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Breeding Advancement for Yield and Yield Related Traits of Desi Chickpea (*Cicer arietinum* L) Varieties in Ethiopia

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ABSTRACT

Thirteen desi chickpea varieties released since 1974 were evaluated in the 2017 cropping season at Jari location. The varieties were laid out in randomized complete block design with three replications. The analysis of variance revealed highly significant differences among tested varieties for all traits except plant height revealing that the varieties tested were highly variable. The average rate of increase in grain yield per year over the past 42 years period was 30.68 kg ha-1yr-1 with a relative genetic gain of 0.73% year-1, which was a significant increase for the last four decades of desi chickpea improvement. The regression of a hundred seed weight against the years of release showed not significantly different from zero. It showed an annual rate of genetic gain of 0.85 g yr-1 with a relative annual genetic gain of 0.23%. The number of pods per plant and number of seeds per pod revealed a non-significant decreasing trend over the past 42 years. Plant height, days to flowering, and days to maturity showed a non-significant trend in the current study. Grain yield showed a non-significant positive association with plant height, days to maturity and a hundred seed weight and non-significant negative association with days to flowering, the number of seed per pod, and the number of pods per plant. The study also showed that varieties developed through hybridization and selection from introduction had higher progress than old varieties and selection from landraces. Therefore, it is more likely that the productivity of desi chickpea in the future can also be increased by developing varieties using similar approaches by combining modern breeding tools.

Key Words: *Kabuli chickpea, Grain yield, hundred seed weight, Genetic gain.*

1. INTRODUCTION

Chickpea is a cool season food legume and grown as a winter crop in the tropics and as a summer or spring crop in the temperate environments. Chickpea is an important source of protein for millions of people in the developing countries [1]. In addition to having high protein content (20-22%), chickpea is rich in fi ber, minerals (phosphorus, calcium, magnesium, iron and zinc) and β-carotene. Based on distinct botanical or morphological features and molecular diversity analysis, chickpea is primarily classified into two major groups: desi type and Kabuli type [2, 3]. Desi chickpea is characterized by the small size seeds (microsperma), pods, leaflets and plantlets. The desi types account for 80-85% of chickpea area. [1]. Chickpea is grown in several regions of Ethiopia with residual moisture on black vertisol soils [4]. It has the ability to grow on residual moisture which gives farmers the opportunity to engage in double cropping, where chickpea is sown at the end of the rainy season following the harvest of the main crop. This allows more intensive and productive use of land, particularly in areas where land is scarce [5].

Chickpea yield improvement is challenging due to the influences of the environment, agronomic practices and genetic factors [6]. Despite the challenges, chickpea breeders have been developing improved varieties over the last four decades. Understanding of the amount of genetic progresses realized through past crop breeding efforts is absolutely essential to improving the efficiency and effectiveness of future breeding endeavors [7 and 8].The perfect calculation of genetic progress realized from long-term breeding efforts is a challenging. But, the performance of genotypes in common environments regressed over years of varietal release of a given crop as a continuous quantitative variable provided the most direct estimate of genetic gain from breeding and has widely

been used in different crops [9]. Example, genetic progresses using the same procedure were reported in sunflower [10], wheat [11, 12 and 13], soybean [14, 15] and maize [16]. Genetic progresses achieved over time from breeding of different crops in Ethiopia have also been studied using the same procedure and documented in haricot bean [17], maize [18], barley [19] and groundnut [20]. However, information on the quantity of genetic achievement made over time from breeding chickpea in Ethiopia is limited. Therefore, the purpose of present study was to assess the quantity of genetic advancement made over-time in grain yield and yield related traits of desi chickpea varieties.

