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HETEROSIS FOR NITROGEN FIXATION AND SEED YIELD AND YIELD COMPONENTS IN CHICKPEA (Cicer arietinum L.)

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ABSTRACT

Chickpea is one of the most cultivated grain legumes in Ethiopia for grain production and amelioration of soil fertility with less attention in research on N-fixation. Therefore, this study was conducted to estimate the magnitude of heterosis for nitrogen fixation and yield and yield associated traits in chickpea (*Cicer arietinum* L.). Six F1 crosses obtained from crossing of four parents (two nodulated and non-nodulated) in a half diallel fashion were evaluated in 2014/15 season in lath house using Randomized Complete Block Design (RCBD) with two replications at Debre Zeit Agricultural Research Center. Significant (P<0.05) differences were exhibited among entries for all traits studied. Considering all traits, relative to the mid parent (MPH), better parent (BPH) and standard heterosis (SH) in percent ranged from 0.009 to 59.8, 0.009 to39.9 and 0.009 to58.8, respectively. The highest degrees of MPH were noted for nodule dry weight and of BPH and SH were noted for number of pods per plant, while the lowest was observed for grain yield (0.009). The hybrid obtained from nodulated parents (ICC5003 x ICC19180) showed high heterosis for number of nodule on the basis of MPH and BPH, while ICC4918x ICC19181 exhibited low heterotic effect which exhibited positive and significant MPH for nitrogen fixed in grain, BPH for seed filling duration and SH for days to 50% flowering, days to 90% maturity and shoot dry weight at maturity traits.

1. INTRODUCTION

Chickpea (*Cicer arietinum* L.) is one of the most important food legume crops widely produced - globally on over 12 million hectares of land from which 10.9 million tons of grain is produced every year (FAOSTAT, 2012). It ranks second in area coverage (15.3% of the total area allotted to food legumes) and third in volume of production (14.6%) after common beans (*Phaseolus vulgaris* L.) and field peas (*Pisum sativum* L.) (Knights *et al.*, 2007). In Ethiopia chickpea production ranks third in area and production among legumes next to faba bean and haricot bean (CSA, 2014/15). Out of 1.6 million hectares allocated for pulse , chickpea covered 239,755 hectares of land from which 458,682 tons of grain was produced, and the productivity was 1.92t/ha (Central Statistical Authority (CSA), 2015). Chickpea is the cheapest and readily available source of protein (20%-30% %), fats (1.4%), carbohydrates (57-60%), ash (4.8%) and (4.9-15.59%) moisture. It makes up the deficiency of cereal diets. From soil fertility management and water conservation point of view, production of chickpea plays a significant role in restoring soil fertility by fixing atmospheric nitrogen and contributes to agricultural sustainability (Gaur *et al.*, 2010) and it can be produced under deficient moisture condition for most field crops. Therefore, targeted efforts to breed genotypes for improved N_2 fixation and rhizobial symbiosis will bring benefits in increased yields of chickpea and will contribute toward sustainability of agricultural ecosystems in which soil-plant-microbe interactions enhanced.

The magnitude of heterosis provides a basis for determining genetic diversity and serves as a guide to the choice of desirable parents (Khattak *et al.*, 2002). In grain legumes, the heterosis is generally due to dominance gene effects but also sometimes due to epistatic interactions (Khattak *et al.*, 2002). Hence, the information regarding epistatic interaction is useful in planning a breeding program for development of pure lines with enhanced yield potential (Khattak *et al.*, 2002). Therefore, this experiment was designed with the objective to estimate the magnitude of heterosis in chickpea genotypes for estimating symbiosis and yield and yield related traits

2. MATERIALS AND METHODS

Both the crossing and evaluation experiments were conducted at Debre Zeit Agricultural Research center (DZARC) during 2013-2014. Two nodulating chickpea (ICC5003 and ICC19180) and two non-nodulating genotypes (ICC4918 and ICC19181) were introduced from ICRISAT (Table 1) and crossed in half diallel fashion to develop F_1 generations as a mating design described by Griffing (1956) Method II Model I without reciprocal crosses. Sufficient amount of flowers were emasculated and pollinated to get F_1 generations. Crossing was done by hand emasculation and pollination using forceps to produce a total of six (6) hybrids. The four parental materials with their six crosses (F_1) and two recently released standard checks (Arerti and Natoli) which are moderately nodulating were planted in Randomized Complete Block Design with 2 replication at Debre Zeit research experimental station using irrigation during 2014. Plant to plant and row to row distance was 10 and 30cm respectively. Each plots consisting of 4 rows of 2 meters long. Two seeds were planted per hill and finally thinned to one plant per hill after 3 weeks of emergence. All other agronomic practice like weeding and irrigation was done as per recommendation. Data on Days to 50% flowering, Days to 90% maturity, Grain production efficiency, Biomass production rate, Economic growth rate, Number of pods per plant, Biomass yield, Grain yield, Grain Harvest index, 100seed weight, Shoot dry weight at physiological maturity, Shoot dry weight ratio, Number of nodules, Shoot nitrogen fixation , N fixed in biomass, N fixed in grain, Nitrogen harvest index (NHI), Grain N yield, Shoot N yield, Biomass N yield, Nodule dry weight and Shoot and grain protein contents. N-content were determined according to Kjeldahl procedure at Debre Zeit Agricultural Research Center Soil Science Research Laboratory Association of Official Agricultural Chemists (AOAC) (1970).

