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Research article

Estimates of direct and indirect effects between yield and yield components and selection indices in chickpea (*Cicer arietinum* L.)

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Abstract: This study was conducted to investigate direct and indirect effects and selection index in eight genotypes of chickpea (*Cicer arietinum* L.). The experiment was carried out in the University of Rajshahi, Bangladesh during the consecutive three crop seasons *viz*., 2009-2010, 2010-2011 and 2011-2012. The direct and indirect effect analysis have been done based on seed weight per plant (seed yield) as a dependent variable. In this study, number of seeds per plant had maximum positive direct effect on seed yield followed by days to first flower and plant height at first flower at genotypic level while at phenotypic level, plant height at maximum flower had the highest positive direct effect on yield followed by plant weight at harvest and number of pods per plant. These results confirmed that these characters had maximum contribution in determining yield. In discriminant function study, high expected genetic gain was observed when two characters *viz*., number of secondary branches at first flower and number of primary branches at maximum flower were in a combination than three or more. Again, number of secondary branches at first flower also had positive direct effect on seed yield and number of primary branches at maximum flower had significant positive total effect on seed yield. The study hereby suggestes that the two traits (i.e. number of secondary branches at first flower and number of primary branches at maximum flower) may be given more emphasis while selecting high yielding chickpea genotypes.
Keywords: Correlation - Path coefficient - Discriminant function - Genetic gain.

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INTRODUCTION

Bangladesh is a dense populated country and in this country the major part of the population suffers from malnutrition, mainly due to deficiency of protein, owing to expensive price of animal protein like meat, fish. Pulse crops (Food legumes) are the second most planted crops in Bangladesh after rice, reflecting the importance of pulses as a source of protein in Bangladeshi diets. Among the pulses, chickpea (*Cicer arietinum* L.) is an important pulse crop of *rabi* (winter) season in Bangladesh.

To formulate proficient breeding program and for developing high-yielding varieties, it is essential to understand the genetics of the yield and related traits. The path-coefficient analysis studies between yield and yield contributing traits will be helpful in sorting out most associated contributing traits to yield. It is recognized that, correlation coefficient indicates only the general association between any two traits without tracing any possible causes of such association. In order to tracing any possible causes of association between seed weight per plant (SW/P) and other yield related traits, calculated correlation coefficient were partitioned into direct and indirect effects by using SW/P as dependent variable. A combination of direct and indirect selection will be effective to get a high selection response. Several researchers such as Saleem *et al*. (2002), Noor *et al*. (2003), Atta *et al*. (2008), Farshadfar & Farshadfar (2008), Sharma & Saini (2010), Ali *et al*. (2011) have emphasized the utility of path coefficient analysis. We know that, yield is a complex quantitative character and influenced by environmental fluctuations. Therefore direct selection for yield as such will not be reliable and fruitful. Hence, selection criteria based on yield components would be helpful in selecting suitable plant types. Thus, construction of selection indices will be highly helpful to discriminate desirable genotypes. The discriminant function provides an efficient method for simultaneous selection (Smith 1936). For this reason, to estimate expected genetic gain of the character through discriminant function methods is necessary. This method has

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been successfully followed by various researchers in various crops such as Deb & Khaleque (2007) in chickpea, Sarker & Deb (2009) in blackgram, Ferdous (2010) in bread wheat, Kumar *et al*. (2012) in rabi sorghum and Sarker *et al*. (2013) in chickpea. Hence, available information will be very helpful for an efficient selection criterion in selecting the most desirable and high yielding genotypes of chickpea.

MATERIALS AND METHODS

The experimental material comprising of eight genotypes of chickpea were evaluated in completely randomized block design with three replications in the University of Rajshahi, Bangladesh during three consecutive rabi seasons *viz*., 2009–2010, 2010–2011, 2011–2012. The observations were recorded on the basis of 15 randomly selected plants for thirteen different characters namely, days to first flower (DFF), plant height at first flower (PHFF), number of primary branches at first flower (NPBFF), number of secondary branches at first flower (NSBFF), days to maximum flower (DMF), plant height at maximum flower (PHMF), number of primary branches at maximum flower (NPBMF), number of secondary branches at maximum flower (NPBMF), plant weight at harvest (PWH), number of pods per plant (NPd/P), pod weight per plant (PdW/P), number of seeds per plant (NS/P) and seed weight per plant (SW/P). The path-coefficient analysis was done by using Wright's (1921,1923) formula as was extended by Dewey & Lu (1959) where, characters except SW/P were independent variables and SW/P was dependent variable. The phenotypic and genotypic variances and co-variances as obtained were used for constructing the discriminant function using different character combinations according to the method as developed by Fisher (1936) and Smith (1936). The expected genetic gain from straight selection {GA(S)} and from discriminant function {GA (D)} was calculated as follows:

$$GA\ (S) = (Z/P) \times (g_{yy})/(t_{yy})^{1/2} \text{ and}$$
$$GA\ (D) = (Z/P) \times (b_{1g1y})/(t_{y2g2y})^{1/2}$$

Where, Z/P = the selection differential in slandered units, for the present study it was 2.06 at 5% level of selection (Lush 1949) Fisher (1936).

g_{yy} and t_{yy}= the genotypic and phenotypic variances of trait.
$b_{1,}\ b_2$ ....b_n= the relative weights for the trait.
$g_{1y,}\ g_{2y}$............................... = the genotypic co-variances of independent trait with y

The expected gain form the discriminant function over straight selection was calculated for all the function as shown below:

Expected gain (%) = [{GA(D)/GA(S)}-1] × 100.

RESULTS

Perusing the table 1 and table 2, the direct effect of the traits *viz*., DFF, PHFF, NSBFF, NSBMF, PdW/P and NS/P was positive at genotypic and the traits *viz*., DFF, PHMF, NSBMF, PWH, NPd/P and PdW/P at phenotypic level. Path coefficient diagrams both at genotypic and phenotypic level of thirteen characters are present in figure 1 & 2 respectively. In the present study, high positive direct effect along with significant positive correlation at genotypic level was exhibited by NS/P followed by PdW/P, NSBMF. The trait, NPd/P showed negative direct effect though; it had significant and positive correlation with seed yield. Among the yield contributed traits at genotypic level, days to first flower had positive direct effect and indirect effect via PHFF, NSBFF, NPBMF, PdW/P and NS/P on seed yield but it had negative indirect effect via rest of the traits and its total effect was negative. The trait PHFF had positive direct effect but negative indirect effects via DMF and PHMF nullify its positive value into negative as total effect on seed yield. NPBFF had the highest negative direct effect which compensated by high positive indirect effect mainly via DFF and NS/P. While, NSBFF had positive direct effect which, was nullified by most of the traits. Days to maximum flower had negative direct effect on seed yield. The total effect of DMF also showed negative but non-significant mainly due to high positive indirect effect of DFF. The negative direct effect of PHMF remains negative due to negative indirect effect via DMF and NPd/P though the total effect was reduced by the positive indirect effects of DFF, PHFF, NSBFF and NS/P. The strong positive indirect effect of NS/P had cancelled the negative direct effect of NPBMF and NPd/P and also increased the total effect value of positive direct effect of NSBMF. On the other hand, high negative indirect effect of NS/P increased the negative total value of PWH. Total effect of pod weight per plant was also increased by positive indirect effect of NS/P. At phenotypic level, the positive direct effect of DFF and PWH were nullified by the comparatively high negative indirect effect of PHFF. Whereas, the negative direct effects of NPBFF and NPBMF were turned into positive total effect mainly due to the

Table 1. Direct (bold) and indirect effects of yield and yield components at genotypic level.