2. MATERIAL AND METHODS

The experiment was conducted at Jari, substation of srinka Agricultural Research Center during the main cropping season of 2017. The site is located at 11^o 21' N latitude and 39^o 38' E longitude at an altitude of 1680 meters above sea level and Soli type is categorized as Vertisol. The experiment consisted of thirteen Desi chickpea varieties released since 1974 (Table 1). The experiment was planted in Randomized Complete Block Design (RCBD) with three replications. The experimental plot size of 4 rows each 4m long and 1.2m wide ($4.8m^2$) with spacing of 30cm between rows, 10cm between plants and 1m between blocks was used. Field management and protection practices were applied based on research recommendation. Data were recorded on: days to flowering, days to maturity, plant height, number of pods per plant, number of seed per pod, hundred seed weight and grain yield.

Table 1. Desi chickpea varieties released in Ethiopia from 1974 to 2016.

No.	Variety	Source	Pedigree	Year of released	Released by
1	DZ-10-11	Ethiopia	--	1974	DZARC
2	Dubie	Ethiopia	--	1978	DZARC
3	Mariye	ICRISAT	K-850-3/27XF378	1985	DZARC
4	Worku	ICRISAT	ICCL-820104	1994	DZARC
5	Akaki	ICRISAT	ICCL-820016	1995	DZARC
6	Kutaye	ICRISAT	ICCV-92033	2005	SARC
7	Mastewal	ICRISAT	ICCV-92006	2006	DARC
8	Fetenech	ICRISAT	ICCV-92069	2006	SARC
9	Natoli	ICRISAT	ICCX-910112-6	2007	DZARC
10	Minjar	ICRISAT	ICC97103	2010	DZARC
11	Dalota	ICRISAT	ICCX-940002-F5-242PO-1-1-01	2013	DZARC
12	Teketay	ICRISAT	JG-74 X ICCL-83105	2013	DZARC
13	Dimtu	ICRISAT	ICCV-93954 X ICC –5003	2016	DZARC

2.1. Statistical Analysis

All measured parameters were subjected to analysis of variance (ANOVA) using PROC GLM of SAS software to assess the difference among the tested varieties. Mean separation was carried out using Duncan's Multiple Range Test (DMRT). The breeding effect was estimated as a genetic gain for grain yield and associated traits; by regressing the mean of each character of each variety against the year of release of the variety using PROC REG procedure. The coefficient of linear regression gives the estimate of genetic gain in kg ha^{-1} yr^{-1} or in % per year [21]. For this study, the year of release was expressed as the number of years since 1974 for the varieties; the year when the first chickpea variety was released. Calculation was done as follows.

Annual rate of gain (b) =CovXY/VarX

Where: Cov= Covariance, Var= Variance, X= the year of variety release and Y= the mean value of each character for each variety.

The relative annual gain achieved over the last 42 years (1974-2016) was determined as a ratio of genetic gain to the corresponding mean value of oldest variety and expressed as percentage. Stepwise regression analysis was carried out on the varietal mean to determine those traits that contributed much for yield variation among varieties. To compute Pearson's product moment correlation coefficients among all characters using means of each variety, PROC CORR in SAS was used.

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3. RESULT AND DISCUSSION

3.1. Grain Yield Potential

The analysis of variance revealed highly significant (P<0.01) differences among tested varieties for all traits except plant height (Table 2) revealing that the varieties tested were highly variable. The yield performance of all Desi chickpea varieties averaged was 4865.65kg ha^{-1}, which ranged from 3943.0 kg ha^{-1} for the variety DZ-10-11 to 6277.7kg ha^{-1} for the variety Dalota (Table 3).

Table 2. Mean squares from analysis of variance for grain yield and other traits of desi chickpea at Jari location

Traits	Mean squares (MS)	
	Jari	
	Variety	Error
DF	27.86**	1.24
DM	33.45**	1.77
PTH	31.98ns	22.04
NPPP	356.55**	93.05
NSPP	0.01**	0.11
HSW	86.94**	1.85
GY	1160303.21 **	251597.16

**, *, ns= Significant at P ≤ 0.01, significant at P ≤ 0.05 and non-significant respectively

€= DF= days to flowering, DM=days to physiological maturity, PTH= plant height (cm), NPPP= number of pods per plant, NSPP= number of seeds per pod, HSW= hundred seed weight (g) and GY= grain yield (Kg ha^{-1}).

