Int.J.Curr.Microbiol.App.Sci (2018) Special Issue-7: 3888-3895

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Special Issue-7 pp. 3888-3895**
Journal homepage: http://www.ijcmas.com

Original Research Article

Evaluation of Chickpea Genotypes on the Basis of their Physiological Growth Parameters

Trisha Sinha*, Subhasis Mondal and Surya Kant Hembramm

Department of Plant Physiology, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India
**Corresponding author*

A B S T R A C T

Chickpea (*Cicer arietinum* L.) is the most important food legume crop of South Asia and the third most important food legume crop in the world after beans (*Phaseolus vulguris* L.) and peas (*Pisum sativum* L.) in terms of annual production (FAO STAT 2013). It belongs to sub-family faboideae under family fabaceae. Chickpea is a valuable source of dietary protein in some parts of the world for humans and in some cases, animal feed. National average of chickpea productivity (920 Kg/ha) is far below its potential yield (5000 Kg/ha) (Gowda and Gaur, 2004). Its yield may be enhanced by improvisation of its agro-techniques as well as by breeding genetically improved cultivars. For both the purposes, growth analysis may be a useful physiological tool that can determine the selection criteria for crop improvement as well as time of input application for foliar development and dry matter production in the interest of better partitioning of assimilate in yield forming organs. The present experiment was conducted with nine genotypes, namely, AGBL-184, IPC-2010-94, IPC-2011-70, ICCV-13107, RSG-888, 24001-4-1, 24004-3-1, 24034-4-1 and 24017-1-1 with the objective to study the growth pattern of chickpea genotypes through growth analysis. For this purpose, observations on the physiological growth parameters like LAI, LAR, SLA, NAR and RGR were calculated using the leaf area and dry weight values of the genotypes in their respective mathematical formulae at 15 days interval up to 60 days, i.e., at 15 DAS (days after sowing), 30 DAS, 45 DAS, 60 DAS. Four genotypes AGBL-184, IPC-2010-94, 24004-3-1 and 24017-1-1 were found to be impressive in terms of morphological and physiological growth parameters. AGBL-184 with a yield of 831 Kg/ha was the best yield performer that was closely followed by IPC-2010-94 with 768 Kg/ha, chickpea genotype 24004-3-1 with 645 Kg/ha and the chickpea genotype 24017-1-1 with 612 Kg/ha. The LAI progressively increased up to beginning of pod maturation where as RGR and NAR were high in the early stages and declined gradually. There were some common points in their growth pattern also: major proportion of elongation occurred within 30 DAS whereas leaf area expansion occurred at high scale after 30 DAS, above ground dry matter accumulation also occurred at higher scale around 45 DAS and post 45 DAS. Seed yield of chickpea was found to be positively associated with LAI, LAR and NAR. RGR only at 60 DAS stage was associated with seed yield. It was not found to be associated with yield at its status on 45 DAS. Higher chickpea yielder were found have high values for physiological growth parameters like LAI, LAR, NAR as well as long period of LAI at peak.

Keywords

Chickpea Genotypes on the Basis of their Physiological Growth Parameters

Introduction

Chickpea (*Cicer arietinum* L.) is widely accepted in cereal rotations to improve the fertility and physical properties of the soil. This nitrogen (N_2) fixing pulse legume has been widely grown throughout South and West Asia and the Mediterranean region for centuries, usually in sequence with either summer or winter cereals (Sandhu *et al.*, 1989; Bhatia *et al.*, 1993 and Lopez-Bellido *et al.*, 1996). Recently, N fixation inputs and N balances, i.e. the difference between N fixation inputs and N in harvested products (outputs), as well as rotational benefits of chickpea have been quantified revealing its importance in nitrogen fixation (Saini *et al.*, 2004). Chickpea is a valuable source of dietary protein in some parts of the world for humans and in some cases as an animal feed. It is a good source of zinc and folate and is an excellent source of protein and carbohydrate and its protein is of high quality as compared to other pulses (Tripathi *et al.*, 1995). It is also very high in dietary fibre and hence a healthy source of carbohydrates for persons with insulin sensitivity or diabetes. Chickpeas are low in fat and most of which is polyunsaturated. One hundred grams of mature boiled chickpeas contains 164 calories, 2.6g of fat (of which only 0.27g is saturated), 7.6g of dietary fibre and 8.9 g of protein. Chickpeas are a rich source of protein, vitamin A and iron (Bender and Bender, 2005). Chickpeas also provide dietary calcium (49mg–53mg/100g). According to the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) chickpea seeds contain on an average 23% protein, 64% total carbohydrates (47% starch, 6% soluble sugar), 5% fat, 6% crude fibre and 3% ash. High mineral content has been reported for phosphorus (340mg/100g), calcium (190mg/100g), magnesium (140mg/100g), iron (7mg/100g) and zinc (3mg/100g). Recent studies have also shown that they can assist in lowering of cholesterol in the bloodstream (Pittaway *et al.*, 2008).