Path	DFF	PHFF	NPBFF	NSBFF	DMF	PHMF	NPBMF	NSBMF	PWH	NPd/P	PdW/P	NS/P	SW/P(r)
DFF	**3.7563**	0.9187	-1.2150	0.3276	-1.9488	-0.8335	0.4236	-0.1409	-0.4645	-1.2827	0.0188	0.3347	0.1061 NS
PHFF	3.1395	**1.0991**	-0.4865	0.7882	-2.0507	-1.2904	0.3754	-0.1936	-0.6189	-0.6351	-0.3630	-0.5175	-0.7536**
NPBFF	2.2804	0.2672	**-2.0013**	-0.3009	-0.9457	-0.3786	-0.2418	0.0163	-0.1902	-2.3274	0.1190	3.9380	0.2349*
NSBFF	1.6550	1.1654	0.8099	**0.7435**	-0.9197	-1.7340	0.6316	-0.5617	-0.7130	0.4226	-1.5564	-1.7616	-1.8183**
DMF	3.8190	1.1761	-0.9874	0.3567	**-1.9167**	-1.1723	0.5886	-0.1568	-0.6932	-1.1104	0.0235	-0.1492	-0.2227 NS
PHMF	2.5644	1.1618	-0.6206	1.0560	-1.8405	**-1.2209**	0.0778	-0.1415	-0.7523	-1.5311	-0.3835	0.7579	-0.8728**
NPBMF	-4.0572	-1.0523	-1.2338	-1.1974	2.8768	0.2423	**-0.3922**	0.3970	0.9145	-1.5458	-0.0191	7.0605	1.9936**
NSBMF	-1.8571	-0.7465	-0.1147	-1.4650	1.0544	0.6062	-0.5463	**0.2850**	0.3983	-1.9643	0.6549	5.2994	1.6042**
PWH	5.3993	2.1050	-1.1777	1.6403	-4.1112	-2.8421	1.1097	-0.3513	**-0.3231**	1.8985	-1.1932	-4.2709	-2.1165**
NPd/P	2.9506	0.4275	-2.8522	-0.1924	-1.3034	-1.1447	-0.3712	0.3429	0.3757	**-1.6328**	-0.1091	4.3644	0.8552**
PdW/P	0.1574	-0.8880	-0.5299	-2.5750	-0.1001	1.0420	0.0166	0.4154	0.8581	0.3965	**0.4494**	1.7580	1.0008**
NS/P	0.2840	-0.1285	-1.7801	-0.2958	0.0646	-0.2090	-0.6255	0.3412	0.3118	-1.6098	0.1784	**4.4272**	0.9585**

Table 2. Direct (bold) and indirect effects of yield and yield components at phenotypic level.

Path	DFF	PHFF	NPBFF	NSBFF	DMF	PHMF	NPBMF	NSBMF	PWH	NPd/P	PdW/P	NS/P	SW/P(r)
DFF	**0.3465**	-0.5942	-0.0208	-0.0037	-0.0085	0.0513	0.0026	-0.0615	0.1768	-0.0139	-0.0689	0.0111	-0.1832 NS
PHFF	0.1941	**-1.0611**	-0.0202	-0.0064	-0.0057	0.3380	0.0041	-0.0565	0.3887	0.0474	-0.0410	0.0050	-0.2138 NS
NPBFF	0.0753	-0.2243	**-0.0957**	-0.0153	-0.0017	0.2215	-0.0045	0.0342	0.0268	0.1443	0.0697	-0.0336	0.1967 NS
NSBFF	0.0441	-0.2308	-0.0497	**-0.0295**	-0.0010	0.2092	-0.0032	0.0155	0.0951	-0.0167	-0.0462	0.0008	-0.0126 NS
DMF	0.2717	-0.5600	-0.0151	-0.0027	**-0.0109**	0.0398	0.0024	-0.0683	0.1455	-0.0721	-0.0652	0.0216	-0.3132**
PHMF	0.0304	-0.6123	-0.0362	-0.0105	-0.0007	**0.5857**	0.0064	-0.0326	0.0461	0.0691	0.0137	-0.0116	0.0474 NS
NPBMF	-0.0372	0.1748	-0.0174	-0.0039	0.0011	-0.1517	**-0.0246**	0.1246	-0.0532	0.0880	0.0343	-0.0236	0.1113 NS
NSBMF	-0.0873	0.2459	-0.0134	-0.0019	0.0030	-0.0781	-0.0126	**0.2440**	-0.0980	0.0828	0.0866	-0.0276	0.3435**
PWH	0.1130	-0.7606	-0.0047	-0.0052	-0.0029	0.0498	0.0024	-0.0441	**0.5423**	0.0906	0.0110	-0.0074	-0.0158 NS
NPd/P	-0.0106	-0.1103	-0.0303	0.0011	0.0017	0.0888	-0.0048	0.0443	0.1078	**0.4559**	0.2235	-0.0897	0.6775**
PdW/P	-0.0797	0.1451	-0.0223	0.0045	0.0024	0.0268	-0.0028	0.0706	0.0200	0.3401	**0.2996**	-0.0700	0.7341**
NS/P	-0.0401	0.0558	-0.0336	0.0002	0.0025	0.0711	-0.0061	0.0704	0.0417	0.4274	0.2193	**-0.0956**	0.7129**

Residual effect = -1.0486 and 0.5393 for Genotypic and Phenotypic Path co-efficient respectively.

