Advances in Agricultural, Animal and Fisheries Sciences (*Eds: Devi Dayal and Shamsudheen M*), 2022, ZNAN Publishers, Society for Technology, Environment, Science& People, Kozhikode, India, Pages: 140-150.
ISBN : 978-81-956227-2-6

Improving the harvest index in early generation selection in F3 population in chickpea (*Cicer arietinum* L.)

Chapter
12

Sunil Kumar, Lakshmi Chaudhary, Uma Devi and Manoj Kumar

Pulses Section, Department of Genetics & Plant Breeding, CCS Haryana Agricultural University, Hisar, Haryana

ABSTRACT

This investigation was undertaken to study the genetics of seed related attributes in chickpea (*Cicer arietinum* L.) in F_3 progenies of eighteen different crosses were sown with 8 rows per cross were hand sown with 4.0-meter row length and spacing of 50 cm x 20 cm during *Rabi* 2020-2021 at Pulses Research Farm, CCSHSU, Hisar, Haryana. Observations were recorded at physiology maturity on five randomly selected plants from each 18 F_3 progenies for high numbers of pods/plant, seed index, seed yield per plant (g per plant), Total biomass yield per plant and harvest index. The F_3 cross combination namely (H 12-55 x CSJ 8962) x CSJ 8962 and H 12-55 x GNG 1958 recorded the highest harvest index i.e., 62.0 % followed by H 13-09 x *reticulatum* 237) x H 13-09 GNG 1581 (60.0 %). From two years data studied in early generation selection may be considered useful because it recorded high seed yield in cross (H12-55 x CSG 8962) x CSG 8962 i.e., 4125 kg/ha and 1799 kg/ha in $F_{2,}$ F_3 progenies during 2019 and 2020 respectively. F_3 progenies were selected for high pod number, seed yield /plant and high harvest index. Selection response through harvest index effective for improvement of seed yield ranged from 36 % to 62.0 % in all the 18 F_3 populations. Improvement in yield via route through selection was obtained when the response was measured through the harvest index. Selection of harvest index in

early generation for improvement of yield was effective when the response was measured in different years in F_2, F_3 progenies because high yielding genotypes may be lost by delay selection. Early generation selecting for high pod number, early maturity, more seed yield and high harvest index were important trait for the genetic improvement of seed yield.

Key words: Chickpea, Early generation, F_3 population, Harvest Index

Introduction

The dry matter production potential of chickpea is about 6 tonne/ha, and even a conservative harvest index of 50–60 % suggests that up to 4.0 to 4.5 t/ha of seed yield should be harvested compared to the world average of only 1014 kg/ha of this crop. The ideal route to realize higher yield in chickpea is to convert a greater amount of accumulated dry matter into seed yield. This approach to increasing yield has fascinated chickpea scientists, but little progress has been made in improving the harvest index on a consistent basis. Seed yield predict by many crop models for the estimation of number of seeds per unit area, number of plants per unit area, and the rate and duration of seed filling (Ritchie *et al*, 1998). In some other crop models, seed yield accumulation is calculated as the product of total biomass accumulation and harvest index (HI), and harvest index is assumed to increase linearly as a function of time after beginning of seed growth with a constant rate (dHI/dt) (Sinclair, 1986). Chickpea is self-pollinated legume crop with 17-24 % protein, 41-50.8 % carbohydrates and high percentage of the mineral nutrients and is the most important pulse crop for human consumption (Jodha and Subbarao, 1987, Maiti, 2001). Chickpea crop require very less water requirement as compare to cereals i.e., 10^{th} part of Wheat and Rice. It grows very well on conserved soil moisture makes them “resilient” to changing climate conditions, as heterozygosity in the population appears to confer resistance to environmental change (Schierenbeck, K.A 2016). As observed by Bishop, *et al*, 2016 heterogeneity in plant populations accelerates opportunities for the selection of more stress-tolerant genotypes and thereby provides resilience to the crop as well as the ecosystem. Globally chickpea is second most important crop grown in an area of 14.60 million ha with an annual production of 14.8 million tons and an average productivity of 1014 kg ha-1, which is much less than estimated potential of 6.0 tons/ha under optimum growing conditions. In India, chickpea is grown annually in an area of 9.54 million ha with an annual 9.07 million tons production and 951.4 kg ha-1 productivity. In Haryana, area under chickpea was 42000 hectares with a total production of 48000 tonnes and an average productivity of 1117 kg per hectares during 2019-20 **(**Anonymous 2020**).**

