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RESEARCH PAPER

Pattern of assimilate partitioning in chickpea (*Cicer arietinum* L.) cultivars for high yield

PRATIBHA KATIYAR
Department of Crop Physiology, Agricultural Biochemistry and Herbal Science, College of Agriculture, Indira Gandhi Krishi Vishwa Vidyalaya, RAIPUR (C.G.) INDIA (Email : pratibhakatiyar@redifmail.com)

Abstract **:** Twenty divergent cultivars of chickpea (*Cicer arietinum* L.) grouped into four categories on the basis of seed index ranged between 12-24 g were tested in field conditions in *Rabi* season in RBD replicated thrice at IGAU, Raipur (C.G.) to study the variability in pattern of assimilate partitioning for high yield. The highest magnitude of genotypic variation was observed for seed yield per plant. The study revealed that the cultivars with higher in CGR, HI, seed index, chlorophyll b and total chlorophyll content at flowering stage, sugar content in seed, lesser nodes and branches per plant and higher pods per plant had the significantly higher economic yield. The results elucidated the number of primary and secondary branches per plant, pod bearing length, effective secondary branches were not affected by seed index. The low test weight cultivars had higher seed yield per unit area. However, the optimum filling stages showed significant impact in assimilate partitioning and economic yield in low and medium seed index cultivars. Higher chlorophyll a, b and total chlorophyll content at flowering stage and lesser nodes and more productive secondary branches per plant contributed significant impact on seed yield.

Key Words **:** DAS (days after sowing),LAI (leaf area index) , LAR (leaf area ratio), LWR (leaf weight ratio), SLA (specific leaf area), SLW (specific leaf weight), CGR (crop growth rate), HI (harvest index)

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INTRODUCTION

Chickpea is an important food legume widely consumed in Asia, the middle East and several mediterranean countries. Chhattisgarh state of India has good ecological conditions for chickpea production but the productivity of chickpea in the state is 528 kg/ha, which is very low in comparison to national average of 855 kg/ha. This gap needs more serious efforts to increase its productivity in the region (Rajput *et al.*, 2003). The study therefore, been planned to identify the morpho physiological traits to find out the pattern of assimilate partitioning in chickpea cultivars for high yield.

MATERIALS AND METHODS

The field experiment was conducted at instructional farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur (CG) in *Rabi* season 2006-07 using twenty cultivars of chickpea grouped in to three categories on the basis of seed index (Seed weight 100 seed) ranged between 12-24g. The experiment was conducted in RBD replicated thrice. The morpho physiological and biochemical observations were taken at different physiological stages of crop growth. Chlorophyll content of leaves was estimated (Yoshida *et al.*, 1972) at 45 and 60 DAS. Sugar content was estimated (Duboise *et al.,* 1951) at 60 and 90 DAS.

Protein content by Microkjeldhal method (AOAC, 1965) at maturity in seed. Growth analysis was done for measuring the LAI (Watson, 1947) LAR (Radford, 1967), LWR (Beadle, 1982), SLA (Kevt *et al.*, 1971), SLW (Beadle, 1982), CGR (Patter and Jones, 1977) and HI (Synder and Carlson , 1984). The morpho-physiological observations were taken at 30 (S I), 60 (S II) 75 (S III) 90 (S IV), 105 (S V) and at physiological maturity. Yield attributes were recorded at physical maturity (dead ripe stage).

RESULTS AND DISCUSSION

The efficient partitioning of photo assimilates towards

Table 1: Mean performance morphological and yield parameters of chickpea cultivars at maturity

