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Direct and Indirect Selection Indices for Genetic Improvement in Chickpea

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Abstract: The present investigation was conducted to probe the direct and indirect selection indices in fifteen genotypes of chickpea (*Cicerarietinum* L.). Field experiment was carried out at Gram Breeding Research Station, Kallurkot, Pakistan, in Rabi season of 2016-17. Path coefficient analysis revealed that harvest index exhibited the highest direct effect on grain yield (0.527), followed by pods plant^{-1} (0.498) and 100 seed weight (0.452). Correlation coefficient studies showed highly significant correlation between harvest index and grain yield (0.941) followed by pods plant^{-1} (0.924) and 100 seed weight (0.502) signifying the importance of these traits for crop improvement. From both, the correlation and path coefficient analysis studies, it is evident that harvest index, pods plant^{-1} and 100 seed weight have positive and significant association to grain yield coupled with high direct positive effect. Therefore, these traits may be focused while attempting chickpea genetic improvement program.

Key words: Direct and indirect indices, Correlation, Grain yield, Chickpea.

INTRODUCTION

Chickpea, commonly known as gram, is one of the important grain legume crops. It is a rich source of protein (20%), along with 60% carbohydrates and 1.6% fats (Ali and Ahsan, 2012). The crop is being cultivated in more than 30 countries, almost all the continents of the world (Mushtaq *et al*., 2013). It is an important rabi crop, contributing about 76% share in total pulses production of Pakistan, occupying > 5% of the area under rabi crops. However, the crop has been facing a 15-18% decline in production due to erratic trends in amount and frequency of rainfalls, as the crop's major share is obtained from Thal region, solely depending on rain (GoP, 2015-16). Irrespective of the fact that the crop ranks second (after India) in terms of acreage, productivity of the crop on per unit area basis in Pakistan is far below (276 kg ha^{-1}) than the world's average production of 952 kg ha^{-1} (FAO STAT, 2014). Therefore, the evolution of potent cultivars of chickpea is direly needed to uplift the yield on existing area.

Determination of type and strength of association among various yield traits and their impact on the final yield is imperative for selection of suitable germplasm for fruitful breeding programs. For improvement in chickpea genotypes, it is important to identify the genetic basis of yield and related traits. The path coefficient analysis for yield contributing traits will be helpful in sorting out the most effective plant variable, on which the selection should rely upon.

In most of the biological systems, various traits are interlinked with each other, to produce the final phenotype. The complexity increases with increasing number of factors interlinked in the system. So, identification of the most related and effective parameter for selection becomes a difficult task for a scientist, attempting to improve that particular system. Path coefficient analysis helps to measure the contributions of linked traits towards the ultimate yield (Singh *et al.*, 1990; Bakhsh *et al.*, 1998).

Correlation analysis is very helpful in deciding the most effective selection criteria for improving yield and its contributing traits (Khan and Qureshi, 2001). Several researchers emphasized the utility of correlation analysis (Noor *et al.*, 2003; Farshadfar and Farshadfar, 2008; Atta *et al.*, 2008; Sharma and Saini, 2010; Ali *et al.*, 2011. Islam *et al*. (1984) documented that grain yield is positively associated to the pods plant^{-1}, biomass and branches plant^{-1} and gave

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emphasis on said parameters to serve as basic criteria for selection. The correlation among yield and yield attributes has been widely studied (Lokendra *et al.* (1999). Saleem *et al.*, 1999; Saleem *et al.*, 2002) and Yucel *et al.* (2006) recorded a significant and positive association between pods plant^{-1} and harvest index with grain yield. Information acquired from path coefficient analysis and correlation is very useful for a plant breeder to devise an efficient selection criterion in breeding program aiming at increased yield.

The main focus of the present study was to analyze the mutual relationship in different metric traits and their direct and indirect influence on the final economic yield (grain yield) through path coefficient and correlation analysis, which could lead as a directional model for determination of an effective selection criteria to evolve the most efficient and potent genotypes.

MATERIALS AND METHODS

The study for investigation of selection criteria in chickpea genotypes through path coefficient analysis and correlation was carried out at the Gram Breeding Research Station, Kallurkot, Pakistan, in Rabi 2016-17. The field experiment consisting of fifteen chickpea genotypes, including 4 commercial varieties, i.e., Bhakkar-11, CM-2008, Noor-13 and Bittle-16, and 12 elite strains, viz.,CH60/10, CH73/10, CH86/10, K010-10, K044-11, K065-11, CC9899, CH 85/06, DO 80-10, DO 72-11 and DO 88-11,was conducted in randomized complete block design (RCBD). All experimental plots comprised 30 centimeter apart 4 rows of 4 meter length. The seed of genotypes was sown with the help of dibbler making 10cm apart holes. Two seeds per hole were sown and later thinned to 1 plant per hole after 10 days of germination. During the pod formation stage insecticide Emamectin @ 200 ml acre^{-1} were sprayed twice (with an interval of 20 days), against pod borer attack.