In sustainable agriculture system, this crop has low production cost, wide climate adaptation, crop rotation suitability and atmospheric nitrogen fixation ability. Yield potential of chickpea is low due to many reasons that make this crop less competitive with those grown other crop during winter season. Yield is a complex character; its expression depends on the functioning and interaction of many physiological component processes, especially the limiting components that vary with variety. Varieties differ extensively in the physiological processes, determining crop yield. Physiological components are complex characters; they result from the interaction of many component processes and environmental influence on the individual processes or the genes controlling them (Wallance *et al*,1972). Development of varieties largely depends on the amount of genetic diversity present in the base population of the material. An attempt has been made in the paper for study of the degree of genetic variation observed in the F_3 population on the basis of new eighteen chickpea crosses and their further consideration in the subsequent year for breeding programme.

Materials and Methods

Experiment was conducted at Pulses Research Area, Department of Genetics and Plant Breeding, during *Rabi* 2019-20 (F_2 progenies) and 2020-2021 (F_3 progenies) is located at latitude of $29^0$10'N and longitude of $75^0$46' E of CCS Haryana Agricultural University, Hisar, The experimental material consisted of 18 progenies with 75 rows of each F_2 population were planted and 8 row of 4 m length of each F3 progenies with spacing of 50 x 20 cm. The data for quantitative traits *viz*., Total biomass yield, 100-seed weight and seed yield (kg per plot) was recorded on plot basis on 18 F_2 progenies. Eighteen crosses involving thirteen chickpea female and fourteen male genotypes were made in 2017-2018. The F_1 generations were raised in *Rabi* 2018-2019 to obtain the F_2 seeds. The F_2 populations along with their parents were field grown at Pulses Research area CCS, Haryana Agricultural University, Hisar during Rabi-2019-2020. Seventy-five rows of each F_2 and single row of each parent were grown with the spacing of 45 x 10. The data were recorded on randomly selected 75 plants from each F_2 and 5 plants from each parent per replication. The F_3 populations of 18 progenies were grown at Pulses Research Area CCS, Haryana Agricultural University, Hisar during Rabi-2020-2021. Eight rows of each F_3 progenies were grown with the spacing of 45 x 10. The data were recorded on plot basis for the trait *viz*. Total biomass yield, no of pods per plant, seed yield per plot, 100 seed weight (seed index).

Results and discussion

The quantitative character namely total biomass yield per plot, seed yield per plot, 100 seed weight and harvest index of eighteen crosses are presented in Table 1 and Figure 1. It is observed that harvest index ranged from 41.80 to 56.8. %, whereas 56.8 % highest harvest index was recorded in the cross combination (H 12-55 x CSJ 8962) x CSJ 8962 and H 13-09 *x reticulatum* 237 followed by 54.80 % in the cross H 12-55 x GNG 1958 during the 2019-20 in F_2 progenies. However lowest harvest index was recorded 41.8 % by the cross viz. H 14-01 x GL 12003 and H 14-22 x PBG 5. It can also be seen from the Table 1 that the all the 18 F_2 progenies showed a fairly wide range of variation for Total biomass yield, number of pods per plant, 100 seed weight (g) and seed yield means these characters are supposed to have a large influence on harvest index. Monpara and Kalariya (2009) reported significant changes in harvest index due to differences in maturity time of bread wheat cultivars.

Table 1. Mean values of F_2 and F3 generations for total biomass yield, seed yield and harvest index during 2019-2020

