and the rate of fruit establishment.

The growth analysis techniques help in understanding, growth pattern and contribution of various plant parts to economical yield. It also helps in finding out yield contributing characters. Thus, growth analysis forms the basis for manipulation of productivity of the crop. The yield of groundnut is largely influenced by the partitioning of assimilates between reproductive and vegetative parts. The growth parameter like absolute growth rate (AGR), crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) contributing the higher yield in groundnut. AGR is the function of amount of growing material present and is influenced by the environment. These growth parameters are greatly influenced by stage of growth and genotypes.

There are two physiological approaches to achieve the target of yield potential. One is physio-genetic, which consists the genotypic differences in physiological traits and another one is the physio-agronomic relates with the management practices. It is ultimately the morpho-physiological variations, which is important for realizing higher productivity as evident from very high and positive association within these traits (Mathur, 1995). Therefore, the present study was undertaken with the objectives to evaluate the physiological, biochemical, growth parameters and yield and yield attribute of groundnut genotypes.

Materials and methods

The experiment was carried out on the experimental field of Oilseed Research Unit, Dr. P.D.K.V., Akola during summer season of 2016. The sowing was done by dibbling method on 28th

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January 2016 by adopting 30 x 10 cm spacing. In the present investigation an attempt has been made to evaluate 24 groundnut genotype of different habit group (Spanish bunch, Virginia bunch and Valencia bunch) for physiological, growth parameter, yield and yield component traits. Observation were recorded on randomly selected five plants on specific days of interval for physiological traits like RWC % and canopy temperature (°c). The observations on leaf area, LAI, dry matter production were recorded at specific days of interval. The growth parameter *viz.,* CGR equation worked out by Blackman (1919) and Watson (1958), RGR given by Fisher (1921) and NAR was calculated by the formula of Radford (1967) were analyzed at various stages of growth. Total leaf chlorophyll content was estimated DMSO method. The leaf area was measured on automatic leaf area meter (model CI 37, 203, CID Inc. USA.). Yield and yield contributing characters were recorded while attaining the physiological maturity on randomly selected five plants. The data were analyzed by adopting the method suggested by Panse and Sukhatme (1954).

Results and discussion

The vegetative phase governs the overall phenotypic expression of the plant and prepares the plant for next important reproductive phase. The root, stem, branches and leaves, all these parts constitute vegetative phase and perform specific functions. In the present investigation, the assimilatory surface of plant measured in terms of leaf area (LA) in dm2 at various stages given in (Table 1). The genotype AK 303 (16.63 dm2/plant) was Virginia type genotype and recorded significantly highest LA at all the stages. Photosynthetic capacity of the plant is a function of leaf area development which could be probably due to increased assimilatory surface at all subsequent growth stages reported by Borkar and Dharanguttikar (2014) in groundnut.

Assimilatory surface area over per unit ground area gives a fairly good idea of photosynthetic capacity of the plant. It was observed that LAI increased with crop age. LAI was the useful parameter not only for dry matter production but also for predicting the efficiency of photosynthetic system. In present investigation, LAI of all the genotype increased significantly. The genotype AK 303 (5.54) showed highest leaf area index at all the growth stages and the genotype AK 343 (3.97) recorded lowest leaf area index at harvest. The genotype earlier studies made elsewhere also indicated similar observations with particular reference to groundnut reported by Jagtap *et al*. (2014).

Dry matter is an important criterion to determine the source-sink relationship and depends upon the net gain in the processes on anabolism and catabolism of plant. The increase in total dry matter could be due to the increase leaf area, leaf area index and plant height. It was observed that total dry matter was less up to juvenile stage and then increases with the age of the plant. The increase in total dry matter could be due to the increase leaf area, leaf area index and plant height. The genotype AK 303 (30.63 g/plant) was continually highest total dry matter production and the genotype Chico (16.57 g/plant) produced lowest total dry matter in all stages. The genotypic differences with respect to total dry weight was also reported by Tamilselvi *et al.* (2015).