Plant growth analysis is widely considered as an explanatory, holistic and integrative approach to interpreting plant form and function. It uses simple primary data in the form of weights, areas, volumes and contents of plant components to investigate processes within and involving the whole plant (Evans, 1972; Causton and Venus, 1981; Hunt, 1982). Plant growth analysis is still considered as the most simple and precise method to evaluate the contribution of the different physiological processes in plant development. The purpose of growth analysis is the determination of the increase in dry matter refer red to a suitable basis (Ali *et al.*, 2004; Gupta and Gupta, 2005; Alam and Haider, 2006 and Yasari and Patwardhan, 2006). With such note appreciation over growth analysis, the present piece work was taken up to evaluate some newly bred genotypes on the basis of their physiological growth parameters.

Materials and Methods

The investigation with nine newly bred promising chickpea lines was conducted in the A-B Block Seed Farm, Kalyani Simanta, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India during the *Rabi* season of 2015-16. The geographical location of the experimental site is at latitude 22°58’ N and the longitude 88°32’ E. It belongs to the agro-climatic zone of new alluvial zone of West Bengal. Its soil is highly fertile with the sandy loam texture and pH of 6.90-7.00. The present experiment was set with nine chickpea genotypes, namely, AGBL-184, IPC-2010-94, IPC-2011-70, RSG-888, 24001-4-1, 24004-3-1, 24034-4-1 and 24017-1-1 in a randomized block design with four replications. These genotypes were

constituent materials for a varietal trial for the year 2014-15 on 'Utilizing chickpea genome sequence for crop improvement' under ICRISAT-ICARDA. The crop was sown in a plot size of 3.0 m X 1.2 m with spacing of 30 cm X 10 cm on 26th November, 2015. The data was analyzed statistically following the analysis of variance method as suggested by Panse and Sukhatme (1978). Mathematical expression of the physiological growth parameters were: Leaf Area Index (LAI) = A/P [A= Total leaf area of the plants and P = Land area in which plants have spread their leaves]; Relative growth rate (RGR) = (Log_e W_2 - Log_e W_1)/ (T_2 - T_1) g g^{-1} [W_1 = Dry weight of the plants at T_1 moment and W_2 = Dry weight of the plants at T_2 moment]; NAR = [(W_2 - W_1) (Log_e A_2 - Log_e A_1)]/[(T_2 - T_1)(A_2 - A_1)] g cm^{-2} d^{-1} [W_1 = Dry weight of the plants at T_1 moment, W_2 = Dry weight of the plants at T_2 moment, A_1 = leaf area at T_1 moment and A_2 = leaf area at T_2 moment]; LAR= A/W, cm^2/g [A= Leaf area in cm^2 and W= Total plant dry weight in g] and SLA =A_L/W_L, cm^2 /g [A_L = Leaf area (cm^2) and W_L = Leaf weight (g)].

Results and Discussion

At 15 DAS of the chickpea genotypes, above average leaf area index (LAI) was obtained in the genotypes like AGBL-184 (0.578), IPC-2010-94 (0.705), ICCV-13107 (0.557) & 24001-4-1 (0.543) and the below average value of LAI was found in the genotypes like IPC-2011-70 (0.424), 24004-3-1 (0.422) & 24034-4-1 (0.381) (from table-1, column 2). However, the highest and lowest values of LAI were recorded in 24017-1-1 (0.725) and RSG-888 (0.233) respectively.