Sl. No.	Cross-combination	Total biomass yield (kg/hectare)	Numbers of pods/ plant	Seed yield (kg/hectare)	100 seed weight (g)	Harvest Index (%)
1	GNG 1581 x HC 5	6563	88	2875	16.8	43.8
2	H 08-18 x JG 12	4638	60	2500	17.6	53.9
3	H 12-29 x GNG 2171	4894	51	2500	17.4	51.1
4	H 12-55 x GNG 1958	4325	49	2375	24.0	54.9
5	H 12-63 x GNG 1581	5288	38	2375	16.7	44.9
6	H 13-01 x GNG 1581	6025	51	2875	17.5	47.7
7	H 13-02 x PBG -7	5013	43	2500	16.0	49.9
8	H 13-03 x PBG 7	5775	58	2625	15.9	45.5
9	H 13-09 x JG 14	5075	40	2125	19.2	41.9
10	H 14-01 x GL 12003	5388	43	2250	14.7	41.8
11	H 14-22 x JG 24	5981	63	2750	20.2	46.0
12	H 14-22 x PBG 5	6275	73	2625	17.6	41.8

13	H 12-55 x CSJ 8962) x CSJ 8962	7256	178	4125	14.8	56.8
14	H 12-63 x ICC 37	4650	85	2250	18.2	48.4
15	H 13-01 x ICC 37	4488	95	2375	16.4	52.9
16	H 13-09 x *reticulatinum*) x H 13-09	3963	70	2250	16.5	56.8
17	Virat x CSJ -741	5438	58	2875	16.1	52.9
18	H 13-12 x *judaicum*	4343	43	2250	17.8	51.8
HC 5 (Check)		5445	78	2458	16.7	45.1
GNG 1581 (Check)		5098	65	65	2039	40.1

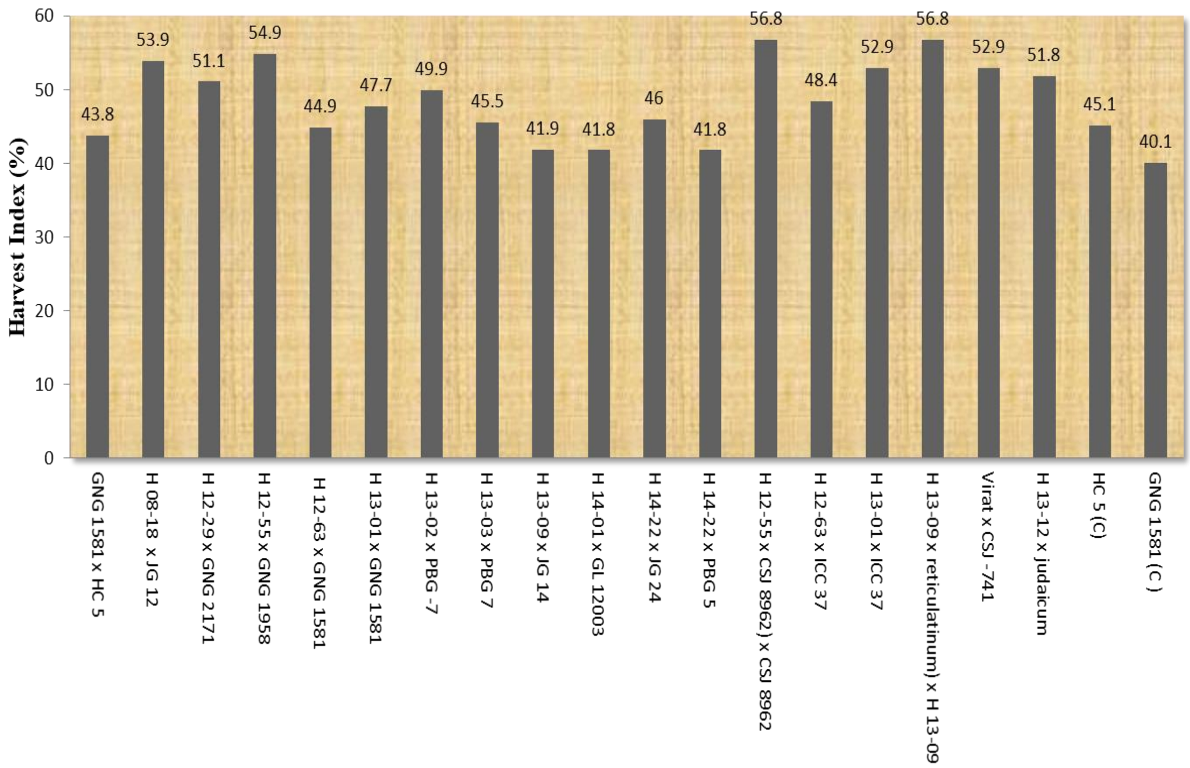

Fig. 1. Comparison of cross combination on the basis of harvest index in F_2 progeny during 201-20