Name of cultivars	Days to flower initiation	Days to maturity	Plant height	No. of nodes/ plant	No. of primary branches/ plant	No. of secondary branches/ plant	Pod bearing length plant	Effective secondary branches/ plant	No. of pods on primary branches/ plant	No. of pods on secondary branches/ plant	Total no. of pods/ plant	Pod weight/ m² (g)	Seed index (g)	Biological yield m² (g)	Seed yield m² (g)	Harvest index (%)
JG 1	44.66	120.00	64.21	29.03	3.51	3.94	20.75	2.73	11.70	7.77	19.47	90.57	16.37	289.66	68.10	23.51
JG 62	52.33	118.33	58.43	33.14	4.95	6.14	21.73	4.55	25.25	17.29	42.54	211.03	13.90	412.00	180.69	43.63
JG 74	52.33	117.00	55.97	29.35	3.09	5.86	21.83	4.21	27.41	19.22	46.63	243.55	14.34	502.00	204.63	40.77
JG 221	52.33	120.00	58.81	29.48	3.90	6.20	21.15	4.19	19.64	12.18	31.83	203.93	16.66	425.00	164.98	38.87
JG 315	51.00	120.66	63.70	33.95	3.73	7.00	22.99	4.64	26.32	14.17	40.50	229.50	15.07	473.00	188.64	39.86
JG 1007	51.33	117.00	60.13	31.49	5.03	10.48	24.14	7.42	18.96	9.27	28.23	112.80	17.94	206.00	93.00	45.54
JG 1258	49.33	120.00	55.81	30.62	4.10	7.17	19.81	5.25	22.55	11.81	34.36	174.86	15.28	388.66	145.80	37.63
JG 1260	51.66	119.66	56.36	31.70	4.03	5.30	20.36	3.92	22.14	12.70	34.84	184.10	12.95	364.00	153.33	42.09
JG 1262	48.66	120.66	53.14	27.62	3.62	6.56	18.69	4.70	15.22	17.81	33.03	196.60	12.83	393.00	161.66	41.03
JG 1263	52.66	120.00	65.65	31.31	3.59	5.96	21.97	4.18	22.17	13.93	36.10	198.86	15.72	400.33	169.84	42.31
JG 1264	51.33	119.33	58.10	30.22	3.47	5.49	19.29	4.07	11.81	10.77	22.58	179.41	22.72	378.00	132.45	35.01
JG 1265	52.00	114.66	62.18	31.99	4.51	6.63	21.92	4.87	25.29	17.18	42.47	203.78	16.17	375.66	162.69	43.33
J78 48	53.66	114.66	59.96	31.06	3.84	7.36	22.14	4.92	19.33	16.48	33.81	165.33	22.79	352.00	148.29	42.08
J78 44	53.33	117.66	57.81	31.07	3.62	6.40	21.03	4.95	19.84	14.66	31.17	186.52	23.70	364.00	153.95	42.53
J79 18	52.00	116.33	59.16	32.45	4.26	5.23	23.20	13.99	24.40	14.51	38.91	203.86	19.57	357.00	170.78	48.04
J79 27	52.66	120.66	55.77	30.18	3.77	7.64	20.81	5.14	17.22	15.55	32.77	179.76	15.37	403.00	145.50	36.04
J79 38	49.33	117.33	58.36	30.92	4.10	7.83	21.77	5.77	23.73	16.85	40.58	190.78	15.04	349.00	157.36	45.07
J80 5	55.33	118.00	53.29	32.36	6.62	6.44	24.40	5.96	22.73	9.77	32.50	128.60	17.03	249.33	95.72	38.54
H 355	50.00	116.66	55.64	31.35	3.23	4.80	20.02	3.87	23.98	13.09	37.07	196.43	13.52	382.33	159.35	41.75
BG 245	53.33	119.33	56.40	29.55	3.73	7.59	20.18	5.47	14.32	16.77	31.10	135.57	19.15	300.33	110.94	37.06
Average	51.56	118.40	58.39	30.94	4.04	6.50	21.41	4.74	20.70	14.09	34.62	180.79	16.80	368.25	148.38	40.23
S.E.	1.0449	0.6207	3.6309	1.5215	0.5963	0.2599	1.1331	0.4754	2.5723	3.5247	4.5710	9.9260	0.4658	15.1151	6.5205	2.3371
C.D. (P=0.05)	2.1149	1.2564	NS	3.0795	1.2070	0.5262	2.2934	0.9622	5.2064	NS	9.2518	20.0902	0.9429	30.5929	13.1975	4.7302
C.D. (P=0.05)	2.8275	1.6798	NS	NS	1.4435	0.7035	3.0662	1.2864	6.9608	NS	12.3693	26.8598	1.2607	40.9014	17.6443	6.3241

NS= Non significant

economic sink is prime factor for achieving maximum production potential of any cultivars. Dry matter partitioning and growth analysis studies indicated that LAI of chickpea cultivars increased significantly up to 90 DAS and optimum LAI was found in between 3-5.5 at 75-90 (SIII - SIV) during flowering stages of crop growth. Shantakumari and Sinha (1972) also found maximum rate of photosynthesis at flower bud initiation in chickpea. LAR was significantly low in high yielding cvs *i.e.,* JG-74, JG-1265, JG-79-38 at 75-90 DAS indicated that low leaf area increased the shoot biomass for plant and smaller leaf size increased photosynthetic efficiency. In these cultivars low LAR probably combined with better translocation and greater sink capacity ultimately resulted high seed yield. CGRwas maximum at 60-75 DAS (S II - S III) during vegetative to flower initiation stages. Slow increase in CGR during early vegetative phase was associated with stem and leaf number, size and weight. Rapid increase in CGR after flower bud initiation (60 DAS) was found significant contributor to increase the number of flowers and pods as well as seed index. CGR was significantly and positively correlated with pod index at 105 DAS (S VI), Prasad *et al.* (1978) also found similar results. CGR was negatively correlated with LAI at this stage 105