Table-1. Phenotypes, nodulation characteristics and origin of the chickpea genotypes used for the study

No	Genotype	Phenotype	Nodulation Characteristics	Origin
1	ICC5003	Desi	Nod^+	ICRISAT
2	ICC19180	Kabuli	Nod^+	ICRISAT
3	ICC4918	Desi	Nod^-	ICRISAT
4	ICC19181	Desi	Nod^-	ICRISAT
5	Arerti	Kabuli	Nod^+	DZARC
6	Natoli	Desi	Nod^+	DZARC

** Nod^+= nodulating , Nod^-= non-nodulating*

2.1. Heterosis

1. Heterobeltosis, the superiority of the F_1 hybrid over its best parent (P_1), expressed as percentage:

$HP(\%) = \frac{(F_1-P1)}{P1} x100$, where, HP= heterobeltosis, P_1 represent best parents in the crosses

2. The mid-parent heterosis was calculated as:

$MH(\%) = \frac{(F_1-(P1+P2)/_2}{(p1+P2)/_2} x100$, where MH=Mid-parent heterosis

3. Economic/ standard heterosis, the superiority of the F_1 hybrid over the standard commercial hybrid variety, expressed as percentage:

$Hs(\%) = \frac{(F1-Sv)}{Sv} x100$, , where, Hs= standard heterosis, and S_v=standard variety

The significance test of all the three heterosis was done for each character in reference of least significance difference (LSD) of each character from the analysis of variance both at 5% and 1% level of probability.

3. RESULT AND DISCUSSION

3.1. Analysis of Variance and Mean Performance of Parents and Hybrids

3.1.1. Phenology and Physiology of the Crop

The mean squares for four parents and six hybrids of chickpea produced by crossing in half diallel fashion and the two standard checks with respect to seven phenology and physiology traits are presented in Table 2. Analysis of variance revealed the presence of significant (P<0.05) differences for all the traits viz. days to 50% flowering, days to 90% maturity, seed filling duration, grain producing efficiency, biomass producing efficiency and economic growth rate of the crop.

Table-2. Mean values of phenology and physiology of the crop of four parents, six F_1 hybrids and the two checks of chickpea genotypes

Genotypes	DF	DM	SFD	GPE	BPR	EGR
ICC5003	54c	111.5cde	57.5de	107.07cde	0.29a	0.04a
ICC5003 X ICC4918	52c	111cde	59 bcde	114.06bcde	0.20cd	0.023cd
ICC5003X ICC19180	54c	109def	55de	102.06def	0.25abc	0.04a
ICC5003X ICC19181	63.5b	117b	53.5e	86.48ef	0.21bcd	0.021cd
ICC4918	48.5c	108ef	59.5bcde	122.96bcd	0.21bcd	0.016d
ICC4918X ICC19180	48.5c	107f	58.5cde	120.89bcd	0.21bcd	0.03ab
ICC4918X ICC19181	48.5c	114.5bc	66ab	136.1bc	0.15de	0.022cd
ICC19180	38.5d	106f	67.5a	175.37a	0.23abc	0.018cd
ICC19180XICC19181	47cd	112.5cd	65.5abc	141.9b	0.20cd	0.017cd
ICC19181	72.5a	127.5a	55de	75.89f	0.12e	0.016d
Arerti	53.5c	114.5bc	61abcd	114.05bcde	0.28a	0.024cd
Natoli	52c	112.5cd	60.5abcde	116.35bcde	0.26ab	0.27bc
GM	52.7	112.6	59.87	117.77	0.21	0.25
CV%	7.46	1.38	4.99	11.03	12.6	17.78

Means in column with the same letter is not significantly different from each other, BPR= biomass production rate in %, CV=Coefficient of variation , DF=days to 50% flowering (# of days), DM=days to 90% flowering (# of days), EGR= economic growth rate in %, GM=Grand mean, , GPE=grain production efficiency in %, SFD=seed filling duration (# of days).