The mean values of cross combination ranged from 39.7 to 62.0 % in the F_3 generation (Table 2 and Figure 2). In F_3 progenies highest harvest index was recorded 62.0 % by the cross-combination in (H13-09 x *reticulatum* 237) x H 13-09 and H 12-55 x GNG 1958 followed by 59.9 % in (H 12-55 x CSJ8962) x CSJ 8962. However the lowest harvest index was reported 39.70 % in GNG 1581 x HC 5 followed by 44.90 in H 13-09 x JG 14.

This suggests that genes involved in the inheritance of harvest index may vary in their nature and are expressed differently in different genetic backgrounds. Further, it was observed that the magnitude of variation among the F_2 and F_3 segregates of a cross was not proportionate to the degree of diversity of the parents involved in a particular cross. Thus, results indicate that parents involved in cross combination with varying level of harvest index behaved differently in releasing variability for harvest index.

Table 2. Mean values of F_3 generations for total biomass yield, seed yield and harvest index during 2020-2021

Sl. No	Cross-combination	Total biomass yield (kg/hectare)	Numbers of pods/ plant	Seed yield (kg/hectare)	100 seed weight (g)	Harvest Index (%)
1	**GNG 1581 x HC 5**	4450	58	1103	20.1	39.7
2	**H 08-18 x JG 12**	2710	40	969	18.2	57.2
3	**H 12-29 x GNG 2171**	3675	51	1281	18.3	55.8
4	**H 12-55 x GNG 1958**	2860	69	1109	24.8	62.0
5	**H 12-63 x GNG 1581**	3450	48	1034	19.5	47.9
6	**H 13-01 x GNG 1581**	3860	71	1325	18.9	54.9
7	**H 13-02 x PBG -7**	3725	63	1113	17.9	47.8
8	**H 13-03 x PBG 7**	3645	48	1028	18.8	45.1
9	**H 13-09 x JG 14**	3450	49	969	21.1	44.9
10	**H 14-01 x GL 12003**	3830	47	1088	18.8	45.4
11	**H 14-22 x JG 24**	3385	53	1097	26.4	51.8
12	**H 14-22 x PBG 5**	3520	36	1013	20.4	46.0
13	**H 12-55 x CSJ 8962) x CSJ 8962**	4805	93	1799	15.1	59.9
14	**H 12-63 x ICC 37**	3420	42	969	20.9	45.3
15	**H 13-01 x ICC 37**	3320	45	1069	20.9	51.5
16	**H 13-09 x *reticulatinum*) x H 13-09**	2670	60	1034	18.9	62.0
17	**Virat x CSJ -741**	3750	58	1113	20.8	47.5

18	**H 13-12 x *judaicum***	2875	53	1047	19.6	58.3
HC 5 (Check)		3350	52	959	15.4	45.8
GNG 1581 (Check)		3645	47	1028	16.1	45.1