The physiological parameters influenced by groundnut genotypes are presented in Table 2. The genotype ICGV-06420 (79.97%) recorded significantly highest relative water content than Chico (66.06%) recorded significantly lowest relative water content followed by AK 159 (70.59%) and AK 345 (71.24%). The genotype ICGV-06420 and TG 68 had the highest RWC and should be a promising parent for drought resistance breeding programmes. Similar result reported by Painnawadee *et al*. (2009) and Kalariya *et al.* (2015). The genotype ICGV 06420 (35.82 ^{0}c) and TG 68 (36.98 ^{0}c) recorded significantly lowest canopy temperature. From the available genotypes ICGV-06420 and TG 68 recorded the lowest canopy temperature at reproductive stage, showing the potential trait for drought resistant and can be used as potential donor parent in breeding programme.

Groundnut varieties had significant influence on total chlorophyll content during the seasons. The genotype TAG 24 (1.90 mg/g) and AK 335(1.77 mg/g) was recorded the higher chlorophyll content and also recorded highest pod yield per plant, chlorophyll content is one of the important factors responsible for better yield. Similar result reported by Jagtap *et al*. (2014). The mean for oil content was recorded to be 48.18%. Valencia group of groundnut genotype recorded lowest oil content than Virginia bunch and Spanish bunch. The genotype AK 159 (50.24%) recorded highest oil content among the genotypes and genotype AK 350 (46.75%) recorded lowest oil content. Similar result reported by Borkar and Dharanguttikar (2014).

Growth analysis is one of the measures for accessing the seed yield of the plant. The physiological basis of yield difference can be measured through an evaluation of difference in growth parameters and their impact on yield. The productivity of crop may be related with the parameters such as CGR, AGR, RGR, NAR and partitioning of total photosynthates into economic and non-economic sink.

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The CGR values indirectly represented the leaf area and crop DMP in these genotypes. The LAI and crop DMP were also observed to be the highest in genotype AK 303 (0.356 g/day) and this genotype recorded highest CGR at vegetative stage. At reproductive stage the genotype AK 335 (0.187g/day) and TAG 24 (0.184 g/day) recorded highest CGR. Crop growth rate was minimum at 40-60 DAS and increased subsequently upto 60-80 DAS found maximum in that stage and decline towered harvesting. Similar results were also reported by Kathirvelan and Kalaiselvan (2006) in groundnut.

Relative growth rate was increased in plant material per unit time. At 60-80 DAS interval, the genotype AK 303 (0.017 g/g/day) recorded significantly higher RGR. At 80 DAS - at harvest interval, the genotype TAG 24 (0.010 g/g/day) recorded significantly higher RGR. Mean RGR was found lowest in 40-60 DAS, highest in 60-80 DAS and again it decreased at 80 DAS - at harvest in present investigation. Similar results were also reported by Sahane *et al.* (1994).

The increment of AGR was observed till 80 DAS and thereafter decreased with progress to maturity. The maximum AGR was observed during flowering and pod development stages (60-80 DAS) of all the genotypes. At 80 DAS- at harvest interval, the genotype AK 350 (0.238 cm/day) record maximum AGR and genotype Chico (0.024 cm/day) recorded lower RGR. Similar results were also reported by Jagtap *et al*. (2014) the AGR was minimum during early vegetative stage and increased with the onset of reproductive phase and again decline at harvest. Result in the line of 00 24 (0.017 g/dm^2/day) and AK 335 (0.016 g/dm^2/day) were recorded significantly higher NAR (Table 3). The NAR had positively significant relationship with leaf area, leaf area index, total dry matter production and total chlorophyll content. Mean NAR was found lowest in 40-60 DAS, highest in 60-80 DAS and again it decreased at 80 DAS - at harvest. The genotype TAG 24 and AK 335 was recorded highest NAR at reproductive stage and also higher in yield production. Similar results were reported by Sahane *et al.* (1994) and Jagtap *et al.* (2009). The data on pod yield and yield contributing characters are presented in Table 2. The genotype TAG 24 (16.36), AK 335 (14.97), AK 265 (13.67), JL 501 (13.53) and AK 358 (13.44) recorded significantly superior over mean value. The genotype AK 303 (6.13) recorded significantly lower no. of pod per plant over mean value (Table 2). The number of pods per plant is genetically controlled phenomenon. The variation in number of pods per plant amongst the genotypes may be due to genetic factor responsible for dry matter production likewise various physiological process like CGR, RGR, NAR, dry pod yield and harvest index were also responsible. Number of pods per plant contributed to the yield of plants. The genotype TAG 24 and AK 335 recorded highest no. of pod per plant and genotype AK 303 recorded lowest no. of pod per plant. Similar result reported by Jagtap *et al.* (2009). The genotype AK 303 (59.67 g) recorded highest 100 kernel weight. Significant variation among the genotypes for 100 kernel weight were also reported by Jahangir *et al*. (2016).