Diagonal value represents the direct effect. '*', '**'and ns for Significance at 5%, 1% and non-significant respectably.

days to first flower (DFF), plant height at first flower (PHFF), number of primary branches at first flower (NPBFF), number of secondary branches at first flower (NSBFF), days tomaximum flower (DMF), plant height at maximum flower (PHMF), number of primary branches at maximum flower (NPBMF), number of secondary branches at maximum flower (NPBMF), plant weight at harvest (PWH), number of pods per plant (NPd/P), pod weight per plant (PdW/P), number of seeds per plant (NS/P) and seed weight per plant (SW/P).

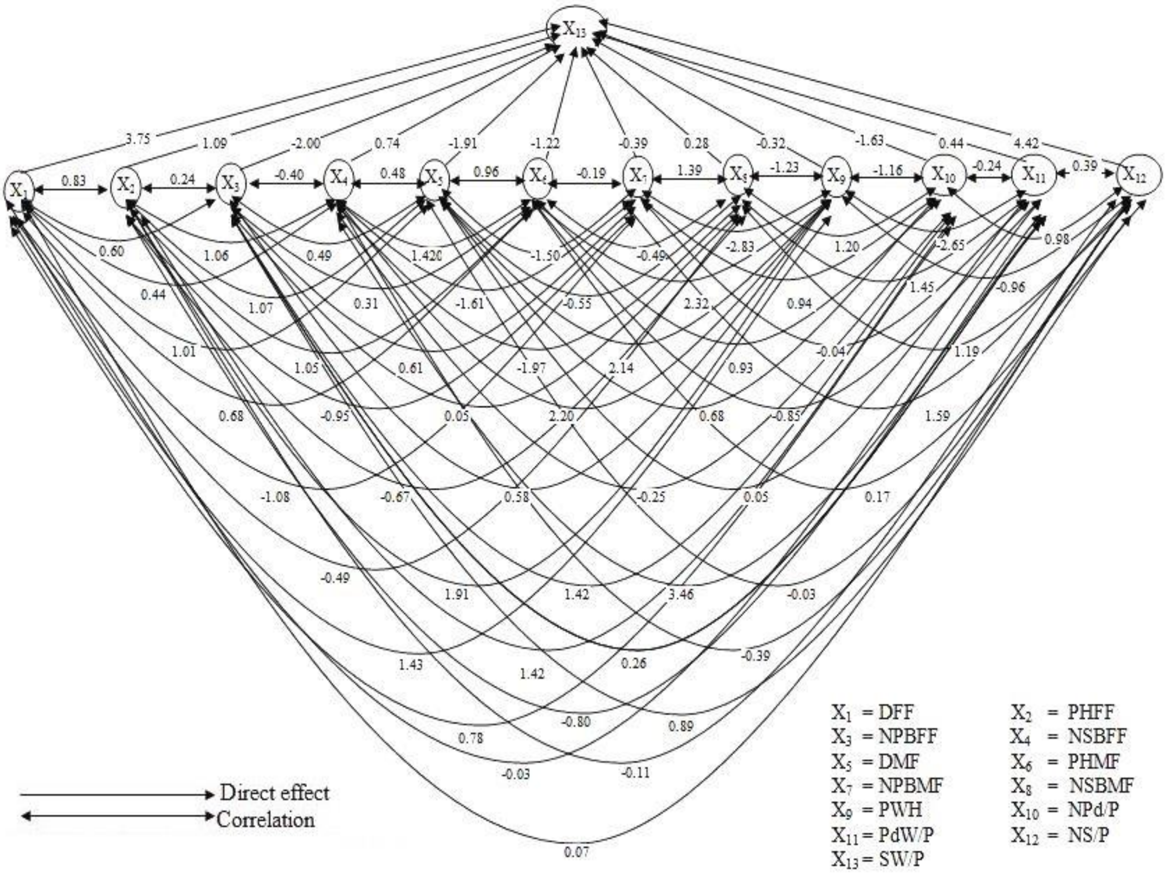

Figure 1. Path coefficient diagram of thirteen yield components at genotypic level

