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Correlation and path coefficient analysis of yield and yield components of chickpea (*Cicer arietinum* L.) under dry land condition in the Bundelkhand region India

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Abstract
Sixteen genotypes were tested the 2016-2017 seasons for their yield performance. In the examined characteristics, positive and significant relationships were found statistically between 100 seed weight and plant height, between the number of secondary branches and plant height, between day to heading and day to maturity, between day to maturity and number of primary and secondary branches, between seed yield and number of pod per plant, and number of seed per pod, between seed yield and biomass and harvest index were determined significantly. Negative and significant relationships were determined statistically between number of pod per plant, and 100 seed weight, between seed per pod and number of secondary branches. Harvest index had the greatest direct effect on seed yield (p.c. =0.901**). Also, its indirect effect on seed yield more positive through plant high, number of pod per plant, number of seed per pod and biomass, but negative and low through day to heading and maturity, 100 seed weight and number of primary branches. The present study thus suggested that selection for high seed yield should be based on biomass (biological yield) and harvest index in kabuli.

Keywords: Path coefficient, yield components, dry land condition and chickpea

Introduction

Chickpea (*Cicer arietinum* L.) is the second most important cool season pulse crop in the world and is grown in at least 33 countries including central and west Asia, south Europe, Ethiopia, North Africa, north and South America and Australia (Anonymous, 2002) [1]. Chickpea acquires importance as it provides food for humans as well as for livestock. Furthermore, chickpea pod covers and seed coats can also be used as fodder. In grain legumes, proteins are an important seed component and are responsible for their relevant nutritional and socio-economic importance. The chickpea seed is a good source of carbohydrates and proteins, which together constitute 80% of the total dry seed weight. West Asia, including Iran is known to be a genetic diversity centre of chickpea and rich in both landrace and wild relatives of chickpea (Singh and Ocampo, 1997) [12]. As in all cultivated plants, the main objective of growing chickpea is for high yield and high quality crops. Since genotypic and environmental factors are the main components for determining yield and quality in plants, a primary aim should be the determination of effects of genotypic factors for selection. As the effect of environment on yield and quality in plants is not hereditable, effect of genotypic factors on yield and quality in plant breeding research need to be examined. When studying with correlations it is of prime importance to recognize the nature of the population under consideration (Padi, 2003) [11]. In addition, simple correlation does not consider the complex relationships between the various characters related the dependent variables Garcia de Moral *et al*., 2005) [5]. Correlation coefficient show relationships among independent variables. But, it is not sufficient to describe this relationship when the causal relationship among variables is needed (Korkut *et al*., 1993) [9]. But, reasons of the path analysis usage are different. They could be mentioned as follows (Ulukan *et al*., 2003) [15]:

- To indicate the relative importance of certain factors contributing to yield reduction by any factors.
- To unravel opposing effects between variables along different paths of influence, which may obscure the importance of certain factors along those paths.
- To determine which variables need to be measured to enables chickpea's biological yield.

In other words, path analysis is used when we want to determine the amount of direct and indirect effect of the causal components on the effect component (Guler *et al*., 2001) [6].

For this reason, Khoshnazar *et al*. (2000) [7], Kolte *et al*. (2000) [8], Stringam *et al*. (2002) [14], Güler *et al*. (2001), Ulukan *et al*. (2003) [15] and Ciffçi *et al*. (2004) [3] determined the direct and indirect effects of various plant characteristics on yield and yield components by using path analysis in rapeseed, chickpea and faba bean Kumar and Arora (1991) [10] determined that biological yield plant^{-1}, pods plant $^{-1}$, 100 seed mass and plant height were the major yield components for selection in chickpea. Although literature is abundant on the use of path coefficient analysis to investigate the relationships between grain yield and yield components in legume, little information is available on the use of this technique to evaluate the formation of yield components in relation to the water regime and its influence on grain-yield variations, especially under Mediterranean environmental conditions (Ayate *et al*., 2014) [2]. In this study relationships among yield and yield component under dry-land condition of Bundelkhand region India were examined to determine which characteristics directly affected yield primarily in dry land condition and how much chickpea yield variation was apparent in chickpea.