The highest dry pod yield was recorded by the genotypes TAG 24 (12.27 g) and AK 335 (11.87 g) due to significant favorable yield contributing characters like number of pods per plant, harvest index and the physiological efficiency of plant, partitioning NAR, CGR, total chlorophyll content etc. Similar type of results were also reported Sahane *et al.* (1994), Kathirvelan and Kalaiselvan (2006) Jagtap *et al.* (2009), Jagtap *et al*. (2014) and Borkar and Dharanguttikar (2014) in groundnut.

5 (45.31%) recorded significantly superior harvest index over mean value (Table 2). Harvest index represents the ultimate partitioning of dry matter in seed (economic yield). It is also proportion of biological yield represented by economic yield. HI reflect the proportion of assimilate distribution between the economic yield and total biomass (Donald 1976). The lowest and the highest harvest index (%) being in genotypes AK 303 (35.24 %) and TAG 24 (50.34 %), respectively similar result reported by Kamshette *et al.* (2015).

The significant differences among the genotypes for total dry matter production, CGR, RGR, NAR and AGR at various stages of growth played an important role in yield determining processes. The values of these growth parameter increased between 60 and 80 DAS and declined thereafter towards maturity. The LAI and crop DMP were also observed to be the highest in genotype AK 303 and this genotype recorded highest CGR. The genotype TAG 24 (0.010 g/g/day) recorded significantly higher RGR. The genotype AK 350 (0.238 cm/day) record maximum AGR. The NAR was positively significant relationship with leaf area, leaf area index, total dry matter production and total chlorophyll content. The genotype TAG 24 and AK 335 was recorded highest NAR at reproductive stage and also higher in yield production.

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Table 1. Vegetative growth influenced by groundnut genotypes.