Table 3. Mean grain yield (Kg/ha) of Desi chickpea varieties at Jari location

Variety	Location
	Jari
DZ-10-11	3943.0d
Dubie	4476.7cd
Mariye	4080.3d
Worku	4580.4cd
Akaki	4850.0bcd
Kutaye	5654.3ab
Mastewal	4896.0bcd
Fetenech	4907.0bcd
Natoli	5083.3bc
Minjar	4483.3cd
Dalota	6277.7 a
Teketay	5218.3bc
Dimtu	4803.0bcd
CV	10.31
Mean	4865.65
R^2	0.71

Means followed by the same letter with in a column are not significantly different from each other at P ≤ 0.05.

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Table 4. Mean Values of Traits from Analysis of Variance for Desi Chickpea Varieties in the Yield Potential Trials at Jari Location.

Variety	Trait					
	DF	DM	PTH	NPPP	NSPP	HSW
DZ-10-11	59 .00^{d}	117.3^{de}	52.73^{ab}	83.73^{bcd}	1.8^{ab}	23.33^{g}
Dubie	60.00^{cd}	118.0^{de}	51.7^{ab}	86.9^{abcd}	1.46^{c}	30.0^{e}
Mariye	68.33^{a}	126.0^{a}	52.0^{ab}	95.27^{abc}	1.33^{cd}	33.67^{cd}
Worku	64.00^{b}	119.7^{cd}	55.2^{ab}	84.13^{bcd}	1.40^{c}	30.33^{e}
Akaki	67.3333^{a}	122.0^{bc}	50.8^{ab}	84.40^{bcd}	1.46^{c}	35.67^{bc}
Kutaye	61.00^{cd}	118.7^{de}	50.7^{ab}	69.93^{de}	1.87^{a}	37.0^{b}
Mastewal	63.33^{b}	121.3^{bc}	46.13^{b}	77.6^{cde}	1.46^{c}	33.0^{d}
Fetenech	61.00^{cd}	117.7^{de}	53.4^{ab}	103.2^{b}	1.4^{c}	26.33^{f}
Natoli	67.33^{a}	127.0^{a}	53.6^{ab}	72.67^{de}	1.4^{c}	33.0^{d}
Minjar	60.33^{cd}	116.7^{e}	46.2^{b}	86.06^{a-d}	1.67^{b}	27.33^{f}
Dalota	62.00^{bc}	122.7^{b}	54.4^{ab}	96.6^{ab}	1.40^{c}	39.3^{a}
Teketay	63.66^{b}	117.7^{de}	56.33^{a}	84.48^{bcd}	1.33^{cd}	40.0^{a}
Dimtu	61.33^{c}	118.7^{de}	56.2^{a}	64.2^{e}	1.2^{d}	40.0^{a}
Cv	1.77	1.11	8.98	11.51	6.00	4.12
Mean	63.00	120.26	52.26	83.8	1.48	33.0
R^2	0.92	0.90	0.45	0.66	0.88	0.96

3.2. Genetic Progress for Yield and other Traits

3.2.1. Grain yield

The mean grain yield of varieties released in 1970s, 1980s, 1990s, 2000s and 2010s were 4209.85, 4080.3, 4715.2, 5135.15 and 5195.58 kg ha^{-1} (Table 6), respectively. The average grain yield of the varieties released in 1990s, 2000s and 2010s was greater than that of the first two oldest varieties in 1970s, by 505.35 kg ha^{-1} (12%), 925.35 kg ha^{-1} (21.98%) and 958.73 kg ha^{-1} (23.41%) (Table 6). This clearly indicates the breeders of chickpea worked a lot to improve Desi chickpea grain yield potential. In line with this finding, [22] reported that improved groundnut varieties produced 10.96% higher pod yield and 23.83% higher seed yield over the check variety. [23)] also reported that the average grain yield of soybean ranged from 1.117 to 1.710 t ha^{-1} for the period of 1980 to 1996. [17] has reported that haricot bean yields in Ethiopia have increased from 2146 kg ha^{-1} in 1972 to 3964 kg ha^{-1} in 1998, representing a rate of increase attributable to genetic improvement of 69.45 kg ha^{-1} per year or 3.3% per year. [24] on soyabean, [19] on food barley , [20] on ground nut and [25]on teff found an increment in seed yield of modern varieties over the farmer's variety.