Parameters recorded were days to flowering (50%), days to maturity (90%), plant height (cm), pods plant^{-1}, 100 seed weight (g) and grain yield (Kg ha^{-1}). Harvest index was calculated by economic yield divided by total biological yield. For estimation of genetic differences among the genotypes for concerned traits analysis of variance was done, following the study of Steel *et al.* (1997). Path coefficients analysis was performed following the study of Dewey and Lu (1959), while, the correlation coefficients were calculated following the study of Singh and Chaudhry (1979).

RESULTS AND DISCUSSION

Results for mean performance of different traits revealed that grain yield ranged from 1273.3 kg to 2302.7 kg ha^{-1} (Table 1). The maximum grain yield was recorded in CH 73/10, while, minimum was noted in DO 72-11. Similarly, maximum values for pods plant^{-1}, plant height, 100 seed weight, days to 90% maturity and harvest index were recorded in CH 73/10, while minimum days were noted in DO 72-11. Maximum days to flowering were recorded in DO 80-10 and minimum were recorded in DO 72-11.

Table 1: Mean performance for various traits of chickpea genotypes.

Genotypes	DF 50%	DM	PH	PP	100SW	HI	YLD
CH 73/10	93.0	160.7	61.3	108.3	25.5	52.7	2302.7
DO 80-10	91.7	158.7	56.0	105.3	24.6	51.4	2040.7
Bhakkar -1	91.0	158.7	55.0	100.0	24.5	51.3	1952.0
CH 85/06	91.0	157.3	54.3	99.3	23.7	50.2	1929.7
CH 86/10	91.0	156.3	53.3	97.0	23.2	49.6	1864.3
Noor-13	90.0	155.7	52.3	95.3	22.9	49.2	1860.0
CM-2008	89.0	155.3	52.0	93.0	22.8	48.6	1843.0
CH 60/10	88.0	155.0	51.7	92.3	22.6	48.5	1821.7
Bittle-16	87.7	154.7	51.7	87.3	22.6	48.5	1788.3
KO 44-11	87.7	154.0	51.3	85.0	21.6	47.8	1724.0
CC 9899	85.7	153.3	51.3	78.0	21.5	47.5	1692.7
KO10-10	85.7	150.7	51.3	75.7	21.3	47.3	1662.0
KO 65-11	85.7	150.0	48.7	74.0	21.3	45.4	1657.3
DO 88-11	85.0	148.3	48.3	71.0	21.3	44.9	1563.7
DO 72-11	84.7	146.7	46.3	59.3	20.6	41.9	1273.3

(DF 50%= Days to 50% flowering, DM= Days to 90% maturity, HI= Harvest index, PH=Plant height at maturity, PP= pods plant^{-1}, 100 SW= 100 Seeds weight, YLD= Grain yield)

Analysis of variance studies revealed remarkable differences between the genotypes for all the included traits (Table 2). To analyze the relative direct and indirect impacts of various traits on grain yield path coefficient analysis was done (Table 3). The highest direct effect on grain yield was presented by harvest index (0.527), followed by the pods plant^{-1} (0.498), 100 seed weight (0.452), and days to 90% maturity (0.380). A direct and positive impact of 100 seed weight, pods plant^{-1}, harvest index and days to maturity on final yield, was reported by many researchers (Noor *et al.*, 2003; Atta *et al.*, 2008; Padmavathi *et al.*, 2013). Similarly, days to 50% flowering exhibited relatively low direct impact

(0.008) on grain yield. Jatasra *et al.* (1978),Gull (1995), Bakhsh *et al.* (1998) and Naveed *et al.* (2012) also documented a direct impact of pods plant^{-1} and harvest index on final yield.

Table 2: Mean square values of different traits of chickpea genotypes.

Source	DF	DF 50%	DM	PH	NPP	100 SW	HI	YLD
Reps	2	3.089	0.956	6.067	9.6	0.236	0.038	3343
Genotypes	14	22.318**	47.594**	37.714**	585.676**	6.271**	22.497**	160841**
Error	28	0.946	2.432	1.209	3.005	0.232	0.511	752
Total	44							

(DF 50%= Days to 50% flowering, DM= Days to 90% maturity, HI= Harvest index, PH=Plant height at maturity, PP= pods plant^{-1}, 100 SW= 100 Seeds weight, YLD= Grain yield)

Table 3: Direct and indirect effects of various traits on final yield.

