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RESEARCH PAPER

Morpho-physiological characterization of chickpea (*Cicer arietinum* L.) genotypes

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Abstract : Thirty two chickpea genotypes were evaluated in RBD with two replications at Mahatma Phule Krishi Vidyapeeth, Rahuri, dist. Ahmednagar (M.S.) during *Rabi*, 2009 for Morpho-physiological characterization. The observations on different plant characters such as morphological, physiological, dry matter accumulation and partitioning, phenological and generative growth and sink capacity were recorded. Partitioning of total dry matter between the vegetative and reproductive plant parts played an important role in determining processes. Studies on leaf area revealed a good indicator for increasing photosynthetic efficiency of plant. The photosynthetic rate, transpiration rate and stomatal conductance were highest at 50 per cent flowering and decreased after 15 days of 50 per cent flowering. The highest yield was recorded by the genotypes, Digvijay, Vijay, ICC-13219, ICC-15868, ICC-1579 and ICC-4593. The most important yield attributes were pod number per plant, grain number per pod and 100 seed weight. These appeared to be the most important characters to determine sink capacity. These genotypes exhibited appropriate behaviour for dry matter production and it's distribution in component parts of plant, rate of protosynthesis, transpiration, stomatal conductance and water use efficiency. Therefore, it can be concluded that the significant variation in yield could be seen in different genotypes due to their differential behaviour in respect of growth, development, phenology, dry matter production potential and translocation of photosynthates from source to sink. In high yielding genotypes the photosynthetic rate, number of pods per plant, seeds per pod, yield per plant, harvest index etc. were observed to be the major yield contributing characters.

Key Words : Morpho-physiological traits, Physiological parameters, Generative growth, Sink capacity

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INTRODUCTION

Among seed legumes, chickpea is an unique food grain consumed in the form of decorticated split cotyledons or as dhal flour (Besan), green leaves as vegetable (Sag). Seeds are also used as vegetable (Chhole). Nutritionally, it is a good source of proteins, carbohydrates, minerals and trace elements. It contains 20 to 26 per cent of proteins as against 6 to 12 per cent in cereals. The quality of protein is similar or better than other legumes. Chickpea also contains 62 per cent carbohydrates, 4 per cent fats and is rich source of calcium, copper, iron and niacin. It also contains vitamin A, B, C and essential fatty acids. It derives more than 70 per cent of nitrogen from symbiotic nitrogen fixation which makes it an important component of cropping system of the subsistence farmer's for alternative agriculture. Yield is a complex trait, governed by many traits and there are ample evidences to show that selections directly for grain yield in plants are not easy. Thus, any morphological character that is associated with higher seed yield or which makes a significant contribution to yielding ability would be useful in the improvement of grain yield. The basic studies on the basis of morpho-physiological traits are needed to overcome the yield barriers within the genotypes. The study on morpho-physiological variations is important for realizing higher productivity (Mathur, 1995). The dry matter accumulation and it's distribution, morpho-physiological

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traits, yield and yield contributing characters that the crop community produces is determined during this period and this number determines, in large part, the final grain yield. Therefore, the present study was undertaken with the objectives of morpho-physiological characterization of chickpea genotypes and it's relevance with yield potential of chickpea genotypes.

MATERIAL AND METHODS

Thirty two chickpea genotypes were evaluated in Randomized Block Desigh with two replications during *Rabi* 2009 at Post Graduate Institute Farm, Department of Agricultural Botany, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (M.S.). The plot size was 2.50 × 0.60 m^2 (2 rows) with the spacing of 30 × 10 cm. The basal dose of N: P: K @ of 25:50:0 $kgha^{-1}$ was given at the time of sowing. A pre-sowing and additional two irrigations were given at flowering and pod development stages, respectively. One hoeing and one hand weeding was done at 15 and 21 DAS. One spraying of heliokil and one spraying of spark were given for controlling the attack of pod borer at the flowering and at pod development stage, respectively. Randomly five plants were selected for recording the observations on morpho-physiological traits. The observations on morphological traits, dry matter production and it's distribution and physiological parameters and generative growth and sink capacity were recorded. The mean data analyzed for analysis of variance by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