[26] also reported substantial increases in seed yield of modern varieties over the older ones in the past 31 years in field pea improvement program in Ethiopia. [27] also indicated an increment in seed yield of modern faba bean varieties as high as 37% over the older varieties in Ethiopia. Similarly, [28] indicated that the average rate of increase in grain yield potential per year of release over the 30 year period was 27.82 kg ha^{-1} at Debre Zeit and 18.02 kg ha^{-1} at Enewari using eleven lentil varieties released in the period from 1980 to 2010 in Ethiopia.

Table 5. Genetic Progress Trend in Grain Yield and Hundred Seed Weight (HSW) for Desi Chickpea Varieties Released from 1974 to 2016 over the first two oldest Varieties Released in 1970s

Variety	Year of release	Mean grain yield (Kg/ha)	Increment over average of the first two oldest varieties(1970s)		Mean HSW(g)	Increment over the first two oldest varieties(1970s)	
			Kg	%		g/HSW	%
DZ-10-11 Dubie	1974 1978	4209.85	---	--	26.67	--	--
Marye	1985	4080.3	-129.55	-3.08	33.67	7	26.25
Worku	1994	4580.4	370.55	8.8	30.33	3.66	13.72
Akaki	1995	4850	640.15	15.21	35.67	9	33.75

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Kutaye	2005	5654.3	1444.45	34.31	37.0	10.33	38.73
Mastewal Fetenech	2006	4901.5	691.65	16.43	29.67	3	11.25
Natoli	2007	5083.3	873.45	20.74	33.0	6.33	23.73
Minjar	2010	4483.3	273.45	6.50	27.33	0.66	2.47
Dalota Teketay	2013	5748	1538.15	36.54	39.65	12.98	48.67
Dimtu	2016	4803	593.15	18.11	40.0	13.33	49.87

Table 6. Genetic Progress Trend in Grain Yield and Hundred Seed Weight (HSW) for Desi Chickpea Varieties Released in 1980s, 1990s, 2000s and 2000s over the first two oldest Varieties Released in 1970s

Variety	Year of release	Mean grain yield	Increment over DZ-10-4		Mean HSW (g)	Increment over DZ-10-4	
			Kg	%		$ghsw^{-1}$	%
DZ-10-11 Dubie	1970s	4209.85	-	-	26.67	-	-
Marye	1980s	4080.3	-129.55	-3.08	33.67	7	26.25
Worku Akaki	1990s	4715.2	505.35	12.00	33	6.33	23.73
Kutaye Mastewal Fetenech Natoli	2000s	5135.15	925.3	21.98	32.33	5.66	21.22
Minjar Dalota Teketay Dimtu	2010s	5195.58	985.73	23.41	36.66	9.99	37.46

Varieties derived from introductions yielded an average of 4984.87 kg/ha, and surpassed the varieties developed from local collections by 775.02 kg ha^{-1} (18.41%) (Table 7). The results of the present study indicated that varieties developed from introduced germplasm contributed a lot to the genetic improvement of the yield potential of Desi chickpea varieties over the past 42 years. Similarly, [29] revealed that the introduction of improved bread wheat varieties in Spain during the 20^{th} century enhanced bread- making quality. Also, [17] and [30] have indicated that introduced materials contributed a lot to the improvement of the genetic yield potential of haricot bean and durum wheat varieties in Ethiopia, respectively. Introduction was mainly facilitated through obtaining generic resources and advanced germplasm lines from international institutes/organizations particularly from ICRISAT and ICARDA, and exchange of material with fellow breeders and breeding programs.