Table 2 : Correlation of physiological parameters of chickpea cultivars at general flowering stage (S-III, 75 days)

	HI	LAI	LAR	LWR	SLA	SLW	CGR	SI
SI	-0.0169	0.3942	0.3265	-0.1112	0.3308	-0.3069	-0.2436	1
CGR	-0.1026	-0.3064	-0.1919	0.0474	-0.2190	0.2968	1	
SLW	0.0708	-0.4663**	-0.8730**	0.3876	-0.9233**	1		
SLA	0.0166	0.4308	0.9419**	-0.3971	1			
LWR	-0.3665	-0.4600*	-0.0750	1				
LAR	-0.1084	0.2971	1					
LAI	0.0207	1						
HI	1							

Table 3 : Correlation of physiological parameters of chickpea cultivars at general pod formation stage (S-IV, 90 days)

	HI	LAI	LAR	LWR	SLA	SLW	CGR	SI
SI	-0.0169	-0.0835	0.0189	-0.0419	0.0001	-0.0355	-0.0319	1
CGR	-0.0170	0.1726	-0.3753	-0.1832	-0.3134	0.2656	1	
SLW	-0.3198	-0.2814	-0.8904**	0.0821	-0.9689**	1		
SLA	0.2281	0.2533	0.9050**	-0.0878	1			
LWR	-0.4355	-0.0523	0.3340	1				
LAR	0.0565	0.2113	1					
LAI	0.1159	1						
HI	1							

Table 4 : Correlation of physiological parameters of chickpea cultivars at pod fill stage (S-V, 105 days)

	HI	LAI	LAR	LWR	SLA	SLW	CGR	SY	SI	PW
PW	0.5031*	-0.4180	-0.2998	-0.0917	-0.2777	-0.1674	0.9102**	0.9864**	-0.2854	1
SI	-0.0169	0.2602	0.0869	-0.5668**	0.2274	-0.1485	-0.3756	-0.2754	1	
SY	0.5524*	-0.4117	-0.3473	-0.1141	-0.3229	-0.1459	0.9193**	1		
CGR	0.4602*	-0.4740*	-0.3781	0.0132	-0.3728	0.0167	1			
SLW	-0.5516*	-0.5672	-0.5897**	0.5610*	-0.6455**	1				
SLA	0.0873	0.6824**	0.9689**	-0.4315	1					
LWR	-0.3748	-0.3419	-0.2133	1						
LAR	0.0540	0.6723*	1							
LAI	0.3536	1								
HI	1									

SY = Seed yield, SI = Seed index, PW = Pod weight

Table 5 : Correlation of biochemical parameters of chickpea cultivars at various growth phases

	45 days					65 days				95 Days		Sugar on maturity				Protein on maturity			Pod fill stage	
	Seed index	Chl a	Chl b	Total chl.	Stem sugar	Leaf sugar	Chl a	Chl b	Total chl.	Stem sugar	Leaf sugar	Stem sugar	Leaf sugar	Pod wall sugar	Seed sugar	Stem protein	Seed protein	Seed yield/ m^2	Leaf ascorbic acid	Pd wall ascorbic acid
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Seed index	1	0.372	0.248	0.313	0.033	0.013	0.081	0.069	0.017	0.531	0.519	0.170	0.198	0.191	0.291	0.308	0.036	0.275	0.065	0.260
Chl a		1	0.942**	0.985**	0.045	0.027	0.038	0.077	0.036	0.230	0.150	0.025	0.019	0.118	0.154	0.213	0.083	0.207	0.081	0.170
Chl b			1	0.985**	0.073	0.124	0.016	0.037	0.011	0.218	0.125	0.092	0.036	0.251	0.246	0.225	0.108	0.150	0.110	0.104
Total chl.				1	0.035	0.078	0.077	0.036	0.011	0.227	0.139	0.048	0.093	0.187	0.203	0.222	0.097	0.181	0.096	0.139
Stem sugar					1	0.972**	0.034	0.298	0.154	0.489*	0.567**	0.109	0.959**	0.142	0.139	0.282	0.381	0.153	0.316	0.222
Leaf sugar						1	0.065	0.329	0.187	0.469*	0.518*	0.173	0.956**	0.068	0.175	0.301	0.402	0.138	0.285	0.289
Chl a							1	0.803**	0.963**	0.042	0.188	0.161	0.095	0.318	0.056	0.380	0.078	0.434	0.268	0.162
Chl b								1	0.934**	0.082	0.210	0.179	0.308	0.349	0.065	0.298	0.070	0.450	0.434	0.097
Chl total									1	0.061	0.206	0.178	0.195	0.349	0.063	0.361	0.124	0.466	0.357	0.140
Stem sugar										1	0.990**	0.362	0.485*	0.375	0.392	0.178	0.352	0.067	0.021	0.237
Leaf sugar											1	0.284	0.560**	0.261	0.316	0.357	0.184	0.083	0.039	0.087
Stem sugar												1	0.110	0.367	0.906**	0.179	0.161	0.430	0.252	0.054
Leaf sugar													1	0.114	0.134	0.390	0.470*	0.166	0.341	0.201
Podwall sugar														1	0.453*	0.102	0.283	0.519 *	0.047	0.384
Seed sugar															1	0.155	0.085	0.464*	0.141	0.174
Stem protein																1	0.087	0.067	0.536**	0.215
Seed protein																	1	0.159	0.068	0.048
Seed yield/m^2																		1	0.028	0.079
Leaf ascorbic acid																			1	0.053
Podwall ascorbic acid																				1