The phenology of crop related with reproductive phase which initiates from the floral bud initiation. The events from the flowering of crop to the development of full matured embryonic seed in terms of period or days are the overall phenology of crop. Therefore, the characters *viz*., days to initiation of first flower and physiological maturity were depicted. The genotypes, Vijay (34.50) and ICC-13219 (35.50 days) required minimum days, whereas, the genotypes, ICC-5474 (47.10), ICC-16018 (46.40) and ICC-8386 (44.50) required maximum days for flower appearance. The genotype, Vijay (93.30), ICC-13219 (94.20), Digvijay (95.10) and ICC-15868 (95.70) required minimum whereas, ICC-5474 (106.40) ICC-16018 (105.30) and ICC-8386 (103.60) required maximum days to physiological maturity (Table 1). The vegetative phase governs the overall phenotypic expression of the plant and prepares the plant for next important reproductive phase. The plant height, branches and leaves, all these parts constitute vegetative phase and perform specific functions. The genotypes, Digvijay (43.50 cm), ICC-1579 (42.50 cm) and ICC-15868 (40.50 cm) were significantly superior over all other genotypes under study for plant height. The genotypes, Digvijay (9.070 dm^2), ICC-1579 (8.760 dm^2) and ICC-15868 (8.105 dm^2) maintained significantly maximum leaf area per plant than rest of the genotypes. The genotype, Vijay maintained higher number of primary (6.30) and secondary (25.30) branches per plant followed by ICC-15868 (5.52 and 24.40). Sarkar (1990) reported that plant height, pod number per plant and total dry matter production (TDMP) exhibited positive significant association with grain yield. The highly significant correlation values were obtained for yield with plant height by Bhardwaj and Singh (1972) and Katiyar *et al.* (1977). Ornan *et al.* (1977) showed the significant correlation between plant height and grain yield per plant.

In legumes, net photosynthesis is generally lower and, in chickpea, rates are generally less than 5 per cent of that in the subtending leaf (Leport *et al*., 1999 and Ma *et al*., 2001). However, in dicots, the role of photosynthesis in reproductive structures to reduce respiratory CO_2 loss has also been emphasized (Flinn *et al.*, 1977; Atkins *et al*., 1977; King *et al*., 1998 and Ma *et al.*, 2001). In the present investigation, Digvijay maintained higher rate of photosynthesis at 50 per cent flowering (27.45 µmol $m^{-2}sec^{-1}$) as well as at 15 days after 50 per cent flowering (12.86 µmol $m^{-2}sec^{-1}$). In addition to this, Vijay (27.25 and 11.80 µmol $m^{-2}sec^{-1}$), ICC-13219 (25.30 and 11.61 µmol $m^{-2}sec^{-1}$), ICC 15868 (25.75 and 11.83 µmol $m^{-2}sec^{-1}$) and ICC-1579 (24.20 and 11.54 µmol $m^{-2}sec^{-1}$) were found superior for rate of photosynthesis at both the stages of growth. The genotype ICC-16018 (15.55 and 7.73 µmol $m^{-2}sec^{-1}$) was inferior for rate of photosynthesis at both the stages of growth (Table 2). It is to be noted that the genotypes having higher rate of photosynthesis had lower rate of transpiration and higher stomatal conductance results into higher water use efficiencies. In the present study, the genotype, Digvijay maintained lower rate of transpiration at 50 per cent flowering (3.95 mmol $m^{-2}sec^{-1}$) as well as at 15 DAF (2.88 mmol $m^{-2}sec^{-1}$), whereas, ICC-16018 (7.95 & 5.62 mmol m^{-2} sec^{-1}) had higher rate of transpirationat both the stages of growth. Vijay (4.13 mmol m^{-2} sec^{-1}), ICC-13219 (4.38 mmol m^{-2} sec^{-1}), ICC-1579 (4.86 mmol m^{-2} sec^{-1}) and ICC-15868 (4.91 mmol m^{-2} sec^{-1}) were also recorded low transpiration rate at 50 per cent flowering. The genotype, Digvijay maintained higher stomatal conductance at 50 per cent flowering (1.635 µmol m^{-2} sec^{-1}) and 15 DAF (0.695 µmol $m^{-2}sec^{-1}$) whereas, ICC-16018 (0.338 and 0.224 µmol m^{-2} sec^{-1}) had least stomatal conductance. The genotypes, Digvijay (6.95 and 4.47), ICC-15868 (5.24 and 4.32) and Vijay (6.60 and 3.96) had higher water use efficiency, whereas, ICC-16018 (1.96 and 1.38) had lower water use efficiency at both the stages of growth.