Table 7. Average Increments in Grain Yield and Hundred Seed Weight (HSW) for Desi Chickpea Varieties Derived from Introduction over Variety Derived from Local Collection

Variety	Grain yield (kg/ha)	Grain yield increment over local collection		Mean HSW (g)	HSW increment over local collection	
		$Kgha^{-1}$	%		$ghsw^{-1}$	%
Local collection derived	4209.85	---	--	26.67	-	-
Introduction derived	4984.87	775.02	18.41	34.12	7.45	27.93

The genetic gain analysis revealed an average rate of increase of 30.68 kg ha^{-1} yr^{-1} in yield potential over the last 42 years since 1974 (Figure 1) in desi chickpea, which is significantly different from zero ($P \leq 0.05$). Similarly, [31] on durum wheat, [32] on Australian spring wheat, [33] on soybean, [34] on tef and [35] on sunflower reported an increases in yield potential of varieties over years of variety release. In contrary, [36] on malt barley, [27] on faba bean and [37] on linseed reported the estimate of genetic progression was not significantly different from zero. Generally, this experiment clearly revealed that better genetic progress was achieved from breeding desi chickpea in Ethiopia. The average relative annual gain in grain yield was 0.73 % per year or about 30.66 % for the whole period (Table 9).

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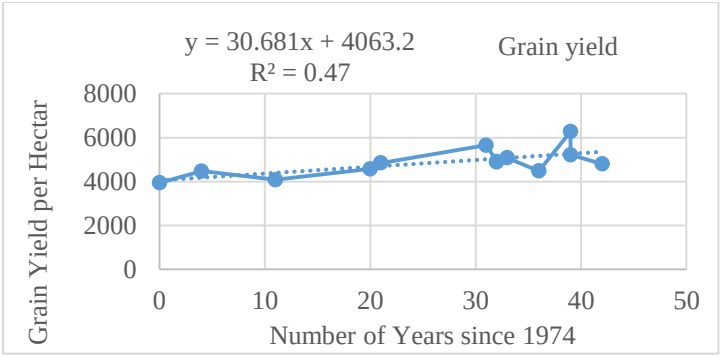

Figure 1. Relationship between year of Desi chickpea variety releases and grain yield at Jari location in Ethiopia

3.2.2. Hundred Seed Weight

Mean hundred seed weight ranged from 23.33g (DZ-10-11) to 40.0g (Teketay and Dimtu) with an average of 33 g (Table 4). The recently released varieties of desi chickpea, Dalota, Tekatay and Dimtu were heavier than the oldest ones (Table 4). Similarly, [38] in malting barley; [9] in hard red winter wheat ,[39] in two-row Nordic spring barley, [27] in faba bean and [37]in linseed found that thousand seed weight of modern varieties were heavier than the older ones. The mean hundred seed weight of varieties that released in 1970s, 1980s, 1990s 2000s and 2010s were 26.67, 33.67,33, 32.33 and 36.66g, respectively (Table 6). This indicated an increase of 7 g (26.25%), 6.33 g (23.73%), 5.66g (21.22%) and 9.99 g (37.46) in hundred seed weight, respectively, over the first two oldest varieties (Table 6).

The regression of hundred seed weight against the years of release showed annual rate of genetic gain of 0.23 g yr^{-1} (Figure 2),reflecting non-significant increase in the trait over the last 42 years of Desi chickpea improvement in Ethiopia with a relative annual genetic gain of 0.85% (Table 9) .similarly, [40] reported the estimated annual gain of thousand seed weight, over the period of 47 years was 0.02 and it has shown non-significant gain of the recent varieties over the older varieties.

Like to the grain yield, varieties derived from introductions gave higher hundred seed weight, which was 34.12 g on average, and exceeded the mean of the varieties developed through local collection by 7.45 g (27.93%) (Table 7). This result is contrary to the finding of [27] in faba bean.