3.1.2. Yield and Yield Components

Analysis of variance indicated that the mean squares for four parents, six hybrids and two checks of chickpea genotypes with respect to grain yield and yield components are presented in Table 3. Results of the analysis showed significant (P<0.05) differences for all the traits viz. number of pods per plant, biomass yield, grain yield, grain harvest index, 100seed weight, shoot dry weight at maturity, shoot dry weight ratio and grain protein content.

Table-3. Mean values of different grain yield and yield components of four parents and their six F1 chickpea hybrids and two check genotypes

Genotypes	NPP	BM	GY	GHI	HSW	SDWM	SDWR	SPC	GPC
ICC5003	92.5ab	0.33a	0.023ab	0.071abcd	24.35a	49.5bc	1.04bc	22.65a	22.7ab
ICC5003 X ICC4918	64.9cdef	0.2cd	0.013cd	0.062bcd	20.4bc	49.5bc	1.04bc	22.25a	20.5abc
ICC5003 X ICC19180	90.7ab	0.3abc	0.024a	0.089ab	25.48a	26.3e	0.55e	23.9a	22.9a
ICC5003 X ICC19181	60.85cdef g	0.3bc	0.011cd	0.045d	17.85cde	39.3cd	0.8cd	23.46a	20.4abc
ICC4918	42bcd	0.2cd	0.009d	0.044d	16.75de	43bcd	0.9bcd	12c	12.0e
ICC4918 X ICC19180	108.55a	0.2cd	0.021ab	0.0	19.5bcd	48.1bc	0.77d	21.06a	20.09c
ICC4918 X ICC19181	77.08bc	0.2de	0.0146cd	0.085abc	18.46cd	36.6d	1.01bc	14.5bc	12.8e
ICC19180	49.8efg	0.3bc	0.012cd	0.048d	22.85ab	36.6d	0.77d	24.15a	19.37cd
ICC19180 X ICC19181	74.4bcd	0.2cd	0.011cd	0.051cd	14.85e	50.9b	1.07b	20.78a	19.34cd
ICC19181	44.12fg	0.15e	0.01cd	0.062bcd	19.6bc	62.3a	1.31a	16.2b	12.09e
Arerti	51.95defg	0.33a	0.0146cd	0.045d	17.85cde	67.2a	1.42a	23.7a	17.18d
Natoli	71.25bcde	0.3ab	0.016bc	0.055bcd	19.1cd	67.1a	1.41a	22.9a	20.2cb
GM	69.00	0.24	0.015	0.06	19.75	47.9	1.01	20.64	18.3
CV%	14.87	12.00	17.8	24.44	8.2	9.1	9.06	9.02	5.8

BM=biomass yield in kg, CV=Coefficient of variation, GHI=grain harvest index in %, GM=Grand mean, GPC=grain protein content in %, GY=grain yield per plant in kg, HSW=hundred seed weight in gm, NPP=number of pod per plant, SDWM=shoot dry weight at physiological maturity in gm, SDWR= shoot dry weight ratio.

If yield is taken as an ultimate impact indicator of the hetrotic values, there are clear indications that the genetic pool in favor of yield has influenced yield of chickpea (Figure 1). This gain gives favorable indication on genetic gain in chickpea as a factor of mobilization of different cluster of favorable genes using divers combination and evaluation designs.

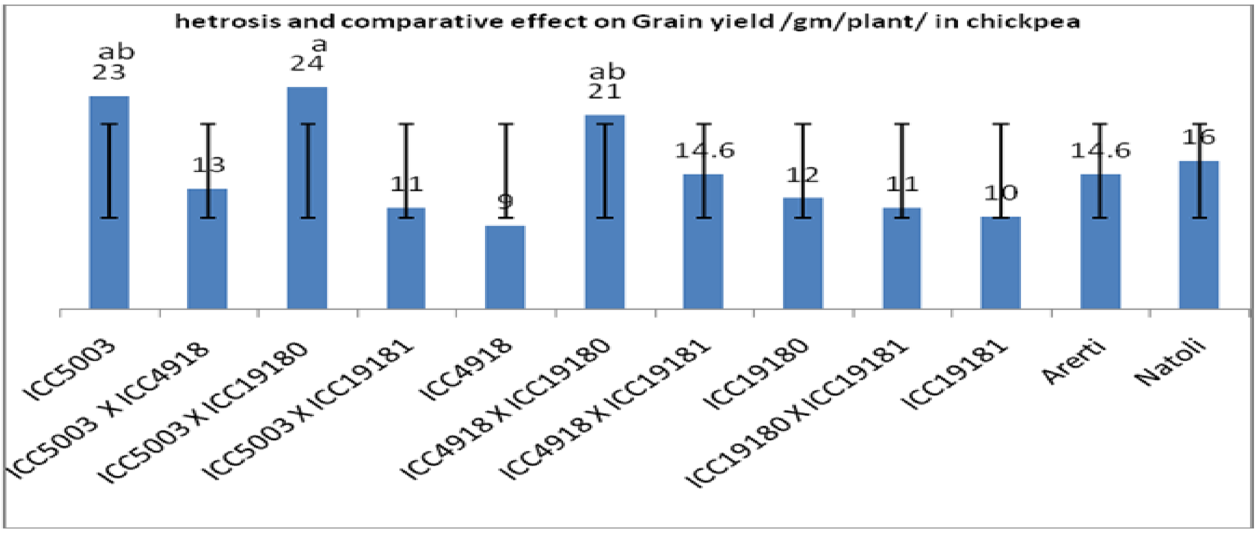

Figure-1. Effective and comparative hetrotic values on economic yield in chickpea