All the physiological processes, both anabolic and catabolic result into a net balance or accumulation of dry matter and hence, the biological productivity of plants is judged from it's actual ability to produce and accumulate dry matter. In a sense, the growth of the plant is nothing but the progressive accumulation of dry matter. The genotype Digvijay maintained higher dry matter accumulation per plant in roots (1.780 g), stem (6.962 g), leaves (4.820 g) and pods

(14.870 g). In addition to this, Vijay, ICC-13219, ICC-11051 were found better for dry accumulation in component parts of plant (Table 3). As a result of higher dry matter accumulation in component parts of plant, the genotypes Digvijay (29.470 g) and Vijay (27.285 g) recorded higher dry matter production per plant. Mokhtassi-Bidgoli *et al.* (2007) reported higher dry

Table 1 : Morpho-physiological traits influenced by chickpea genotypes

Genotypes	Days to initiation of flowering	Days to physiological maturity	Plant height (cm)	Leaf area per plant (dm^2)	Number of primary branches	Number of secondary branches
ICC-7593	41.20	99.30	36.00	4.650	5.02	18.50
ICC-13219	35.50	94.20	39.20	7.405	5.25	21.30
ICC-13	44.25	102.40	32.00	5.630	4.05	18.30
ICC-15868	36.00	95.70	40.50	8.105	5.52	24.40
ICC-3453	42.20	101.30	35.75	7.025	4.50	21.12
ICC-659	37.40	98.80	34.00	6.775	5.00	18.05
ICC-485	38.20	100.30	32.50	4.760	4.02	14.10
ICC-1360	44.20	103.20	34.80	5.065	4.83	16.50
ICC-11039	42.50	102.40	35.25	5.685	4.20	13.20
ICC-16018	46.40	105.30	31.40	4.135	3.60	12.04
ICC-5474	47.10	106.40	32.33	5.075	3.80	14.00
ICC-2096	43.00	102.40	36.00	5.390	5.20	17.50
ICC-8386	44.50	103.60	31.20	4.465	4.16	14.13
ICC-15183	40.30	99.60	31.35	4.895	4.72	18.50
ICC-15888	37.50	97.30	35.50	4.680	4.25	18.50
ICC-93030	35.50	98.20	35.20	4.930	5.40	19.20
ICC-16982	44.30	101.90	33.20	7.195	4.62	15.33
ICC-923	37.30	97.20	35.36	4.800	5.30	16.00
ICC-5593	37.60	96.50	36.30	6.965	4.75	18.30
ICC-1579	36.20	95.80	42.50	8.760	5.20	24.30
ICC-4593	37.30	100.30	36.75	6.685	4.50	15.33
ICC-11051	38.50	98.20	34.20	6.110	5.30	16.22
ICC-15858	36.90	96.30	36.10	4.455	4.00	17.30
ICC-10945	42.50	99.40	33.25	5.965	4.70	22.30
ICC-122	43.70	100.10	34.23	6.770	4.50	17.50
ICC-409	37.30	97.30	32.80	6.455	5.00	20.23
ICC-437	43.50	99.60	35.20	5.900	4.60	21.00
ICC-1031	41.40	102.30	36.35	6.920	5.01	18.20
ICC-432	43.30	100.10	34.27	4.530	4.70	15.33
ICC-93008	42.20	102.40	36.25	6.720	4.35	14.50
Vijay	34.50	93.30	39.10	5.720	6.30	25.30
Digvijay	36.30	95.10	43.50	9.070	4.70	20.20
Mean	40.81	97.15	34.44	6.116	4.91	18.86
S.E. ±	1.08	1.04	1.17	0.536	0.37	1.11
C.D. (P=0.05)	3.11	3.01	3.38	1.549	1.06	3.22

matter accumulation, HI, seed weight and 1000-seed weight were found to be closely related to high yielding genotypes.