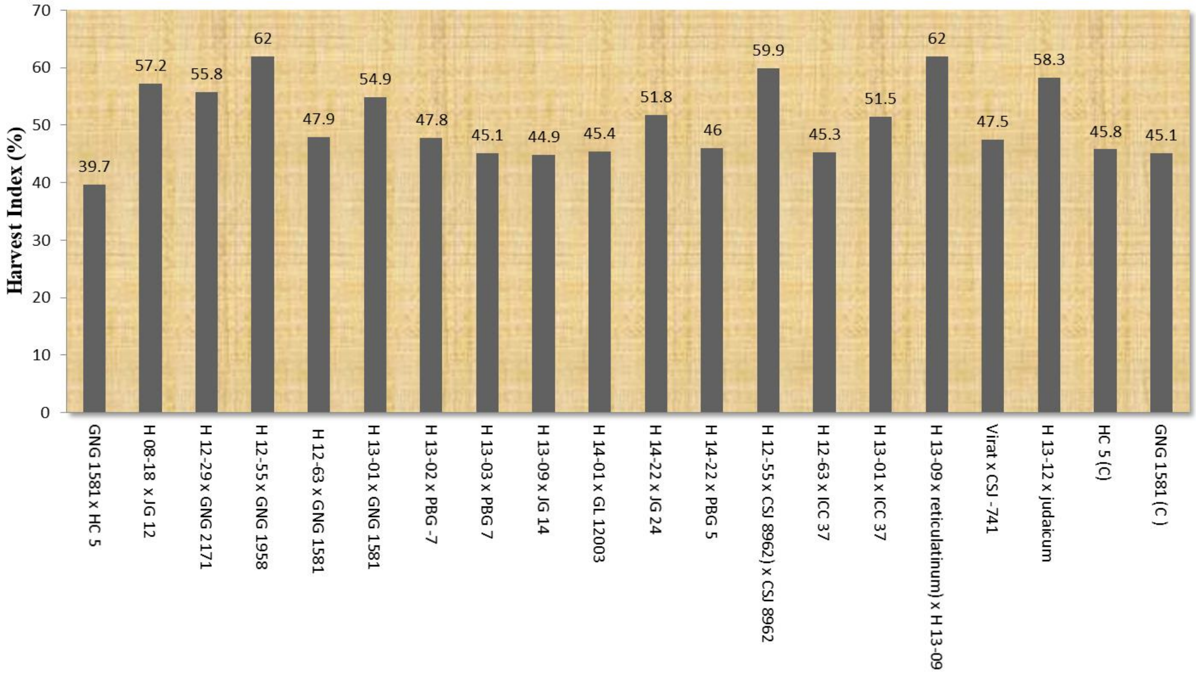

Fig. 2. Comparison of cross combination on the basis of harvest index in F2 progeny during 2020-21

As reported in Table 3 and Figure 3 the mean values of cross combination ranged from 41.8 to 59.4 % in the F_2 and F_3 generation. From figure 3 highest harvest index was recorded 59.4 % by the cross-combination in (H 13-09 x *reticulatum* 237) x H 13-09 followed by 58.5 % in H 12-55 x GNG 2171 and 58.4 % in H 12-55 x GNG 1958. Whereas, the lowest harvest index was reported 41.8.7 % (GNG 1581 x HC 5) followed by 42.60 % (GNG 1581 check variety of chickpea).

Table 3. Mean values of F_2 and F_3 generations for total biomass yield, no of pods/plant, seed yield and harvest index

Sl. No	Cross-combination	Total biomass yield (kg/hectare)	Numbers of pods/ plant	Seed yield (kg/hectare)	100 seed weight (g)	Harvest Index (%)
1	**GNG 1581 x HC 5**	5507	73	1989	18.5	41.8
2	**H 08-18 x JG 12**	3674	50	1735	17.9	55.6

3	**H 12-29 x GNG 2171**	4285	51	1891	17.9	53.5
4	**H 12-55 x GNG 1958**	3593	59	1742	24.4	58.5
5	**H 12-63 x GNG 1581**	4369	43	1705	18.1	46.4
6	**H 13-01 x GNG 1581**	4943	61	2100	18.2	51.3
7	**H 13-02 x PBG -7**	4369	53	1807	17.0	48.9
8	**H 13-03 x PBG 7**	4710	53	1827	17.4	45.3
9	**H 13-09 x JG 14**	4263	45	1547	20.2	43.4
10	**H 14-01 x GL 12003**	4609	45	1669	16.8	43.6
11	**H 14-22 x JG 24**	4683	58	1924	23.3	48.9
12	**H 14-22 x PBG 5**	4898	55	1819	19.0	43.9
13	**H 12-55 x CSJ 8962) x CSJ 8962**	6031	136	2962	15.0	58.4
14	**H 12-63 x ICC 37**	4035	64	1610	19.6	46.9
15	**H 13-01 x ICC 37**	3904	70	1722	18.7	52.2
16	**H 13-09 x *reticulatinum*) x H 13-09**	3317	65	1642	17.7	59.4
17	**Virat x CSJ -741**	4594	58	1994	18.5	50.2
18	**H 13-12 x *judaicum***	3609	48	1649	18.7	55.1
HC 5 (Check)		4398	65	1268	16.1	45.5
GNG 1581 (Check)		4372	56	1052	15.1	42.6