3.1.3. Symbiosis Parameters

The analysis of variance (Table 4) revealed a significant difference among number of nodule, shoot nitrogen yield, shoot nitrogen fixation, nitrogen fixed in grain, grain nitrogen yield, biomass nitrogen yield, nitrogen harvest index and nodule dry weight. A significant difference between genotypes with respect to number of nodules per plant was also recorded in this study (Table 5). Variation for number of nodule was recorded in the current study, among nodulated and non nodulated genotypes.

Table-4. Mean values of symbiosis parameters of 4 parents and 6 F_1 chickpea genotypes

Genotypes	NN	SNF	NFB	NFG	NHI	GNY	NDW
ICC5003	52b	45.91a	46.52a	47.1a	0.07bc	0.083a	71.8cd
ICC5003XICC4918	26d	44.89a	43.16a	41.2ab	0.05bcd	0.045cd	95.7b
ICC5003XICC19180	57.3a	48.81a	48.26a	47.7a	0.08a	0.088a	50.9d
ICC5003XICC19181	22.9d	47.70a	44.66a	41.1ab	0.04d	0.036cde	48.9d
ICC4918	0.00g	0.00b	0.00b	0.0d	0.044cd	0.018e	0.00e
ICC4918X ICC19180	14.8e	41.57a	41.04a	40.3b	0.09a	0.069ab	61.8d
ICC4918X ICC19181	0.00g	13.43b	10.57b	6.3d	0.07ab	0.03de	0.00e
ICC19180	17.8e	49.28a	44.29a	38.1b	0.041d	0.037cde	157a
ICC19180XICC19181	8.9f	40.94a	39.52a	38b	0.048cd	0.035cde	106.8b
ICC19181	0.00g	20.03b	12.89b	0.8d	0.049cd	0.018e	0.00e
Arerti	46.5c	48.30a	40.60a	29.9c	0.03d	0.04cd	70.9cd
Natoli	23.6d	46.58a	43.81a	40.6ab	0.05cd	0.054bc	86.8bc
GM	22.5	37.29	34.6	30.9	0.058	0.046	62.4
CV%	8.4	24.4	16.6	10.9	21.6	19.5	16.8

Means in a column followed by same letter are not significant at ($p \geq 5$)
CV=Coefficient of variation , GM=Grand mean, GNY=grain nitrogen yield, NDW=nodule dry weight milligram, NFG=nitrogen fixed in grain, NHI=nitrogen harvest index in %, NN=number of nodule, SNF=shoot nitrogen fixation, NFB=nitrogen fixed in biomass

3.2. Heterosis

Mid-parent heterosis, heterobeltiosis and standard heterosis values were estimated for Phenological and physiological data, Yield and yield component data and Symbiosis data collected (Table 5).

The cross ICC5003XICC19180 revealed the highest heterotic effects for shoot nitrogen fixation, nitrogen fixed in biomass, nitrogen fixed in grain, grain nitrogen yield, nodule dry weight, shoot protein content, grain protein content and economic growth rate over the mid parent. ICC5003XICC4918 showed positive and significant heterosis over the mid-parent for number of nodule, grain nitrogen yield, grain yield and economic growth rate. Significant and positive heterotic value over mid parent was estimated in ICC5003XICC19180 for nitrogen fixed in biomass, nitrogen fixed in grain and grain protein content. Cross ICC4918XICC19180 exhibited the highest heterotic effect over mid parent for number of pod per plant, number of nodule, nitrogen fixed in biomass, nitrogen fixed in grain, grain nitrogen yield, shoot protein content, grain protein content and economic growth rate. From all crosses, ICC4918XICC19180 only revealed the highest heterotic effect for nitrogen fixed in grain over mid parent. However, hybrid ICC19180XICC19181 showed the highest value for heterosis over mid-parent for number of pod per plant, nitrogen fixed in grain, nodule dry weight, shoot protein content and grain protein content (Table 5). This result was in agreemeent with the report of Abdul *et al.* (1990) for 100seed weight, number of pods per plant , grain yield and harvest index in mung bean. Afsari *et al.* (2001) reported positve and signifcant heterosis for grain yield, number of pod per plant and biological yield in chickpea but, negative heterosis for 100 seed weight and harvest index. Of the crosses, ICC5003XICC4918 was identified as best progeny for some of the symbiotic triats like shoot nitrogen fixation, nitrogen fixed in biomass, nitrogen fixed in grain, grain nitrogen yield, nodule dry weight, shoot protein content and grain protein content. Therefore, this cross can be used for further heterosis breeding on these symbiotic traits in chickpea.