SI.NO.	Genotypes	Leaf area (dm^2/plant)			Leaf area index			Total dry matter production (g/plant)		
		60DAS	80DAS	At harvest	60DAS	80DAS	At harvest	60DAS	80DAS	At harvest
1	AK 265	9.74	10.88	13.31	3.25	3.63	4.44	12.80	18.40	23.88
2	AK 303	10.62*	13.34*	16.63*	3.54*	4.38*	5.54*	16.49*	23.60*	30.63*
3	TAG 24	8.32	10.44	13.78	2.77	3.48	4.59	12.55	17.92	25.28
4	JL 776	7.62	9.92	14.10	2.54	3.31	4.70	13.85	18.79	23.47
5	JL 501	7.60	10.69	13.78	2.53	3.56	4.59	14.61	19.49	26.45
6	AK 159	8.04	10.22	13.62	2.68	3.41	4.54	11.74	16.32	22.58
7	TG 68	7.10	9.98	14.12	2.37	3.31	4.71	13.69	18.17	24.40
8	TG 70	7.56	9.93	13.22	2.52	3.31	4.41	11.30	16.02	22.03
9	TG 75	7.36	10.10	12.15	2.45	3.37	4.04	13.62	18.31	24.27
10	AK 340	7.49	9.84	13.51	2.50	3.28	4.51	11.98	16.60	22.40
11	AK 343	6.62	9.87	11.93	2.21	3.29	3.97	11.25	15.31	19.50
12	AK 345	7.79	10.15	13.04	2.60	3.38	4.35	14.18	19.18	24.95
13	AK 350	9.39*	12.28	14.55	3.13	4.09	4.85	13.03	17.82	24.07
14	AK 355	9.04*	11.00	14.07	3.01	3.67	4.96*	12.71	17.88	24.67
15	AK 358	8.49	12.38	14.61	2.83	4.13	4.87	14.73	20.75*	27.90*
16	AK 359	8.46	10.36	13.84	2.81	3.45	4.61	15.21	20.73*	27.08
17	AK 360	8.76	10.83	13.02	2.92	3.61	4.34	13.92	18.32	24.00
18	Dh 86	8.43	10.53	14.21	2.81	3.51	4.74	14.09	18.41	24.71
19	AKG 18-1	9.34	12.34	15.02*	3.11	4.11	5.00	14.64	19.89	26.13
20	Chico	7.55	11.01	12.24	2.51	3.67	4.08	8.65	12.25	16.57
21	PKVG-8	8.66	10.78	14.01	2.88	3.59	4.67	13.12	17.65	23.95
22	AK 335	8.42	10.47	14.38	2.81	3.49	4.80	14.52	19.42	26.88
23	TAG 14-73	8.96*	10.97	12.80	2.99	3.66	4.26	13.39	18.17	23.79
24	ICGV-06420	7.90	12.14	14.64	2.63	4.08	4.88	13.01	18.43	25.42
	Mean	**8.30**	**10.85**	**13.77**	**2.77**	**3.62**	**4.59**	**13.29**	**18.24**	**24.38**
	SE(m) ±	0.637	0.651	0.631	0.212	0.217	0.210	0.78	0.73	1.23
	CD at 5 %	1.818	1.858	1.803	0.606	0.619	0.601	2.23	2.09	3.51

* Indicates significantly superiority over mean value.

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Table 2. Biochemical, Physiological yield contributing parameters influenced by groundnut genotypes.

SI.NO.	Genotype	No. of pod/ plant	100 kernel weight (g)	Pod yield/plant (g)	Harvest index %	Relative water content (%)	Total Chlorophyll content (mg/g)	Canopy temperature (^{0}c)	Oil content %
1	AK 265	13.67*	43.33	9.37	39.14	76.14	1.67	39.07	49.11*
2	AK 303	6.13	59.67*	10.77	35.24	76.49	1.75	37.67	48.23
3	TAG 24	16.36*	43.67	12.27*	50.39*	74.05	1.90	39.53	47.99
4	JL 776	12.49	46.00	9.49	40.40	73.00	1.16	38.47	47.44
5	JL 501	13.53*	35.00	10.70	40.46	74.31	1.74	39.09	47.70
6	AK 159	12.16	43.67	8.65	38.29	70.59	1.57	38.69	50.24*
7	TG 68	10.51	44.33	9.17	37.47	78.07	1.62	36.98*	47.06
8	TG 70	9.65	48.00	8.47	38.47	72.14	1.37	39.21	47.68
9	TG 75	10.70	41.67	9.30	38.27	77.13	1.52	38.61	47.58
10	AK 340	10.47	43.33	9.10	40.66	77.18	1.46	39.31	47.46
11	AK 343	9.23	41.67	7.24	37.07	74.85	1.25	40.18	46.86
12	AK 345	10.57	42.67	9.13	36.73	71.24	1.76	41.10	49.75*
13	AK 350	8.20	38.67	8.74	36.42	73.49	1.15	42.79	46.75
14	AK 355	8.60	38.33	9.13	37.02	71.96	1.39	42.59	46.95
15	AK 358	13.44*	44.00	10.61	38.17	75.21	1.06	38.73	48.68
16	AK 359	14.15	38.00	10.90	40.25	77.54	1.76	39.96	48.95
17	AK 360	13.34	48.67*	9.37	39.15	73.75	1.74	37.40	49.77*
18	Dh 86	11.57	46.33	10.53	42.66	74.49	1.74	40.00	48.66
19	AKG 18-1	13.33	45.67	9.70	37.38	74.81	1.75	38.72	48.21
20	Chico	6.73	32.67	5.33	36.82	66.06	0.70	42.84	48.40
21	PKVG-8	12.33	45.67	10.03	41.90	77.40	1.57	38.56	48.28
22	AK 335	14.97*	40.67	11.87*	45.31*	76.56	1.77	39.88	47.01
23	TAG14-73	13.23	49.33*	9.37	39.33	76.72	1.36	40.69	47.61
24	ICGV-06420	12.25	46.00	9.75	36.32	79.97*	1.74	35.82*	50.00*
	Mean	**11.57**	**43.62**	**9.54**	**39.31**	**74.74**	**1.50**	**39.07**	**48.18**
	SE(m)±	0.66	1.684	0.55	1.65	1.66	0.16	0.72	0.178
	CD at 5 %	1.87	4.810	1.58	4.72	4.74	0.46	2.06	0.509