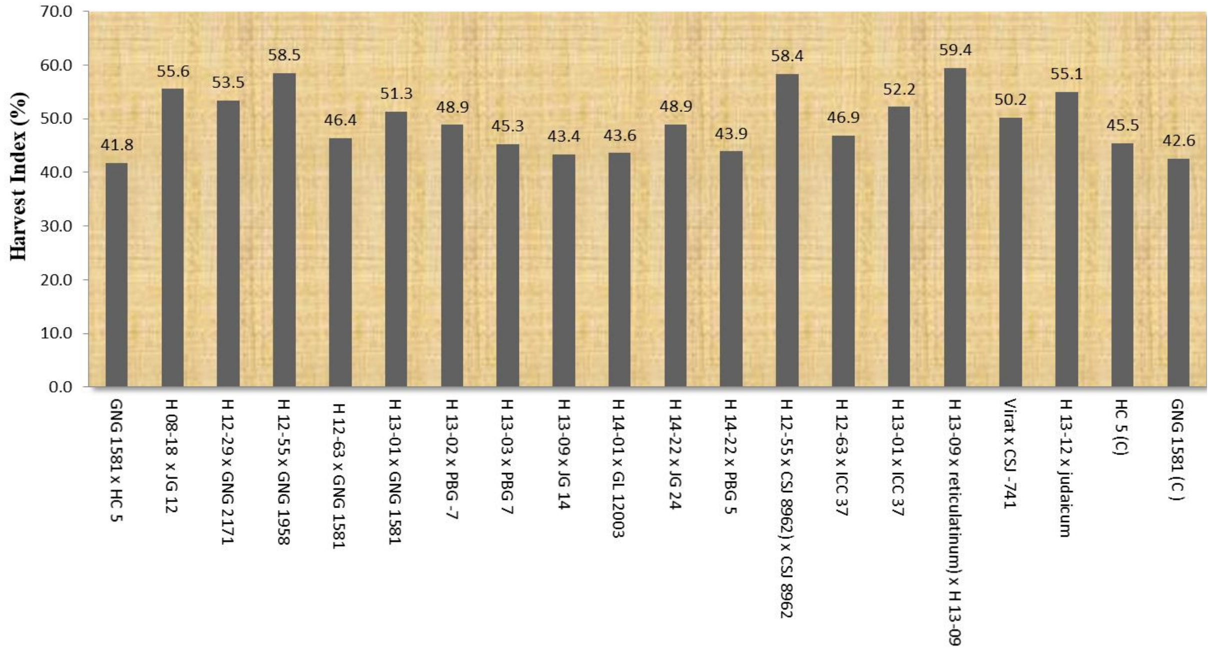

Fig. 3. Comparison of cross combination on the basis of harvest index in F2 and F3 progeny

The (H 13-09 x *reticulatum* 237) x H 13-09, H 12-55 x CSJ 8962) x CSJ 8962, which recorded the highest harvest index in F_2 as well as in F_3 mean indicated that these three-way crosses have better parent of mean indicating transgressive segregation. This suggests that genes involved in the inheritance of harvest index may vary due to genotype and environment interaction (G x E) in their nature and are expressed differently in different genetic backgrounds. Considering this phenomenon of segregation pattern, harvest index should be exploited in later generations (F_2 to F_6) to select genotypes as it forms a useful measure of yield potential and easy to measure on a large number of plants. The limit up to which harvest index can be increased in chickpea is considered to be around 50 % suggests that further improvements in partitioning of biomass would be possible by Qureshi *et al*, 2004. Large variability together with high heritability coupled with high genetic advance for harvest index, as obtained in present study, indicating genetic gain in yield improvement by exerting selection pressures for harvest index in early segregating generations is possible. The results obtained in current study are in agreement with those reported by Kumar *et al*, (1999), Gumber *et al*, (2003), Singh *et al*, (1980) and Sidramappa *et al*, (2008).

Harvest index is an important aspect of dry weight partitioning in favour of seeds. It is relationship between source (leaf, stem, root) to ultimately to sink (seed). Obviously, its correlation should be positive with seed yield and often negative with total biomass yield.