Best parent heterosis (heterobeltiosis) showed negative and insignificant heterotic effects for most of the traits (Table 5). ICC5003XICC4918 revealed significant heterotic effect over the best parent for number of nodule, grain nitrogen yield, grain yield and economic yield. Cross ICC4918xICC19180 showed the highest heterotic effect over best parent for days to 50% flowering, number of pod per plant, and economic growth. ICC4918XICC19181 showed positive and significant heterobeltiosis for seed filling duration. But heterotic effect over best parent in ICC19180XICC19181 was positive and significant for days to 90% maturity and seed filling duration). Similar to current study, in mungbean, Abdul *et al.* (1990) observed non-significnat heterotic effect (heterobeltiosis) for 100seed weight , number of pod per plant , grain yield and harvest index. Afsari *et al.* (2001) also observe positive heterosis over best parent for biomass and number of pod per plant in chickpea.

ICC5003XICC4918 revealed positive and significant heterosis over the standard parents for days to 50% flowering, days to 90% maturity, number of nodule, shoot dry weight at maturity, shoot dry weight ratio, and economic growth rate. ICC5003XICC19180 showed significant heterosis over standard parent for days to 50% flowering, days to 90% maturity, number of nodule, nitrogen fixed in grain, grain nitrogen yield, grain yield, grain protein content and economic growth rate. Standard heterosis was positive and significant for days to 50% flowering, days to 90% maturity and number of nodule, in ICC5003XICC18191. ICC4918XICC19180 exhibited significant heterosis over standard parent for days to 50% flowering, number of pod per plant, shoot dry weight at maturity, and economic growth rate. ICC4918XICC19181 showed significant heterosis over standard parent for days to 50% flowering, days to 90% maturity and shoot dry weight ratio. ICC19180XICC19181 showed only significant heterosis over standard parents for days to 90% maturity, shoot dry weight at maturity and shoot dry weight ratio (Table 5). Abdul *et al.* (1990) reported positve and significnat heterosis over standard parents in mung bean for number of pod per plant. Afsari *et al.* (2001) also found positive standard heterosis for harvest index in chickpea. The result of this study could be an indicator to recognize the most promising genotypes to be exploited either as F_1 hybrids or as a resource population for further selection.

In self-pollinating crops, the main universal shortcoming in the use of hybrid varieties is the difficulty of producing large quantities of hybrid seed (Saxena and Rupela, 1987; Singh, 2008). The same authors indicated that the difficulty of producing hybrid seeds hinder the utilization of heterosis in chick pea (Saxena and Rupela, 1987) and also the direct utilization of heterosis in legumes is limited due to cleistogamous nature of their flower (Afsari *et al.*, 2001).