DAS (S-VI) (Table 4). JG-1 had maximum CGR whereas, JG-74 had maximum seed yield and HI, pod weight, biological yield, total number of pods on primary branches.

The chlorophyll content 'b' and total chlorophyll content was positively correlated with seed yield. However, a negative correlation of chlorophyll content with seed yield was reported by Dhopte *et al.* (1985). The sugar content of leaves and stem varied significantly in leaves and stem. JG-1264 had maximum sugar content in shoot and also in seed. The association of leaf sugar at general pod formation stage (90 DAS, S-V) was also positively correlated with stem sugar. Stem sugar at maturity was positively correlated with seed sugar while, pod wall sugar was negatively correlated with seed sugar indicated that in most of the cultivars translocation of sugar from pericarp to cotyledons was inefficient (Table 5). Generally, the seed sugar was positively correlated with seed yield *i.e.,* JG-1258. Stem and leaf sugar at pod fill stage was positively correlated with seed index. In cv. J 78-44 relatively more efficient translocation of photo assimilates was found towards economic sink. The cultivars has significant variation in pod wall sugar. However, Shantakumari and Sinha (1972) reported non significant variation in pod wall sugar. A gradual decrease in stem sugar indicated a similar trend of translocation of photoassimilates towards economic sink in the study.

The protein content was significantly varied at maturity in seeds and it was not affected by seed index of the cultivars. The number of days to flower initiation was positively correlated with seed yield. JG-1 had required minimum period (45 days) for flower initiation and also had minimum yield (Table 1). Similar association was found by Jatasra *et al.* (1978). The plant height did not vary significantly while, Mishra (1972) reported the negative correlation of plant height with seed yield and on contrary of it Singh *et al.* (1977) and Mishra and Rao (1984) reported positive correlation. The number of primary branches per plant, pod weight and pod bearing length were not affected by seed index. There was a negative correlation between number of primary branches with seed index. However, Singh *et al.* (1973) reported a negative correlation of pod bearing length with seed yield. The positive association was found in primary branches and seed yield. There was a positive association between pod bearing length and seed yield in cultivars JG-74 and J 80-5. The significant variation was obtained in effective secondary branches in the cultivars but did not reveal a positive trend with regard to seed index. The number of pods on primary branches had significant variation in cultivars and positively correlated with seed yield. Tomar *et al.* (1982), Khedar *et al.* (1984) and Mishra and Rao (1984) also found positive correlation. It was observed that the pods on secondary branches had non significant difference and were not affected by seed index.

The biological yield was positively correlated with seed yield. The biological yield and harvest index did not show any positive trend with seed index (Table 5). Harvest index (HI) solely can not be a criteria for selection. It may fail to indicate accurately the comparative yield of seed per unit of land when cultivars and crop stand differ in LA, LAI, leaf senescence and abscission. Thus, shoot biomass may alter the HI and render the comparasion of biological yield and partitioning efficiency of the cultivars unrealistic if the sampling intervals are longer. HI can be a better selection criteria than any of its components (Singh *et al.,* 1986). Path-coefficient analysis exhibited that the characters such as biological yield/plant, pods/plant and 100 seed weight were found very important in chickpea. Indirect effects of all the other traits except harvest index through biological yield/plant were also positive. Therefore, biological yield/plant, pods/plant and 100 seed weight appears to be the major yield components from the selection point of view in chickpea reported by Arora and Kumar (1994).

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