	DF 50%	DM	PH	PP	100 SW	HI	YLD
DF 50%	**0.008**	–0.099	0.022	–0.029	0.117	0.068	0.086
DM	–0.002	**0.380**	–0.064	–0.229	–0.347	–0.356	–0.618
PH	–0.001	0.155	**–0.156**	–0.182	0.051	–0.170	–0.302
NPP	–0.001	–0.175	0.057	**0.498**	0.106	0.438	0.924
100 SW	0.002	–0.291	–0.018	0.117	**0.452**	0.240	0.502
HI	0.001	–0.257	0.050	0.414	0.206	**0.527**	0.941

(DF50%= Days to 50% flowering, DM= Days to 90% maturity, HI= Harvest index, PH=Plant height at maturity, PP= pods plant^{-1}, 100 SW= 100 Seeds weight, YLD= Grain yield)

Direct effect, exhibited by plant height, was negative, while, all other traits showed positive direct effects. Although, plant height had a significant association, yet it revealed a negative direct effect. Contrary to current results, Singh *et al.* (1995) testified positive direct effects of biomass and plant height, however, they applied supplementary irrigation contrary to current study and conducted study purely under rain fed conditions. Saleem *et al.* (1999) described negative direct effects of plant height, which are in line with the current findings.

Coefficients of genotypic (G) and phenotypic (P) correlation for different attributes are given in Table 4. Results showed that the values for genotypic correlations were somewhat higher than the phenotypic correlation for the majority of the traits studied, exhibiting higher genetic association among the traits. Parallel results were documented by Islam *et al.* (1984). Pods plant^{-1}, 100 seed weight and harvest index revealed a considerable and significant correlation with grain yield. A very strong correlation was noted between harvest index and grain yield (0.941), followed by pods plant^{-1} (0.924) and 100 seed weight (0.502).

Table 4: Genotypic (G) and phenotypic (P) correlation coefficients for various traits in chickpea genotypes.

		DF 50%	DM	PH	PP	100 SW	HI
DM	G	–0.261					
	P	–0.214					
PH	G	–0.138	0.409*				
	P	–0.116	0.334				
NPP	G	–0.060*	–0.460*	–0.365			
	P	–0.048*	–0.422*	–0.340			
100 SW	G	0.259	–0.767**	0.113	0.235		
	P	0.219	–0.655*	0.133	0.229		
HI	G	0.130	–0.676*	–0.322	0.832**	0.456*	
	P	0.107	–0.586*	–0.287	0.810**	0.442*	
YLD	G	0.086	–0.618*	–0.302	0.924**	0.502*	0.941**
	P	0.080	–0.561*	–0.286	0.909**	0.464*	0.906**

(DF 50%= Days to 50% flowering, DM= Days to 90% maturity, HI= Harvest index, PH=Plant height at maturity, PP= pods plant^{-1}, 100 SW= 100 Seeds weight, YLD= Grain yield)

Pods plant^{-1} presented considerable correlation with harvest index (0.832). The current findings were in line with former studies, which showed a positive relationship between seed yield and pods plant^{-1} (Arshad *et al.*, 2004; Atta *et al.*, 2008; Diriba *et al.*, 2014). In addition, Saleem *et al.* (2002) and Yucel *et* *al.* (2006) described parallel association of 100 seed weight and pods plant^{-1} with grain yield.

Similarly, correlation among 100 seed weight and numbers of pods plant^{-1} was non-significant (0.235). Hamdi *et al.* (2003) documented positive correlation between 100 seed weight and harvest index. 100 seed weight exhibited significant positive correlation to harvest index (0.456). These results revealed a positive association among 100 seed weight and 50% flowering (0.259) which was followed by harvest index (0.130) and grain yield (0.086). Noor *et al.* (2003) also documented positive correlation of days to flowering to biomass and100 seed weight.

Plant height presented a significant positive association to days to 90% maturity (0.409) and showed a negative association withpodsplant^{-1} (–0.340), harvest index (–0.287) and grain yield (–0.286). Negative correlation between pods plant^{-1} and plant height was supported by Khan and Qureshi (2001). Negative association was exhibited by days to 90% maturity to pods plant^{-1} (–0.460), 100 seed weight (–0.767), harvest index (–0.676) and grain yield (–0.618). Results regarding days to maturity were supported by Saleem *et al.*, (2002), who also supported negative association among days to maturity and pods plant^{-1}.

Harvest index, pods plant^{-1} and 100 seed weight showed remarkable linear association with grain yield, signifying the influence of these plant traits for increased grain yield. Nakaseko (1984) emphasized the importance of harvest index in improvement of final economic yield. Diaz Carrasco *et al.* (1985) also focused on increased pods plant^{-1} to enhance the grain yield. Amongst the yield-contributing attributes, 100 seed weight exhibited a strong linear association with harvest index. Significant correlation was exhibited by pods plant^{-1} to harvest index, indicating that enhanced pods plant^{-1} are linked with higher harvest index.

CONCLUSION

Maximum direct positive effects of harvest index along with a strong parallel type of association with grain yield suggested that the selection based on this parameter would be fruitful for evolution of high yielding chickpea genotypes. Pods plant^{-1} and 100 seed weight were also indicated as the most effective traits for improving yield of chickpea. These traits might be focused in selecting genotypes for higher grain yield potential.

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