Table-5. Mid parent heterosis, heterobeltiosis and standard heterosis

	ICC5003XICC4918			ICC5003XICC19180			ICC5003XICC19181			LSD	
	HM(%)	HP(%)	HS(%)	HM(%)	HP(%)	HS(%)	HM(%)	HP(%)	HS(%)	5%	1%
DF	1.46 ^{ns}	-3.70 ^{ns}	35.06*	16.8 ^{ns}	0.0 ^{ns}	40.26**	0.4 ^{ns}	17.6 ^{ns}	64.9**	9.63	13.8
DM	0.31 ^{ns}	0.00 ^{ns}	14.08**	3.6 ^{ns}	-2.5 ^{ns}	10.56**	-6.0 ^{ns}	1.9 ^{ns}	15.5**	3.52	5.1
SFD	-1.69 ^{ns}	-10.8 ^{ns}	-10.77 ^{ns}	-16.9 ^{ns}	-24.6 ^{ns}	-24.6 ^{ns}	-22.9 ^{ns}	-14.0 ^{ns}	-43.1 ^{ns}	7.46	10.7
NPP	-4.77 ^{ns}	-5.53 ^{ns}	30.32 ^{ns}	-1.7 ^{ns}	-14.6 ^{ns}	15.86 ^{ns}	-11.1 ^{ns}	-26.6 ^{ns}	-0.4 ^{ns}	25.35	36.4
NN	0.00 ^{ns}	-50 ^{ns}	46.07**	64.2**	10.2*	221.9**	-11.9 ^{ns}	-56.0 ^{ns}	28.7*	4.2	6.0
SNF	95.56*	-2.22 ^{ns}	-8.91 ^{ns}	2.6 ^{ns}	6.3 ^{ns}	-0.95 ^{ns}	44.7 ^{ns}	3.9 ^{ns}	-3.2 ^{ns}	21.63	31.1
NFB	85.55**	-7.22 ^{ns}	-2.55 ^{ns}	6.3 ^{ns}	3.7 ^{ns}	8.96 ^{ns}	50.3*	-4.0 ^{ns}	0.8 ^{ns}	13.22	19.0
NFG	74.95**	-12.5 ^{ns}	8.14 ^{ns}	12.0 ^{ns}	1.3 ^{ns}	25.20**	71.6**	-12.7 ^{ns}	7.9 ^{ns}	5.89	8.5
NHI	30.23 ^{ns}	21.74 ^{ns}	21.7 ^{ns}	27.3 ^{ns}	21.7 ^{ns}	21.74 ^{ns}	-45.1 ^{ns}	-53.3 ^{ns}	-39.1 ^{ns}	0.07	0.1
GNY	23.53**	-16.0 ^{ns}	0.00 ^{ns}	26.1 **	16.0**	38.10**	-25.7 ^{ns}	-48.0 ^{ns}	-38.1 ^{ns}	0.02	0.0
SNY	-10.24 ^{ns}	-38.7 ^{ns}	-18.57 ^{ns}	-6.7 ^{ns}	-18.3 ^{ns}	8.57 ^{ns}	33.9 ^{ns}	-15.1 ^{ns}	12.9 ^{ns}	0.21	0.3
BNY	-1.86 ^{ns}	-33.1 ^{ns}	-12.22 ^{ns}	0.0 ^{ns}	-11.9 ^{ns}	15.56 ^{ns}	17.6 ^{ns}	-23.7 ^{ns}	0.0 ^{ns}	0.22	0.3
BM	-17.86 ^{ns}	-30.3 ^{ns}	-8.00 ^{ns}	-3.4 ^{ns}	-15.2 ^{ns}	12.00 ^{ns}	4.2 ^{ns}	-24.2 ^{ns}	0.0 ^{ns}	0.07	0.1
GY	10.17 ^{ns}	-5.8 ^{ns}	-5.80 ^{ns}	13.0*	13.0*	13.04*	-32.8 ^{ns}	-40.6 ^{ns}	-40.6 ^{ns}	0.01	0.01
GHI	34.88 ^{ns}	31.8 ^{ns}	3.57 ^{ns}	14.3 ^{ns}	0.0 ^{ns}	0.00 ^{ns}	-42.9 ^{ns}	-54.3 ^{ns}	-42.9 ^{ns}	0.09	0.1
HSW	-3.00 ^{ns}	-17.7 ^{ns}	-10.92 ^{ns}	-9.9 ^{ns}	-13.3 ^{ns}	-6.11 ^{ns}	-19.4 ^{ns}	-27.8 ^{ns}	-21.8 ^{ns}	3.75	5.4
SDWP	7.49 ^{ns}	0.00 ^{ns}	35.25*	-38.9 ^{ns}	-46.9 ^{ns}	-28.1 ^{ns}	-29.7 ^{ns}	-36.9 ^{ns}	7.4 ^{ns}	10.65	15.3
SDWR	7.22 ^{ns}	0.00 ^{ns}	35.06*	-39.2 ^{ns}	-47.1 ^{ns}	-28.6 ^{ns}	-31.9 ^{ns}	-38.9 ^{ns}	3.9 ^{ns}	0.23	0.3
NDW	166.57**	33.29 ^{ns}	-39.04 ^{ns}	-55.5 ^{ns}	-67.6 ^{ns}	-67.6 ^{ns}	36.2 ^{ns}	-31.9 ^{ns}	-68.9 ^{ns}	24.53	35.2
SPC	28.53*	-1.76 ^{ns}	7.21 ^{ns}	9.9 ^{ns}	5.3 ^{ns}	14.90 ^{ns}	20.8 ^{ns}	3.5 ^{ns}	13.0 ^{ns}	4.22	6.1
GPC	18.16**	-9.69 ^{ns}	5.67 ^{ns}	8.8 ^{ns}	0.9 ^{ns}	18.04**	17.8**	-9.7 ^{ns}	5.7 ^{ns}	2.06	3.0
GPE	-4.19 ^{ns}	-16.7 ^{ns}	-33.73 ^{ns}	-32.0 ^{ns}	-46.0 ^{ns}	-46 ^{ns}	-22.9 ^{ns}	-38.4 ^{ns}	-63.8 ^{ns}	31.99	46.0
BPR	-17.65 ^{ns}	-30.0 ^{ns}	-20.00 ^{ns}	-6.7 ^{ns}	-12.5 ^{ns}	0.00 ^{ns}	7.1 ^{ns}	-25.0 ^{ns}	-14.3 ^{ns}	0.06	0.1
EGR	9.52*	-14.8 ^{ns}	9.52*	33.3**	18.5**	52.38**	-3.8 ^{ns}	-7.41 ^{ns}	19.0 ^{ns}	0.02	0.02