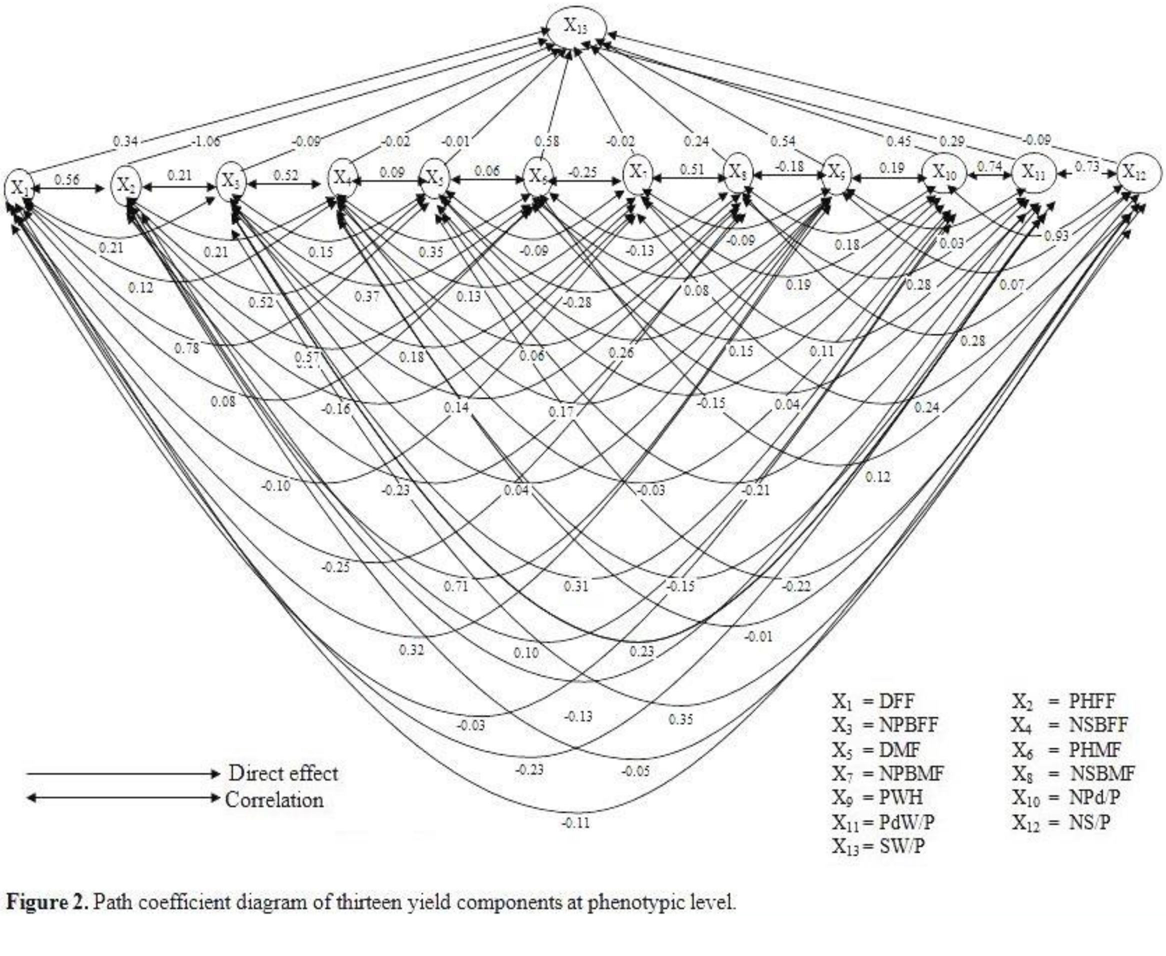

Figure 2. Path coefficient diagram of thirteen yield components at phenotypic level.