The highest and lowest leaf area ratio (LAR) at 15 DAS was registered in 24017-1-1 (27.798 cm^2/g) and RSG-888 (11.520 cm^2/g) respectively (from table-1, column 3). Of the rest of the genotypes, the above average LAR value was recorded in the genotypes, namely, IPC-2010-94 (25.201 cm^2/g), 24001-4-1 (27.685 cm^2/g) and 24004-3-1 (22.501 cm^2/g). The below average values were recorded in the genotypes like AGBL-184 (19.102 cm^2/g), IPC-2011-70 (21.198 cm^2/g), ICCV-13107 (20.331 cm^2/g) and 24034-4-1 (15.964 cm^2/g). Specific leaf area at 15 DAS was highest in 24001-4-1 (94.158 cm^2/g) and the genotypes with above average SLA values were IPC-2010-94 (69.352 cm^2/g), IPC-2011-70 (64.308 cm^2/g), 24004-3-1 (68.079 cm^2/g) & 24017-1-1 (94.086 cm^2/g) whereas the below average SLA values were observed in AGBL-184 (53.835 cm^2/g), ICCV-13107 (54.990 cm^2/g) & RSG-888 (30.232 cm^2/g) and the genotype with lowest SLA value was 24034-4-1 (39.173 cm^2/g) (from table-1, column 4).

At 30 DAS of the chickpea genotypes, above average leaf area index (LAI) was obtained in the genotypes like AGBL-184 (2.15), IPC-2011-70 (2.17), 24001-4-1 (1.78) & 24017-1-1 (2.34) and the below average value of LAI was found in the genotypes like ICCV-13107 (1.64), 24004-3-1 (0.94) & 24034-4-1 (0.97) (from table-2, column 2). However, the highest and lowest values of LAI were recorded in IPC-2010-9 (2.66) and RSG-888 (0.88) respectively.

The highest and lowest leaf area ratio (LAR) at 30 DAS was registered in 24017-1-1 (38.48 cm^2/g) and RSG-888 (15.28 cm^2/g) respectively (from table-2, column 3). Of the rest of the genotypes, the above average LAR value was recorded in the genotypes, namely, IPC-2010-94 (34.65 cm^2/g), IPC-2011-70 (34.35 cm^2/g) & 24001-4-1 (38.04 cm^2/g) and the below average values were recorded in the genotypes like AGBL-184 (27.02 cm^2/g), ICCV-13107 (24.45 cm^2/g),

24004-3-1 (20.67 cm^2/g) & 24034-4-1 (17.83 cm^2/g). Specific leaf area at 30 DAS was highest in 24017-1-1 (111.84 cm^2/g) and the genotypes with above average SLA values were IPC-2010-94 (74.79 cm^2/g), IPC-2011-70 (76.01 cm^2/g) & 24001-4-1 (105.40 cm^2/g) whereas the lowest SLA was recorded in RSG-888 (41.448 cm^2/g) and the genotypes with below average SLA values were AGBL-184 (57.85 cm^2/g), ICCV-13107 (59.20 cm^2/g), 24004-3-1 (66.49 cm^2/g) & 24034-4-1 (56.26 cm^2/g) (table-2, column 4).

So, from the results in terms of the values of growth and its different versions of rates and indices of the chickpea genotypes at 30 DAS, the genotype, IPC-2010-94, was recorded to top in leaf area, LAI and RGR. However, the genotype, 24017-1-1, that was highest in leaf area in the previous stage was at par with the topper of this stage. The genotype, 24017-1-1, showed highest LAR and SLA. Such results indicated that AGBL-184 though was ahead in the dry weight values actually lagging behind in terms of growth rate and interestingly the genotype 24017-1-1 that was found to lead in terms of LAR showed lowest RGR.

The highest and the lowest leaf area at 45 DAS was observed in the genotype IPC-2010-94 (285.77 cm^2) and 24004-3-1 (84.64 cm^2) respectively. At this stage, the genotypes like AGBL-184 (246.06 cm^2), IPC-2011-70 (223.44 cm^2), 24001-4-1 (220.89 cm^2) 24017-1-1 (191.26 cm^2) were found to have above average leaf area and genotypes like ICCV-13107 (170.02 cm^2), RSG-888 (120.52 cm^2) & 24034-4-1 (109.67 cm^2) were recorded with below average leaf area. Specific leaf area at 45 DAS was highest in 24001-4-1 (127.25 cm^2/g) and the genotypes with above average SLA values were IPC-2010-94 (95.62 cm^2/g) & 24017-1-1 (122.06 cm^2/g) whereas the lowest SLA was recorded in 24034-4-1 (61.258 cm^2/g) and the genotypes with below average SLA values were AGBL-184 (80.020 cm^2/g), IPC-2011-70 (81.178 cm^2/g), RSG-888 (60.078 cm^2/g) & 24004-3-1 (75.85 cm^2/g) (from table-3, column-4).