BM=biomass yield, BNY=biomass nitrogen yield, BPR= biomass production rate, DF=days to 50% flowering, DM=days to 90% flowering, EGR= economic growth rate GHI=grain harvest index, GNY=grain nitrogen yield, GPC=grain protein content, GPE=grain production efficiency, GY=grain yield, HM=mid-parent heterosis, HP=best parent heterosis, HS= standard heterosis, HSW=hundred seed weight, NDW=nodule dry, NFB=nitrogen fixed in grain, NFG=nitrogen fixed in grain, NHI=nitrogen harvest index, NN=number of nodule , NPP=number of pod per plant, SDWP=shoot dry weight at physiological maturity, SDWR= shoot dry weight, SFD=seed filling duration, SNF=shoot nitrogen fixation, SPC=shoot protein content, SNY=shoot nitrogen yield

Table-6. Continued

	ICC4918XICC19180			**ICC4918XICC19181**			**ICC19180XICC19181**			**LSD**	
	HM (%)	**HP (%)**	**HS (%)**	**HM (%)**	**HP (%)**	**HS (%)**	**HM (%)**	**HP (%)**	**HS (%)**	**5%**	**1%**
DF	11.5^{ns}	25.97*	26.0*	-19.8^{ns}	0.00^{ns}	25.97*	-15.3^{ns}	22.08^{ns}	2207.8^{ns}	9.63	13.8
DM	-3.3^{ns}	3.52^{ns}	3.5^{ns}	-8.0^{ns}	-0.62^{ns}	13.38**	-3.03^{ns}	12.7**	1267.6**	3.52	5.1
SFD	-23.1^{ns}	-23.1^{ns}	-23.^{ns}	18.5^{ns}	48.84*	-1.54^{ns}	22.22^{ns}	53.5**	5348.8^{ns}	7.46	10.7
NPP	83.3**	58.1**	118.1**	27.8^{ns}	4.80^{ns}	44.58^{ns}	59.06*	49.80^{ns}	4979.9^{ns}	25.35	36.4
NN	66.3^{ns}	-16.8^{ns}	-16.9^{ns}	0.0^{ns}	0.00^{ns}	-100^{ns}	0.00^{ns}	-50^{ns}	-5000^{ns}	4.2	6.0
SNF	68.7^{ns}	-15.6^{ns}	-15.6^{ns}	34.1^{ns}	-32.9^{ns}	-72.7^{ns}	18.14^{ns}	-16.9^{ns}	-1692.4^{ns}	21.63	31.1
NFB	85.3*	-7.34^{ns}	-7.3^{ns}	64.0^{ns}	-18.0^{ns}	-76.1^{ns}	38.23^{ns}	-10.7^{ns}	-1076.9^{ns}	13.22	19.0
NFG	111.5**	5.77^{ns}	5.8^{ns}	1475*	687.5^{ns}	-83.4^{ns}	95.37**	-0.26^{ns}	-26.25^{ns}	5.89	8.5
NHI	11.1^{ns}	8.70^{ns}	8.7^{ns}	0.0^{ns}	-13.3^{ns}	13.04^{ns}	-13.21^{ns}	-23.3^{ns}	-2333.3^{ns}	0.07	0.1
GNY	26.7**	-9.52^{ns}	-9.5^{ns}	5.3^{ns}	0.00^{ns}	-52.4^{ns}	3.23^{ns}	-23.8^{ns}	-2380.9^{ns}	0.02	0.0
SNY	7.7^{ns}	-20.0^{ns}	-20.0^{ns}	-5.1^{ns}	-17.6^{ns}	-60^{ns}	20.00^{ns}	-18.5^{ns}	-1857.1^{ns}	0.21	0.3
BNY	11.3^{ns}	-17.8^{ns}	-17.8^{ns}	-2.6^{ns}	-11.6^{ns}	-57.7^{ns}	18.40^{ns}	-17.7^{ns}	-1777.8^{ns}	0.22	0.3
BM	-4.2^{ns}	-8.00^{ns}	-8.0^{ns}	-5.3^{ns}	-21.7^{ns}	-28^{ns}	15.00^{ns}	-8.00^{ns}	-800^{ns}	0.07	0.1
GY	-1.7^{ns}	-15.9^{ns}	-15.9^{ns}	-5.9^{ns}	-9.43^{ns}	-30.4^{ns}	-13.11^{ns}	-23.1^{ns}	-2318.8^{ns}	0.01	0.01
GHI	4.0^{ns}	-7.14^{ns}	-7.1^{ns}	-1.8^{ns}	-20.0^{ns}	0.00^{ns}	-23.81^{ns}	-31.4^{ns}	-3142.8^{ns}	0.09	0.1
HSW	-3.2^{ns}	-14.8^{ns}	-14.8^{ns}	-0.2^{ns}	-5.77^{ns}	-19.3^{ns}	-30.12^{ns}	-35.1^{ns}	-3515^{ns}	3.75	5.4
SDWP	21.5^{ns}	12.91^{ns}	31.4*	-30.2^{ns}	-41.3^{ns}	0.00^{ns}	2.93^{ns}	-18.3^{ns}	-1829.8*	10.65	15.3
SDWR	-7.8^{ns}	-14.4^{ns}	0.0^{ns}	-8.6^{ns}	-22.9^{ns}	31.17 *	2.88^{ns}	-18.3^{ns}	-1832.1*	0.23	0.3
NDW	-21.3^{ns}	-60.64^{ns}	-60.6^{ns}	0.0^{ns}	0.00^{ns}	-100^{ns}	36.05*	-31.9^{ns}	-3197.4^{ns}	24.53	35.2
SPC	28.7 *	1.44^{ns}	1.4^{ns}	2.8^{ns}	-10.5^{ns}	-30.3^{ns}	30.81*	16.35^{ns}	1634.6^{ns}	4.22	6.1
GPC	28.0**	3.61^{ns}	3.6^{ns}	6.2^{ns}	5.79^{ns}	-34^{ns}	22.54**	-0.52^{ns}	-51.55*	2.06	3.0
GPE	-31.6^{ns}	-38.6^{ns}	-38.6^{ns}	36.2^{ns}	-1.79^{ns}	-21.9^{ns}	26.80^{ns}	-14.3^{ns}	-1431.9^{ns}	31.99	46.0
BPR	-4.8^{ns}	-14.3^{ns}	-14.3^{ns}	0.0^{ns}	-21.4^{ns}	-37.1^{ns}	9.80^{ns}	-20^{ns}	-2000^{ns}	0.06	0.1
EGR	33.3**	14.3**	14.3**	-25.0^{ns}	-40.00^{ns}	-28.6^{ns}	-26.09^{ns}	-32^{ns}	-3200^{ns}	0.02	0.02