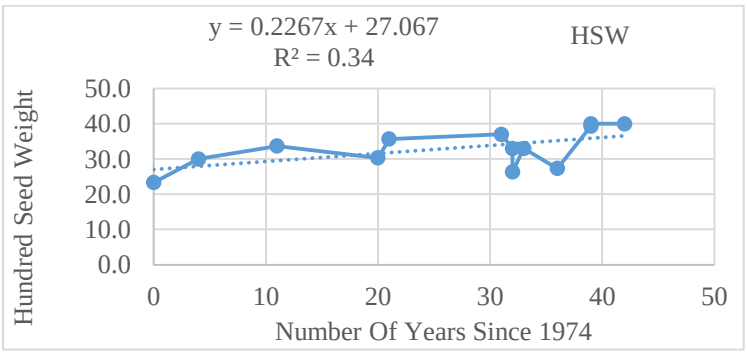

Figure 1. Relationship between year of Desi chickpea variety releases and hundred seed weight at Jari location

Table 8. Estimation of mean values and regression coefficient (b) of various agronomic traits from linear regression of the mean value of each character for each variety against the year of release

Character	Mean	R^2	b	Intercept
Days to flowering	63.00	0.001	0.007	62.8
Days to maturity	120.26	4E-05	0.002	120.23
Plant height	52.26	0.008	0.021	51.71
Number of pod per plant	83.80	0.056	-0.187	88.67
Number of seed per pod	1.48	0.096	-0.004	1.59
Hundred seed weight	33.00	0.34	0.23	27.07
Grain yield	4865.65	0.46	30.681*	4063.1

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Table 9. Annual Relative Genetic Gain and Correlation Coefficients for Grain Yield and Different Attributes of Desi Chickpea Varieties

Characters	Mean of the first two oldest variety (1970s)	Relative genetic gain (% year^{-1})	Correlation coefficient(r)	
			GY/ha	HSW
Days to flowering	59.5	0.012	-0.018	0.345
Days to maturity	117.65	0.001	0.137	0.294
Plant height	52.22	0.041	0.190	0.356
Number of pod per plant	85.32	-0.219	-0.053	-0.354
Number of seed per pod	1.63	-0.245	-0.047	-0.439
Hundred seed weight	26.67	0.851	0.653	--
Grain yield	4209.85	0.729	--	0.653

3.2.3. Plant height

The analysis of variance revealed non-significant (P<0.01) differences among tested varieties for plant height(Table 2) .The regression of plant height against the years of release showed annual rate of genetic gain of 0.021cm ha^{-1} year^{-1} (Table 8) with a relative annual genetic gain of 0.041%, though it was not significantly different from zero (Table 9). In contrary to this study, [41] and [30] observed a significant reduction in plant height in winter wheat in turkey and durum wheat in Ethiopia, respectively. According to [42], has reported a negatively non- significant annual rate of gain in plant height against year of release with the average annual genetic gain and annual relative percentage gain of -0.39 cm year^{-1} and -0.16% per year.

3.2.4. Number of Pods per plant and seeds per pod

Mean number of pods per plant and number of seeds per pod at Jari location was 83.8 and 1.48 respectively (Table 4). From this study, the number of pods per plant and number of seeds per pod followed a decreasing trend over 42 years of Desi chickpea improvement program as seen from non-significant negative linear regression coefficients of(Table 8) with relative annual gains of -0.219 and -0.245, respectively(Table 9). Similarly, [28] have reported a decreasing trend in number of pods plant^{-1}and number of seeds pod^{-1} on lentil yield improvement. This indicates that chickpea yield improvement involved a decrement in seed per pod and number of pod per plant. In contrast, [17] revealed there was an increasing tendency in the number of pods plant^{-1} with an average annual rate of gain of 0.119 pods plant $^{-1}$ year^{-1} and the test proved that no significant change was achieved by the improvement program since the start of coordinated bean improvement program in 1972. The negative improvement in number of pods plant^{-1} and number of seeds pod^{-1}may be considered as the result of a negative compensatory response to the slight increment in seed size during the period variety development, which is similar to the findings of [43] in faba bean. However, for simultaneous improving seed size and number of pods plant^{-1} and number of seeds plant^{-1} a compromise between selection progresses for both traits must be made, or the breeder must fix a minimum standard for one trait while choosing for the other.