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Table 3. Growth parameters influenced by groundnut genotypes

SI.NO.	Genotypes	Crop growth rate (g/day)		Relative growth rate (g/g/day)		Absolute growth rate (cm day^{-1})		Net assimilation rate (g/dm^2/day)	
		60-80 DAS	80-at harvest	60-80 DAS	80-at harvest	60-80 DAS	80-at harvest	60-80 DAS	80-at harvest
1	AK 265	0.279*	0.137	0.016	0.008	0.359	0.121	0.028	0.012
2	AK 303	0.356*	0.176	0.017*	0.008	0.397*	0.139	0.031*	0.013
3	TAG 24	0.269*	0.184	0.015	0.010*	0.286	0.117	0.029*	0.017*
4	JL 776	0.247	0.117	0.014	0.006	0.304	0.122	0.029*	0.013
5	JL 501	0.244	0.174	0.013	0.009*	0.298	0.130	0.027	0.015
6	AK 159	0.229	0.156	0.015	0.009*	0.298	0.158	0.025	0.014
7	TG 68	0.224	0.156	0.013	0.008	0.325	0.129	0.026	0.014
8	TG 70	0.236	0.150	0.015	0.009*	0.221	0.157	0.028	0.014
9	TG 75	0.235	0.149	0.013	0.008	0.276	0.174	0.027	0.015
10	AK 340	0.231	0.145	0.014	0.009*	0.188	0.123	0.028	0.013
11	AK 343	0.203	0.105	0.013	0.007	0.185	0.129	0.025	0.011
12	AK 345	0.250	0.144	0.013	0.007	0.253	0.115	0.028	0.014
13	AK 350	0.239	0.156	0.015	0.009*	0.385	0.238	0.022	0.015
14	AK 355	0.259	0.170	0.015	0.009*	0.399*	0.189	0.026	0.015
15	AK 358	0.301*	0.179	0.015	0.008	0.288	0.142	0.029*	0.015
16	AK 359	0.273*	0.159	0.013	0.008	0.227	0.173	0.029*	0.015
17	AK 360	0.220	0.142	0.012	0.008	0.334	0.110	0.022	0.013
18	Dh 86	0.216	0.158	0.013	0.008	0.257	0.122	0.024	0.014
19	AKG 18-1	0.263	0.156	0.013	0.008	0.324	0.156	0.025	0.012
20	Chico	0.180	0.108	0.014	0.008	0.199	0.024	0.024	0.010
21	PKVG-8	0.227	0.157	0.014	0.009*	0.255	0.160	0.023	0.014
22	AK 335	0.245	0.187	0.013	0.009*	0.260	0.147	0.029	0.016*
23	TAG 14-73	0.239	0.141	0.013	0.008	0.237	0.193	0.024	0.013
24	ICGV-06420	0.271*	0.175	0.015	0.009*	0.295	0.215	0.026	0.014
	Mean	**0.247**	**0.153**	**0.014**	**0.008**	**0.285**	**0.144**	**0.026**	**0.014**
	SE(m) ±	0.017	0.013	0.001	0.000	0.038	0.037	0.001	0.001
	CD at 5 %	0.049	0.036	0.003	0.001	0.110	NS.	0.003	0.002

N.S. – Non- significant * Indicates significantly superiority over mean value.