Yield is compound character and is sum of the contributions made by a number of physiological characters. To the Plant Scientists, it is the net economic gains from the source and sinks capacity. Yield improvements have been achieved through directional selections for yield contributing traits (Akbar and Kamran, 2006). In pulses, the pods/plant,

Table 2: Physiological parameters influenced by chickpea genotypes at various stages of growth

Sr. No.	Genotypes	Photosynthetic rate (μmol m^{-2} sec^{-1})		Transpiration rate (mmol m^{-2} sec^{-1})		Stomatal conductance (μmol m^{-2} sec^{-1})		Water use efficiency	
		I	II	I	II	I	II	I	II
1.	ICC-7593	23.75	10.40	5.25	4.76	0.566	0.480	4.52	2.18
2.	ICC-13219	25.30	11.61	4.38	3.08	1.114	0.643	5.78	3.77
3.	ICC-13	18.45	10.71	6.85	4.58	0.715	0.341	2.69	2.34
4.	ICC-15868	25.75	11.83	4.91	2.74	1.484	0.607	5.24	4.32
5.	ICC-3453	20.50	9.99	6.16	4.50	0.934	0.324	3.33	2.22
6.	ICC-659	19.10	9.96	6.41	4.34	0.641	0.427	2.98	2.29
7.	ICC-485	17.60	9.00	5.68	3.65	0.645	0.309	3.10	2.47
8.	ICC-1360	17.95	9.91	5.20	4.02	1.070	0.332	3.45	2.47
9.	ICC-11039	21.75	9.31	5.40	4.77	0.730	0.344	4.03	1.95
10.	ICC-16018	15.55	7.73	7.95	5.62	0.338	0.238	1.96	1.38
11.	ICC-5474	17.00	8.61	7.06	5.08	0.560	0.224	2.41	1.69
12.	ICC-2096	23.30	11.21	6.51	4.10	0.965	0.378	3.58	2.73
13.	ICC-8386	16.65	8.82	7.01	5.51	0.382	0.364	2.38	1.60
14.	ICC-15183	19.35	11.10	6.66	4.91	0.936	0.553	2.91	2.26
15.	ICC-15888	19.80	9.63	6.74	4.03	0.932	0.309	2.94	2.39
16.	ICC-93030	17.50	11.16	5.10	4.06	0.630	0.359	3.43	2.75
17.	ICC-16982	22.05	8.89	5.50	4.46	1.040	0.491	4.01	1.99
18.	ICC-923	16.75	9.80	6.18	5.45	0.790	0.557	2.71	1.80
19.	ICC-5593	19.10	9.98	6.18	4.51	0.624	0.588	3.09	2.21
20.	ICC-1579	24.20	11.54	4.86	3.64	1.291	0.595	4.98	3.17
21.	ICC-4593	23.60	9.85	4.96	3.53	0.901	0.591	4.76	2.79
22.	ICC-11051	24.05	10.95	5.98	4.38	0.852	0.400	4.02	2.50
23.	ICC-15858	23.70	8.38	6.08	3.87	0.567	0.315	3.90	2.17
24.	ICC-10945	23.15	11.31	5.04	4.48	0.897	0.480	4.59	2.52
25.	ICC-122	22.70	11.22	6.73	4.08	0.624	0.310	3.37	2.75
26.	ICC-409	20.40	9.46	6.41	4.10	0.695	0.308	3.18	2.31
27.	ICC-437	22.65	8.54	6.03	4.40	0.835	0.479	3.76	1.94
28.	ICC-1031	22.70	9.48	5.66	4.20	0.720	0.429	4.01	2.26
29.	ICC-432	20.20	10.02	5.39	4.34	0.595	0.354	3.75	2.31
30.	ICC-93008	17.85	9.42	5.45	4.15	0.655	0.304	3.28	2.27
31.	Vijay	27.25	11.80	4.13	2.98	1.491	0.671	6.60	3.96
32.	Digvijay	27.45	12.86	3.95	2.88	1.635	0.695	6.95	4.47
Mean		21.19	10.05	5.41	4.14	0.824	0.407		
S.E. ±		1.26	1.19	0.917	0.987	0.120	0.084		
C.D. (P=0.05)		3.64	N.S.	N.S.	N.S.	0.324	0.242		