Suitable recombination may be recovered through line x tester, biparental mating or diallel selective mating system. In chickpea breeding programme, efforts are being made continually to make several crosses per year to accelerate the development of new varieties. In such situations, handling of segregating generations is very difficult and expensive. Therefore, selection of promising crosses for further advancement may be necessary. Our results of the present study indicated that more emphasis should be given to the (H 13-09 x *reticulatum* 237) x H 13-09, H 12-55 x CSJ 8962) x CSJ 8962, H 12-55 x GNG 1958 and H 08-18 in an effort to developing better yielding variety. From this material, we have already two new chickpea variety has been released on national level viz. H 12-55 (2020) i.e. HC 7 (Haryana Chana number 7) for north west plain zone (NWPZ) for late sown condition which mature in 140 days and H 08-18 (HC 6) for Haryana state for normal as well as late sown condition mature in 150 days. New variety H 08-18 (HC 6) recorded the highest protein content (21.76 %) as compared to other new variety released from north zone not recorded more than 20.0 % protein content. However, it is necessary to do further study on F_3–derived F_4-F_6 population to see the response of early and advanced generation's selection for seed yield and other useful traits. Parents with diverse genetic backgrounds involving in production of several crosses would be desirable in order to exert among cross selection, and achieve accelerated yield improvement in chickpea. The results of studied also indicated that wild *Cicer* annual accessions of *C. reticulatum* species can be exploited for traits of interest for diversification of cultivated gene pool and subsequent use in chickpea improvement.

References

Anonymous. (2020). Economic Survey of Haryana, Department of Economics and Statistical Haryana. Page no 36.

Bishop, J. Potts, S.G. and Jones, H.E (2016). Susceptibility of faba bean (*Vicia faba* L.) to heat stress during floral development and anthesis. *J. Agron. Crop Sci. 202*, 508–517.

Gumber R K, Singh S. and Rathore P, (2003). Genetic parameters for different leaf and seed traits in chickpea. *Legume Research*, Vol. 26, pp. 36-38.

Jodha N.S. and Subbarao K.V. (1987). Chickpea: World importance and distribution. In: Saxena, M.C. and Singh, K.B.(Eds.). *The chickpea*. CAB International, Wallingford, U.K.

Kumar V, Kar, C. S. and Sharma P. C. (1999). Variability, correlation and path coefficient analysis in chickpea (*Cicer arietinum* L.). *Environment and Ecology*, Vol. 17, pp. 936-939, (*Pl. Br. Absts*. (2000) Vol. 70, No. 5, pp. 4912.

Maiti R. K. (2001). The chickpea crop. In: Maiti R. and Wesche-Ebeling P.(Eds.). *Advances in chickpea science*. Science Publishers, Inc., Enfield, NH.pp.1-32.

Monpara B. A. and Kalariya R. P. (2009). Changes in certain yield traits as influenced by differences in maturity time in bread wheat. *Plant Archives*, Vol. 9, pp. 335-339.

Qureshi A. S, Shaukat A. and Bakhsh. A. (2004). An assessment of variability for economically important traits in chickpea (*Cicer arietinum* L.). *Pakistan Journal of Botany*, Vol. 36, pp. 779-785.

Ritchie, J.T., Singh, U., Godwin, D.C. and Bowen, W.T. (1998). Cereal growth, development and yield. In: Tsuji, G.Y., Hoogenboom, G., Thornton, P.K. (Eds.), Understanding Options for Agricultural Production, Kluwer Academic Publishers, Dordretcht, pp. 79–98.

Schierenbeck, K.A. (2016). Population-level genetic variation and climate change in a biodiversity hotspot. *Annal. Bot. 119*, 215–228.

Sidramappa, Patil S. A., Salimath P. M. and S. T. Kajjidoni. (2008). Direct and indirect effects of phenological traits on productivity in recombinant inbred lines population of chickpea. *Karnataka J. Agric. Sci*. 21(4): 491-493.

Sinclair, T.R.(1986). Water and nitrogen limitations in soybean grain production. I. Model development. *Field Crops Res*. 15, 125–141.

Singh H P, Saxena M .C. and Sahu J.P. (1980). Harvest index in relation to yield of grain legumes. *Tropical Grain Legume Bulletin*, Vol. 17/18, pp. 6-8.

Wallance D. H., Ozbun J. L. and Munger H. M, 1972. Physiological genetics of crop yield. *Advances in Agronomy*, Vol. 24, pp. 97-146.