IPC-2010-94 at this stage also topped in leaf area and LAI. However, the genotype 24001-4-1 was highest in LAR and SLA and the genotype 24001-3-1 was highest in RGR at this stage. Interesting point to note here is that the genotype with highest LAI (IPC-2010-94) at this stage was among the genotypes with very poor RGR.

At 60 DAS, the highest and the lowest leaf area at 60 DAS was observed in the genotypes IPC-2010-94 (524.89 cm^2) and 24004-3-1 (308.75 cm^2) respectively. At this stage, the genotypes like AGBL-184 (460.40 cm^2) & IPC-2011-70 (455.09 cm^2) were found to have above average leaf area and genotypes like ICCV-13107 (364.88 cm^2), RSG-888 (316.17 cm^2), 24001-4-1 (369.95 cm^2), 24034-4-1 (348.95 cm^2) & 24017-1-1 (371.18 cm^2) were recorded with below average leaf area.

At 60 DAS of the chickpea genotypes, above average leaf area index (LAI) was obtained in the genotypes like AGBL-184 (10.29) & IPC-2011-70 (10.11) and the below average value of LAI was found in the genotypes like ICCV-13107 (8.11), RSG-888 (7.02), 24001-4-1 (8.22), 24034-4-1 (7.75) & 24017-1-1 (8.25). However, the highest and lowest values of LAI were recorded in IPC-2010-94 (11.66) and 24004-3-1 (6.86) respectively (table 4, column 2).

The highest and lowest leaf area ratio (LAR) at 60 DAS was registered in IPC-2010-94 (42.20 cm^2/g) and ICCV-13107 (29.68 cm^2/g) respectively.

Table.1 Values of physiological growth parameters of the chickpea genotypes at 15 DAS

Genotype	LAI	LAR (cm^2/g)	SLA (cm^2/g)
AGBL-184	0.578	19.102	53.835
IPC-2010-94	0.705	25.201	69.352
IPC-2011-70	0.424	21.198	64.308
ICCV-13107	0.557	20.331	54.990
RSG-888	**0.233**	**11.520**	30.232
24001-4-1	0.543	27.685	**94.158**
24004-3-1	0.422	22.501	68.079
24034-4-1	0.381	15.964	**39.173**
24017-1-1	**0.725**	**27.798**	94.086
Mean	0.508	21.256	63.135
S.Em(±)	0.026	0.950	3.260
C.D. at 5%	0.076	2.760	9.520

Table.2 Values of physiological growth parameters of the chickpea genotypes 30 DAS

Genotype	LAI	LAR (cm^2/g)	SLA (cm^2/g)	RGR (mg/g/day)	NAR ($mg/cm^2/day$)
AGBL-184	2.15	27.02	57.85	32.00	2.7
IPC-2010-94	**2.66**	34.65	74.79	**42.75**	2.3
IPC-2011-70	2.17	34.35	76.01	40.50	2.7
ICCV-13107	1.64	24.45	59.20	33.43	2.6
RSG-888	0.88	15.28	41.45	39.98	**5.1**
24001-4-1	1.78	38.04	105.40	22.30	1.8
24004-3-1	0.94	20.67	66.49	23.55	2.9
24034-4-1	0.97	17.83	56.26	34.60	3.2
24017-1-1	2.34	**38.48**	**111.84**	18.05	1.7
Mean	1.73	27.86	72.14	31.90	2.8
S.Em (±)	0.03	0.85	2.40	2.04	0.20
C.D. at 5%	0.09	2.48	7.00	5.97	0.44

Table.3 Values of physiological growth parameters of the chickpea genotypes at 45DAS:

Genotype	LAI	LAR (cm^2/g)	SLA (cm^2/g)	RGR mg/g/day	NAR ($mg/cm^2/day$)
AGBL-184	5.47	32.53	80.02	17.43	1.70
IPC-2010-94	6.35	39.79	95.63	18.00	1.40
IPC-2011-70	4.97	34.64	81.68	21.65	1.60
ICCV-13107	3.78	26.21	68.93	19.85	2.10
RSG-888	2.68	22.66	60.08	24.08	2.50
24001-4-1	4.91	46.02	127.20	30.73	1.30
24004-3-1	1.88	20.23	75.85	37.70	2.30
24034-4-1	2.44	21.81	61.26	24.15	2.40
24017-1-1	4.25	38.33	122.06	27.4	1.10
Mean	4.06	31.36	85.86	24.55	1.80
S.Em (±)	0.10	1.15	2.73	0.87	0.10
C.D. 5%	0.29	3.37	7.98	2.55	0.30

Table.4 Values of physiological growth parameters of the chickpea genotypes at 60 das

Genotype	LAI	LAR (cm^2/g)	SLA (cm^2/g)	RGR (mg/g/day)	NAR ($mg/cm^2/day$)
AGBL-184	10.29	36.27	89.68	14.75	0.95
IPC-2010-94	11.66	42.20	114.61	12.90	0.89
IPC-2011-70	10.11	38.41	98.05	15.28	1.10
ICCV-13107	8.11	29.68	85.44	17.00	1.49
RSG-888	7.02	30.03	82.85	19.23	1.71
24001-4-1	8.22	40.69	137.82	20.38	1.00
24004-3-1	6.86	30.29	87.02	18.95	2.18
24034-4-1	7.75	33.39	94.61	17.95	1.75
24017-1-1	8.25	36.09	133.58	21.15	0.81
Mean	8.69	35.23	102.63	17.51	2.32
S.Em (±)	0.19	0.94	2.77	0.87	0.05
C.D. 5%	0.54	2.73	8.09	2.52	0.15

Table.5 Yield along with days to flower and days to maturity

Genotype	Yield (kg/ha)	Days to Flower	Days to Maturity	Seed filling period
AGBL-184	830.53	62	107	45
IPC-2010-94	767.98	64	104	40
IPC-2011-70	236.30	71	109	38
ICCV-13107	382.25	53	105	52
RSG-888	276.61	60	105	45
24001-4-1	281.48	63	107	44
24004-3-1	644.96	56	108	52
24034-4-1	146.2	58	106	48
24017-1-1	611.50	53	106	53

Of the rest of the genotypes, the above average LAR value was recorded in the genotypes, namely, AGBL-184 (36.27 cm^2/g), IPC-2011-70 (38.42 cm^2/g), 24001-4-1 (40.69 cm^2/g) & 24017-1-1 (36.09 cm^2/g) and the below average values were recorded in the genotypes like RSG-888 (30.03 cm^2/g), 24004-3-1 (30.29 cm^2/g) & 24034-4-1 (33.39 cm^2/g) (table 4, column 3).

Specific leaf area at 60 DAS was highest in 24001-4-1 (137.82 cm^2/g) and the genotypes with above average SLA values were 24017-1-1 (133.58 cm^2/g) and IPC-2010-94 (114.61 cm^2/g) & whereas the lowest SLA was recorded in RSG-888 (82.85 cm^2/g) and the genotypes with below average SLA values were AGBL-184 (89.68 cm^2/g) IPC-2011-70 (98.05 cm^2/g), ICCV-13107 (85.44 cm^2/g), 24004-3-1 (87.02 cm^2/g) & 24034-4-1 (94.61 cm^2/g) (table 4, column 4).

So, from the results at 60 DAS (table 4), it is evident that IPC-2010-94 at this stage also topped in leaf area, LAR and LAI. However, the genotype 24001-4-1 was highest in SLA and the genotype 24017-1-1 was highest in RGR at this stage. Interesting point to note here also is that the genotype with highest LAI and LAR (IPC-2010-94) at this stage was lowest in RGR. The genotypes with moderate LAI and LAR like 24017-1-1 and 24001-4-1 showed very impressive RGR at

this stage clearly indicating more dominating role of the efficiency factor than the leaf area.

Further, average value of LAI gradually increased over time up to 60 DAS, average value of LAR and SLA was also found to increase though not to the extent of LAI. But the mean value RGR decreased overtime at least up to 60 DAS.

The yield of AGBL-184 was highest followed by IPC-2010-94, 24004-3-1 and 24017-1-1. The rest of the genotypes were far below these high yielding genotypes. The first two genotypes had very high LAI value along with moderately long seed filling period where as rest two high yielders had prolong seed filling period along with moderately high LAI value. It appeared that LAD during seed filling period essentially played very important role in dry matter production and yield formation. This result was corroborated by Buttery in 1974 and Machado *et al.*, in 1982.