comparatively high positive indirect effect of PHMF. The traits PHFF, NSBFF and DMF had negative direct effect on seed yield. The total effect of these trait also had negative due negative indirect effect via various traits especially PHFF for latter two traits. The high negative indirect effect of PHFF also reduces positive direct effect of PHMF. The positive direct effect of NSBMF, NPd/P and PdW/P exhibited positive total effect mainly due to comparatively high positive indirect effect of PHFF, PdW/P and NPd/P respectively. The Negative direct effect of NS/P was counterbalanced by the high positive indirect effect via NPd/P and PdW/P.

Various selection indices based on different character combinations including seed yield are presented in Table 3. In the present investigation, among the thirteen characters positive expected gain was exhibited by NPBMF (7603.25%), which was the highest value followed by NSBFF (4599.44%) and NSBMF (1739.66%). Most of the traits exhibited negative expected gain. The result revealed that a maximum genetic gain of 3424.93% was expected when two attributes *viz.*, NSBFF and NPBMF were included in the function followed by three characters, four characters and five characters combination. Further increases in the genetic gain with the addition of more traits are negligible. The inclusion of NSBFF and/or NPBMF in an index increases the values of expected gain greatly. But when the DMF, PHMF and/or PWH were included with other characters in an index, it reduces the expected gains in majority of the cases.

Table 3. Expected genetic gain in % for over straight selection from use of various selection indices in chickpea genotypes. Indices showing vales over 200 are shown only.

Selection Index	Genetic Gain	Selection Index	Genetic Gain
X_{13}	-147.40	$X_4+X_6+X_8$	316.42
X_1	-159.90	$X_4+X_7+X_8$	1546.28
X_2	69.03	$X_4+X_7+X_{11}$	427.45
X_3	685.76	$X_4+X_7+X_{13}$	327.16
X_4	4599.44	$X_4+X_8+X_9$	297.69
X_5	-245.78	$X_4+X_8+X_{11}$	722.75
X_6	198.28	$X_4+X_8+X_{13}$	636.93
X_7	7603.25	$X_5+X_7+X_8$	281.10
X_8	1739.66	$X_6+X_7+X_8$	346.72
X_9	-183.29	$X_6+X_8+X_{11}$	255.33
X_{10}	-252.84	$X_6+X_8+X_{13}$	240.87
X_{11}	59.37	$X_7+X_8+X_9$	340.98
X_{12}	-52.00	$X_7+X_8+X_{11}$	806.78
X_3+X_7	1568.18	$X_7+X_8+X_{13}$	713.47
X_3+X_8	1235.46	$X_7+X_{11}+X_{13}$	207.18
X_4+X_7	3424.93	$X_8+X_9+X_{11}$	233.13
X_4+X_8	1552.64	$X_8+X_9+X_{13}$	217.34
X_5+X_8	256.03	$X_8+X_{11}+X_{13}$	434.27
X_6+X_7	242.68	$X_3+X_4+X_5+X_8$	221.01
X_6+X_8	330.30	$X_3+X_4+X_6+X_7$	203.46
X_7+X_8	1712.80	$X_3+X_4+X_6+X_8$	291.03
X_7+X_{11}	552.81	$X_3+X_4+X_7+X_8$	1149.15
X_7+X_{13}	428.01	$X_3+X_4+X_7+X_{11}$	343.77
X_8+X_9	315.48	$X_3+X_4+X_7+X_{13}$	275.84
X_8+X_{11}	776.98	$X_3+X_4+X_8+X_9$	270.79
X_8+X_{13}	682.46	$X_3+X_4+X_8+X_{11}$	606.99
$X_3+X_4+X_7$	1148.73	$X_3+X_4+X_8+X_{13}$	543.15
$X_3+X_5+X_8$	234.60	$X_3+X_5+X_7+X_8$	257.80
$X_3+X_6+X_7$	220.52	$X_3+X_6+X_7+X_8$	318.98
$X_3+X_6+X_8$	303.45	$X_3+X_6+X_8+X_{11}$	237.41
$X_3+X_7+X_8$	1247.96	$X_3+X_6+X_8+X_{13}$	224.42
$X_3+X_7+X_{11}$	428.30	$X_3+X_7+X_8+X_9$	310.07
$X_3+X_7+X_{13}$	347.57	$X_3+X_7+X_8+X_{11}$	677.76
$X_3+X_8+X_9$	286.48	$X_3+X_7+X_8+X_{13}$	608.49
$X_3+X_8+X_{11}$	648.34	$X_3+X_8+X_9+X_{11}$	215.13
$X_3+X_8+X_{13}$	578.89	$X_3+X_8+X_9+X_{13}$	201.10
$X_4+X_5+X_8$	240.84	$X_3+X_8+X_{11}+X_{13}$	386.00
$X_4+X_6+X_7$	223.33	$X_4+X_5+X_7+X_8$	266.54
$X_4+X_6+X_7+X_8$	333.20	$X_3+X_4+X_7+X_8+X_{11}$	638.17
$X_4+X_6+X_8+X_{11}$	244.92	$X_3+X_4+X_7+X_8+X_{13}$	574.18
$X_4+X_6+X_8+X_{13}$	231.02	$X_3+X_4+X_8+X_9+X_{11}$	203.44