Materials and Methods

Sixteen chickpea genotypes (*Cicer arietinum* L.) were obtained from the AICRP, chickpea ICAR New Delhi, India (Table 2). The chickpea genotypes were evaluated under dry-land condition terminal drought stress at the experimental field of Rani Lakshmi Bai Central Agricultural University, Jhansi, India, in 2016-2017. Climatic data related to the research location are shown in Table 1. The trials were carried out in a randomized complete block design with three replicates, each plot consisting of one row (2 m length) with 10 plants sown by hand (Sowing was made on 20 November, each year). Measurements and observations of examined characters were done on five plants, which had been randomly chosen in the mid-row of each plant. The following measurements and observation were made: day to heading and maturity, plant height, number of pods per plants, number of seeds per pods, 100 seed weight, number of primary and secondary branches, biomass, harvest index and seed yield plant $^{-1}$. Time to maturity was recorded as sowing to pod maturity time, plant height was measured before harvesting and other characters were measured at or after harvest. In order to determine the relationships between examined characteristics and yield, correlation coefficient were firstly calculated. Path coefficients were than calculated to understand the direct characters effect on yield. All statistical analysis was done using MSTATC and SAS software.

Table 1: Climatic data of the research location

Month	Rainfall (mm)	Temperature (^{0}c)	Relative Humidity (%)
November 2015	40.2	26	20
December	38.5	14	28
January	29.1	9	54
February	-	21	23
March	-	29	31
April	5.0	36	38
November 2016	37.1	24	28
December	40.3	11	39
January	31.0	8	56
February	-	22	25
March	-	31	18
April	3.0	38	22

Table 2: List of 16 chickpea accessions used for genetic diversity

S.N.	Name	Entry
1	CSG-8962	01
2	PBG-1	02
3	ENNEGERY	03
4	JG-315	04
5	ICCV-92944	05
6	RSG-888	06
7	PUSA-372	07
8	JG-11	08
9	JAKI	09
10	BG-1103	10
11	BDG-72	11
12	PHULE G-5	12
13	C-235	13
14	BG-1053	14
15	BG-1108	15
16	BCG-1	16

Results

Positive and significant relationships were found statistically between 100-seed weight and plant height, between the number of secondary branches and plant height, between day to heading and day to maturity, between day to maturity and number of primary and secondary branches, between seed and number of pod plants^{-1} and number of seed pod^{-1}, between seed yield and biomass and harvest index. Negative and significant relationships were determined statistically between number of pod plant^{-1} and 100-seed weight, between seeds pod^{-1} and number of secondary branches (Table 3). The direct and indirect effects of ten examined characters on seed yield were estimated by path coefficient (Table 4). Harvest index had the greatest direct effect on seed yield (p.c. = 0.901**). Also, its indirect effect on seed yield more positive through plant high, number of pod plant^{-1}, number of seeds pod^{-1} and biomass, but negative and low through day to heading and maturity, 100 seed weight and number of primary branches. The main reason for strong direct effect of harvest index was due to the strong positive correlation (0.92**) of this character with seed yield. The second highest direct effect on seed yield was of the biomass (p.c. = 0.194**). Biomass had positive indirect effect on seed yield via most of the observed characters.

Table 3: Phenotypic correlation coefficients among various pairs of characters

Characters	PH	100SW	PB	SB	NPP	NSP	DH	DM	BIO	HI	Y
PH	1.00	1.00									
100SW	0.381**	-0.130	1.00								
PB	-0.210*	-0.107	0.261**								
SB	0.377*	-0.150*	-0.098	1.00							
NPP	-0.172	0.208	0.271**	0.299**	1.00						
NSP	0.351**	-0.021	0.557**	-0.267*	0.050	1.00					
DH	-0.390**	0.104	0.443**	0.230**	0.029	-0.420**	1,00*				
DM	0.357**	-0.020	0.124	0.307**	0.129	-0.432	0.431**	1.00			
BIO	0.094	-0.173	-0.167	-0.037	0.176	0.097**	0.053	-0.059	1.00		
HI	0.250**	-0.024	0.158	0.087	0.446**	0.256	-0.155	-0.112	0.020	1.00	
Y	0.232*	0.060	-0.106	0.082	0.500	0.267	-0.122	-0.103	0.217*	0.92**	1.00