3.2.5. Days to flowering and maturity

The average days of date of flowering and date of maturity were 63 and 120.26 days (Table 4). The regression analysis of days to flowering against the year of release indicated a non- significant increase in annual genetic gain of 0.007 days yr^{-1} (Table 8) with the relative genetic gain of 0.012 % (Table 9). In addition, days to physiological maturity showed a non- significant positive increase in annual genetic gain of 0.002 days per year (Table 8), with relative genetic gain of 0.03% (Table 9). Similarly, [17, 43, 24 and 30] found a non-significant increase in days to maturity in haricot bean, faba bean, soyabean and durum wheat breeding, respectively. In contrast, [36] on malt barley and [44, 20] on common bean reported negative trends for days to flowering and maturity

3.3. Association between traits

According to [45], grain yield in chickpea is a complex character which is the final product of a number of secondary traits, direct selection for yield must be supported with indirect selection using secondary traits. The correlation coefficients of grain yield with all the traits studied are presented in (Table 10). There was a non-significant positive correlation between grain yield and plant height. Similarly, [46] on tef, [17] on haricot bean, [43] on faba bean, [47] on soybean, [36] on malt barley and [42] on lowland sorguom reported no association of grain yield with plant height.

Number of pods plant^{-1} and number of seeds pod^{-1} showed a non-significant association with grain yield (Table 10), indicating that any improvement in these traits had as such no negative or positive contribution to grain yield as the genetic controls of these

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traits and that of grain yield are independent. Correspondingly, [43] on faba bean indicated that number of pods plant^{-1} and number of seeds plant^{-1} were negatively associated but statistically non-significant. The correlation of grain yield with hundred seed weight was not significant though it was sizeable and positive (Table 10).

Table 10. Estimates of correlation coefficient among traits of Desi chickpea varieties

	YOR	DF	DM	PH	NPPP	NSPP	HSW	GY
DF	0.030	1						
DM	0.006	0.836**	1					
PTH	0.090	0.086	0.050	1				
NPPP	-0.237	0.022	0.006	0.003	1			
NSPP	-0.302	-0.467	0.368	-0.55	-0.143	1		
HSW	0.653*	0.345	0.294	0.356	-0.354	-0.439	1	
GY	0.681*	-0.018	0.137	0.190	-0.053	-0.047	0.653	1

**, *, Significant at $P \leq 0.01$and significant at $P \leq 0.05$ respectively.

DF= days to flowering, DM=days to physiological maturity, PTH= plant height (cm), NPPP= number of pods per plant, NSPP= number of seeds per pod, HSW= hundred seed weight (g), YOR= year of release and GY= grain yield (Kg ha^{-1}).

Stepwise regression analyses using grain yield as dependent variable indicated that, hundred seed weight was trait which contributed to grain yield. About 43% of the variation in Desi chickpea grain yield was explained by hundred seed weight (Table 11).

Table 11. Summary result of selection from stepwise regression analysis of mean grain yield as dependent variable and the other traits as independent variable

	Grain Yield	
Independent Variable	Regression coefficient (b)	R^2 (%)
Hundred seed weight	0.23*	0.43

4. CONCLUSION

Assessment of the genetic progress achieved through crop breeding helps breeders evaluate the strengths and weaknesses of the breeding program. This experiment clearly revealed that better genetic progress was obtained from breeding Desi chickpea in Ethiopia for grain yield than it was for seed size during the last 42 years. Conventional breeding scheme is time taking, laborious and the desirable traits are masked by environmental effect. Incorporation of modern breeding tools (biotechnology) such as molecular markers, have paramount importance to identify the target genes and make use of desirable traits of diverse genetic resource of the country for sustainable development of improved varieties. Integrated breeding approach aid to know genetic makeup of different varieties that can be used effectively for breeding and conservation program. The study clearly showed that varieties developed through hybridization and selection from introduction had higher improvement than old varieties and selection from landraces. Therefore, it is more likely that the productivity of desi chickpea in the future can also be increased by developing varieties using similar approaches by combining of modern breeding tools.

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