$X_4+X_7+X_8+X_9$	323.85	$X_3+X_4+X_8+X_{11}+X_{13}$	364.63
$X_4+X_7+X_8+X_{11}$	755.22	$X_3+X_6+X_7+X_8+X_{11}$	251.31
$X_4+X_7+X_8+X_{13}$	669.98	$X_3+X_6+X_7+X_8+X_{13}$	238.09
$X_4+X_8+X_9+X_{11}$	220.21	$X_3+X_7+X_8+X_9+X_{11}$	235.43
$X_4+X_8+X_9+X_{13}$	205.16	$X_3+X_7+X_8+X_9+X_{13}$	220.95
$X_4+X_8+X_{11}+X_{13}$	409.14	$X_3+X_7+X_8+X_{11}+X_{13}$	412.02
$X_5+X_7+X_8+X_{11}$	213.47	$X_4+X_5+X_7+X_8+X_{11}$	202.49
$X_5+X_7+X_8+X_{13}$	200.08	$X_4+X_6+X_7+X_8+X_{11}$	259.86
$X_6+X_7+X_8+X_{11}$	270.01	$X_4+X_6+X_7+X_8+X_{13}$	245.69
$X_6+X_7+X_8+X_{13}$	255.30	$X_4+X_7+X_8+X_9+X_{11}$	242.50
$X_7+X_8+X_9+X_{11}$	254.92	$X_4+X_7+X_8+X_9+X_{13}$	226.92
$X_7+X_8+X_9+X_{13}$	238.63	$X_4+X_7+X_8+X_{11}+X_{13}$	438.18
$X_7+X_8+X_{11}+X_{13}$	462.39	$X_6+X_7+X_8+X_{11}+X_{13}$	205.14
$X_3+X_4+X_5+X_7+X_8$	244.76	$X_3+X_4+X_6+X_7+X_8+X_{11}$	242.03
$X_3+X_4+X_6+X_7+X_8$	306.87	$X_3+X_4+X_6+X_7+X_8+X_{13}$	229.28
$X_3+X_4+X_6+X_8+X_{11}$	227.89	$X_3+X_4+X_7+X_8+X_9+X_{11}$	224.18
$X_3+X_4+X_6+X_8+X_{13}$	215.38	$X_3+X_4+X_7+X_8+X_9+X_{13}$	210.31
$X_3+X_4+X_7+X_8+X_9$	294.95	$X_3+X_4+X_7+X_8+X_{11}+X_{13}$	391.39

Where, X_1 = DFF, X_2 = PHFF, X_3 = NPBFF, X_4 = NSBFF, X_5 = DMF, X_6 = PHMF, X_7 = NPBMF, X_8 = NSBMF, X_9 = PWH, X_{10} = NPd/P, X_{11} = PdW/P, X_{12} = NS/P and X_{13} = SW/P.