I: At 50 % flowering, II: 15 days after 50 % flowering (DAF) N.S. = Non-significant

seeds/per pod and seeds/ plant have direct influence on the grain yield. In the present investigation, the genotypes, Vijay (86.00), ICC-13219 (85.02), ICC-3453 (71.33) and Digvijay (70.25) for pods per plant; Vijay (95.00), ICC-13219 (94.50), ICC-15868 (91.00) and ICC-1579 (87.00) for seeds per plant; Digvijay (24.22 g/100 seed), ICC-15868 (22.90 g/100 seed), ICC-13219 (22.40 g/

Table 3 : Dry matter production and it's distribution in component parts of plant influenced by chickpea genotypes

Sr. No.	Genotypes	Dry matter production (g)				
		Root	Stem	Leaves	Pods	Total
1.	ICC-7593	1.130	4.680	2.375	6.790	13.700
2.	ICC-13219	1.410	6.825	2.620	9.660	19.245
3.	ICC-13	1.280	2.050	1.275	7.455	12.060
4.	ICC-15868	1.350	4.975	2.455	12.440	19.440
5.	ICC-3453	0.890	3.820	1.560	9.030	15.300
6.	ICC-659	1.305	4.120	1.360	5.840	12.565
7.	ICC-485	1.100	2.540	2.620	6.035	12.295
8.	ICC-1360	1.005	3.080	2.295	6.565	12.950
9.	ICC-11039	1.025	5.780	1.445	9.580	18.030
10.	ICC-16018	0.835	2.030	0.625	5.185	9.575
11.	ICC-5474	0.860	2.610	1.325	6.195	12.010
12.	ICC-2096	1.220	3.180	2.445	7.780	14.625
13.	ICC-8386	1.230	3.720	2.102	6.670	13.120
14.	ICC-15183	1.155	2.275	2.165	6.305	11.895
15.	ICC-15888	0.865	3.272	1.865	7.345	14.650
16.	ICC-93030	1.015	2.890	1.455	6.095	11.455
17.	ICC-16982	1.065	4.040	2.475	8.300	15.515
18.	ICC-923	0.900	3.725	2.565	5.230	12.550
19.	ICC-5593	1.280	2.530	1.700	6.985	13.480
20.	ICC-1579	0.840	4.235	2.540	11.355	19.110
21.	ICC-4593	1.295	2.885	1.480	11.535	18.255
22.	ICC-11051	1.110	6.250	2.480	9.315	16.520
23.	ICC-15858	1.380	2.615	0.655	7.345	15.505
24.	ICC-10945	1.005	6.125	2.785	6.680	15.615
25.	ICC-122	1.315	5.145	2.455	7.915	17.460
26.	ICC-409	0.920	2.815	0.820	5.340	10.810
27.	ICC-437	0.900	2.230	1.780	7.055	12.120
28.	ICC-1031	1.185	4.137	2.146	7.055	15.185
29.	ICC-432	1.035	4.860	2.345	7.795	16.365
30.	ICC-93008	0.895	5.610	2.367	6.275	16.395
31.	Vijay	1.450	6.757	4.620	13.040	27.285
32.	Digvijay	1.780	6.962	4.820	14.870	29.470
	Mean	1.116	4.458	2.499	7.974	16.018
	S.E. ±	0.058	0.309	0.174	0.629	0.807
	C.D. (P=0.05)	0.166	0.892	0.503	1.816	2.331

Table 4: Yield and yield contributing characters influenced by chickpea genotypes