The variations in the chickpea genotypes in respect of all morphological and physiological growth parameters were found to exist substantial. The chickpea genotype, 240017-1-1, was all along among the top few genotypes with very high LAR, specifically highest up to 30 DAS. It was highest in RGR at 60 DAS. However, the chickpea genotype, 24004-3-1, that was below average in almost all counts at almost every stage recorded highest RGR at 45 DAS and it maintained its position in RGR among the top few performers. AGBL-184 with a yield of 831 Kg/ha was the highest yielder closely followed by IPC-2010-94 with 768 Kg/ha. The chickpea genotypes, 24004-3-1 with 645 Kg/ha and 24017-1-1 with 612 Kg/ha also were above average performers. The patterns of growth of the genotypes were not similar in terms of their rhythm of stem elongation, leaf area expansion as well as whole plant dry weight. Seed yield was strongly associated with LAI, NAR and LAR but RGR which was found not be associated in 45 DAS showed a positive association at the 60 DAS stage. Leaf area exhibited positive association with seed yield. Finally it may be concluded that physiological growth parameters are good indicator of high yield. They may be used as selection criteria for breeding genotypes.

References

Alam, M. Z.; and Haider, S. A. (2006). Growth attributes of barley (*Hordeum Vulgare* L.) cultivars in relation to different doses of nitrogen fertilizer. Journal of Life and Earth Sciences. Vol. 1(2): 77-82.

Ali, H.; Khan, M. A. and. Randhawa, S. A. (2004). Interactive effect of seed inoculation and phosphorus application on growth and yield of chickpea (*Cicer arietinum* L.). International Journal of Agriculture & Biology. Vol. 6(1): 110-112.

Bhatia, V.S.; Singh, B.N. and Lal, S. (1993). Variability and interrelationship of yield and its attributes in chickpea. *Indian J. Pulses Res.*, 6(1): 1-5.

Buttery, B. R. and Buzzell, R. I. (1974). Evaluation of methods used in computing net assimilation rates of soybeans (*Glycine max* (L.) Merrill). *Crop Science* 14: 41-42.

Causton, D R, Venus JC. (1981). The biometry of plant growth. London: Edward Arnold.

Evans, G. C. (1972). The quantitative analysis of plant growth. Oxford: Blackwell Scientific Publications.

Gowda, C. L. L. and Gaur, P. M. (2004) Global scenario of chickpea research: present status and thrusts. International

Crops Research Institute for the Semi-Arid Tropics, Patancheru 502 324, AP.

Gupta, N. K. and Gupta, S. (2005). Plant Physiology. Oxford and IBH Publishing, pp. 580.

Hunt, R. (1982). Plant growth curves. London: Edward Arnold.

Ladizinsky, G. and Alder, A. (1975). Genetic relationships among annual species of *Cicer*. *Theort. Applied Genet.*, 48: 197-203.

Lopez, F.B.; Johansen, C. and Chauhan, Y. S. (1996). Effects of timing of drought stress on phenology, yield and yield components of short duration pigeonpea. Journal of Agronomy and Crop science, 177: 311-320.

Saini V. K.; Bhandari S. C. and Tarafdar J. C. (2004). Comparison of crop yield, soil microbial C, N and P, N-fixation, nodulation and mycorrhizal infection in inoculated and non-inoculated sorghum and chickpea crops. Field Crops Research. Vol. 89: 39-47.

Sandhu, S. K. and Mandal, A. K. (1989). Genetic variability and regression studies in gram (*Cicer arietinum* L.). *J. Res. Punjab Agric. Univ., Ludhiana*, 7: 423-427.

Singh, K. B. (1987). Chickpea breeding. In the Chickpea. M.C. Saxena and K.B. Singh (eds). CAB International, Wallingford, Oxon, U.K. pp. 127-162.

Tripathi, A. K.; Pathak, M. M.; Singh, K. P. and Singh R. P. (1995). Path co-efficient analysis in chickpea. *Indian J. Pulses Res.*, 8(1): 71-72.

Yasari E. and Patwardhan A. M. 2006. Physiological analysis of the growth and development of canola (Brassica napus L.) under different chemical fertilizer application. Asian Journal of Plant Sciences. Vol. 5(5): 745-752.