DFF= Days to first flower, PHFF= Plant height at first flower, NPBFF= Number of primary branches at first flower, NSBFF= Number of secondary branches at first flower, DMF= Days to maximum flower, PHMF= Plant height at maximum flower, NPBMF= Number of primary branches at maximum flower, NPBMF= Number of secondary branches at maximum flower, PWH= Plant weight at harvest, NPd/P= Number of pods per plant, PdW/P= Pod weight per plant, NS/P= Number of seeds per plant and SW/P= Seed weight per plant.

DISCUSSION

In the present study, high positive direct effect along with significant positive correlation coefficient of NS/P at genotypic level indicated that this character had maximum contribution in determining yield in this crop. Observation of this investigation also revealed that most of the traits had high positive indirect effect on seed yield through NS/P. Thus improving this trait may increase seed yield as well as performance of some traits. It also indicates the true relationship between this trait and seed yield and direct selection through this trait will be effective. Therefore, NS/P may be given more emphasis while selecting high yielding chickpea genotypes. Whereas, NPd/P show negative direct effect but it had significant and positive correlation with seed yield indicating indirect selection of this trait may be effective. Saleem *et al.* (1999), Deb & Khaleque (2005), Yucel *et al*. (2006) and Zali *et al*. (2011) reported the similar results for NS/P but it dissimilar with Renukadevi & Subbalakshmi (2006). They found NPd/P as positive and NS/P as negative direct effect on seed yield. NPd/P noted as the highest positive direct effect on yield by Noor *et al*. (2003), Ciftci *et al*. (2004), Atta *et al.* (2008), Farshadfar & Farshadfar (2008), Thakur & Sirohi (2009), Sharma & Saini (2010) Ali *et al*. (2011) and Padmavathi *et al*. (2013). On the other hand, Vaghela *et al*. (2009), Ali *et al*. (2009), Yucel & Anlarsal (2010) found NS/P and NPd/P both as positive direct effect on seed yield while Mushtaq *et al*. (2013) found both as negative direct effect on seed yield. Among the yield attributed traits at genotypic level, the direct effect of NPBFF and NPBMF had negative but total effect was positive mainly due to high positive indirect effects on seed yield via NS/P indicating that indirect selection of NPBFF and NPBMF through NS/P might be helpful in yield improvement but since the direct effect was negative, so direct selection for these traits to improve yield will not be desirable. This result is in line with the findings of Saleem *et al*. (1999). The traits DFF, PHFF and NSBFF had positive direct effect on seed yield but comparatively low along with negative association with seed yield, indirect effect also low and negative so, direct and indirect selection may not be desirable for these traits to improving seed yield in chickpea on the other hand, NSBMF and PdW/P had low but positive direct effect along with positive correlation with yield they had also high indirect effect via NS/P, so direct selection of NSBMF and PdW/P might be helpful in yield improvement. Whereas, direct or indirect selection of DMF, PHMF and PWH will not be effective due to their negative direct effect and negative association with seed yield. At the phenotypic level, direct selection for NSBMF, NPd/P and PdW/P to improve yield will be helpful due to their positive direct effect along with significant positive correlation with seed yield. While indirect selection of NS/P might be helpful. But direct or indirect selection of DMF will not be effective due to its negative direct effect and negative association with seed yield.

The results of discreminant function revealed that a maximum genetic gain of 3424.93% was expected when two attributes *viz*., NSBFF and NPBMF were included in the function. Similar results were reported by Sarker *et al*. (2013) in chickpea. It is always preferable to use a discriminant function containing a minimum number of traits which may lead to the maximum genetic gain. Deb & Khaleque (2007) in chickpea, Ferdous *et al*. (2010) in wheat and Kumar *et al*. (2013) in rabi sorghum obtained highest expected gain in five, three and six characters combinations, respectively. In this study negative expected gains were found in some cases. Similar result was reported by Deb & Khaleque (2007) in chickpea. Therefore, in this investigation this two yield components *viz*., NSBFF and NPBMF may be considered as the primary yield components and SW/P will increased by the improvement of these character. Hence, the selection index based on NSBFF and NPBMF may be considered as appropriate selection index for seed yield improvement in chickpea genotypes.

CONCLUSION

Positive and significant correlation and high contribution to seed yield suggested that selection for high yield in chickpea could be enhanced by NS/P and PdW/P as a selection criteria along with NSBFF and NPBMF.

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