Sr. No.	Genotypes	Pods/ plant	Seeds/plant	Seeds/pod	100 seed wt (g)	Yield/ Plant (g)	Harvest index (%)
1.	ICC-7593	50.50	60.50	1.10	16.05	8.22	34.90
2.	ICC-13219	85.02	94.50	1.10	22.40	15.99	41.38
3.	ICC-13	77.17	78.50	1.00	18.45	11.75	36.52
4.	ICC-15868	65.00	91.00	1.90	22.90	15.66	40.90
5.	ICC-3453	71.33	76.33	1.00	17.05	10.49	37.13
6.	ICC-659	29.33	38.50	1.20	15.85	9.86	36.32
7.	ICC-485	25.50	25.50	1.40	16.35	10.96	38.01
8.	ICC-1360	60.32	80.25	1.60	16.45	10.80	37.47
9.	ICC-11039	49.25	41.75	1.20	16.36	8.24	32.11
10.	ICC-16018	15.30	17.50	1.10	13.16	7.01	30.40
11.	ICC-5474	15.00	16.50	1.20	15.62	7.32	31.93
12.	ICC-2096	41.52	65.00	1.10	18.30	10.76	35.94
13.	ICC-8386	28.50	28.50	1.30	14.40	7.75	32.05
14.	ICC-15183	45.33	48.50	1.00	19.65	9.13	34.52
15.	ICC-15888	54.05	51.50	1.20	16.75	10.91	37.19
16.	ICC-93030	50.50	56.33	1.30	20.15	8.00	34.10
17.	ICC-16982	36.30	60.00	1.90	20.27	10.17	35.57
18.	ICC-923	25.40	35.55	1.00	18.60	9.86	34.73
19.	ICC-5593	61.43	80.50	1.20	21.80	11.34	37.37
20.	ICC-1579	82.00	87.00	1.10	21.85	14.12	39.80
21.	ICC-4593	69.00	82.30	1.30	20.34	13.07	39.30
22.	ICC-11051	63.27	70.50	1.20	17.76	12.82	38.99
23.	ICC-15858	46.55	46.80	1.00	20.85	9.45	35.24
24.	ICC-10945	35.00	35.25	1.00	16.57	10.86	36.51
25.	ICC-122	18.00	35.30	1.70	20.40	12.04	37.53
26.	ICC-409	47.12	49.33	1.70	15.21	11.15	36.44
27.	ICC-437	51.50	52.25	1.40	17.47	8.85	32.14
28.	ICC-1031	64.25	69.50	1.10	18.21	12.80	38.51
29.	ICC-432	41.75	43.00	1.20	18.07	11.69	36.94
30.	ICC-93008	28.50	37.40	1.00	15.95	10.17	34.67
31.	Vijay	86.00	95.00	1.20	21.45	16.46	43.91
32.	Digvijay	70.25	70.50	1.20	24.22	16.31	44.56
	Mean	53.70	57.48	1.26	18.41	10.98	36.44
	S.E. ±	0.87	0.91	0.07	0.93	0.65	0.99
	C.D. (P=0.05)	2.50	2.62	0.21	2.68	1.88	2.85

100 seed) and ICC-5593 (21.80 g/100 seed) for bold seed size; Vijay (16.41 g), Digvijay (16.31 g), ICC-13219 (15.99 g) and ICC-15868 (15.66 g) for seed yield per plant and Digvijay (44.56%), Vijay (43.91%), ICC-13219 (41.38%) and ICC-15868 (40.90%) were promising for related characters (Table 4).

The genotypes, Digvijay, Vijay, ICC-13219 and ICC-15868 recorded the higher seed yield per plant as an account source and sink source. These genotypes exhibited significantly superior performance for morphological characteristics. The higher rate of dry matter accumulation and it's distribution in component parts of plant, higher rate of photosynthesis, lower rate of transpiration, higher stomatal conductance and higher water use efficiency are the important characteristics of these genotypes. In consideration to this interference, the genotypes performing for better morpho-physiological traits were better for further physio-genetic studies. Therefore, the genotypes, Digvijay, Vijay, ICC-13219 and ICC-15868 may be considered as for future breeding programme for improvement in physiological point of view.

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