*, * significant at 0.05 and 0.01 probability

BM=biomass yield, BNY=biomass nitrogen yield, BPR= biomass production rate, DF=days to 50% flowering, DM=days to 90% flowering, EGR= economic growth rate GHI=grain harvest index, GNY=grain nitrogen yield, GPC=grain protein content, GPE=grain production efficiency, GY=grain yield, HM=mid-parent heterosis, HP=best parent heterosis, HS= standard heterosis, HSW=hundred seed weight, NDW=nodule dry, NFB=nitrogen fixed in grain, NFG=nitrogen fixed in grain, NHI=nitrogen harvest index, NN=number of nodule , NPP=number of pod per plant, SDWP=shoot dry weight at physiological maturity, SDWR= shoot dry weight, SFD=seed filling duration, SNF=shoot nitrogen fixation, SPC=shoot protein content, SNY=shoot nitrogen yield

4. SUMMARY AND CONCLUSION

Chickpea has great importance as food, feed and fodder. Chickpea is valued for its nutritive seeds with high protein content, 25.3-28.9% after de-hulling. Among the food legumes, chickpea is the most hypocholesteremic agent; germinated chickpea was reported to be effective in controlling cholesterol level in rats. Secretion of leaves, stem and pods consist of malic and oxalic acids, giving a sour taste which are supposed to lower the blood cholesterol levels. The crops medicinal applications include use for bronchitis, aphrodisiac, catarrh, cholera, cutamenia, constipation, diarrhea, flatulence, dyspepsia, snakebite, sunstroke, and warts. Seeds are considered antibilious. However, low attention was given for the crops for the last many years in terms of management and input application.

In the present study a*nalysis of variance showed significant differences among genotypes for all studied agronomic and symbiotic traits.* The highest mid-parent heterosis was recorded for nodule dry weight in ICC5003XICC4918 while the lowest was noted for ICC5003XICC19180 for grain yield. High heterobeltiosis was estimated for number of pods per plant in ICC4918XICC19180 and the lowest was observed for ICC5003XICC1918 for grain yield. The highest value for standard heterosis was obtained for number of nodule in hybrid ICC5003XICC19180 whereas; the lowest was noted for grain yield in the same hybrid. Therefore, cross ICC5003XICC19180 is identified as a best hybrid for all the three heterosis; hence, one can use these materials for heterosis breeding.

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