*, **: Significant at 5 and 1% probability level, respectively, Plant Height (PH), 100-Seed Weight (100SW), No. of Primary Branches (PB), No. of Secondary Branches (SB), No. of pods per plant (NPP), No. of seeds per pod (NSP), Day to Heading (DH), Day to Maturity (DM), Biomass (BIO), Harvest Index (HI) and seed yield (Y) in 16 chickpea lines

Table 4: The direct and indirect contribution of various characters to seed yield in chickpea

Characters	Indirect effect										Correlation with Yield
	1	2	3	4	5	6	7	8	9	10	
PH	**0. 048**	0.0010	-0.003	0.0020	0.0080	0.0020	-0.0050	-0.0030	-0.0182	0.237	0.232*
100SW	0.012	**-0.0019**	-0.001	0.0090	-0.0100	0.0020	-0.0010	0.0002	-0.0003	-0.022	-0.060
PB	-0.060	-0.0005	**0.015**	-0.0010	0.0047	-0.0022	0.0072	-0.0004	-0.0240	-0.157	-0.158
SB	-0.012	0.0007	0.004	**-0.0060**	0.0140	0.0020	0.0030	0.0003	-0.0070	0.082	0.082
NPP	-0.005	0.0010	-0.001	-0.0010	**0.0320**	0.0004	0.0005	0.0001	0.0340	0.420	0.500**
NSP	0.012	0.0001	0.004	0.0016	0.0024	**-0.0082**	-0.0050	-0.0004	0.0190	0.420	0.207**
DH	-0.012	-0.0005	0.008	-0.0014	0.0018	-0.0033	**0.0130**	0.0040	0.0100	-0.146	-0.122
DM	-0.011	0.0001	0.006	-0.0018	0.0062	-0.0034	0.0056	**0.0010**	-0.0110	-0.105	-0.103
BIO	-0.003	-0.0001	-0.001	0.0002	0.0082	0.0007	0.0007	-0.0006	**0.1943**	0.190	0.217*
HI	0.008	0.0008	-0.002	-0.0005	0.00210	0.0020	-0.0002	-0.0001	0.0040	**0.901**	0.920**

Plant Height (PH), 100-Seed Weight (100SW), No. of Primary Branches (PB), No. of Secondary Branches (SB), No. Of pods per plant (NPP), No. of seeds per pod (NSP), Day to Heading (DH), Day to Maturity (DM), Biomass (BIO), Harvest Index (HI); *, **: Significant at 5 and 1% probability level, respectively Plant height (0.048), number of pod plant^{-1} and number of primary branches (0.015) were the third highest positive direct contributors to seed yield following harvest index and biomass. Plant height had positive and high indirect effects on seed yield via harvest index (0.237). However, it had negative indirect effects via biomass (-0.003), number of pod plant^{-1} (-0.0082) and 100 seed weight (-0.0019). The correlation between number of pods plant^{-1} and seed yield was positively significant (0.50**) and this character had the highest indirect effect on seed yield via harvest index.

Discussion

The results of the present study showed that even through the relationships (correlations) among some characters were significant (Table 3), the path coefficient values were found non-significant (Table 4). According to these results; linear relations among examined characters are insufficient in plant breeding programs. As in our research, Erman *et al*. (1997) [4], Güler *et al*. (2001) [6] and Ciffçi *et al*. (2004) [3] stated that positive and significant relationships were found between seed yield and number of pods plant and harvest index and negative and significant relationships were between seed yield and 100 seed weight. In present research, the high and positive relations observed between the number of pods plant^{-1} and seed yield (r = 0.5**) was similar to the results of Güler *et al*. (2001) [6] and Singh *et al*. (1990) [13]. The highest and positive relationships observed between seed yield and harvest index (0.92**) were similar to Erman *et al*. (1997) [4] and Ciffçi *et al*. (2004) [3]. As results, determining the linear relations among components affecting yield was insufficient to determine selection in chickpea breeding activities. Also, it was essential that the amount of direct and indirect effect of the causal components on the effect component were determined. The present study thus suggests that selection for high seed yield should be based on biomass (biological yield) and harvest index in Kabuli chickpea. Hence, the production feasibility of a wide array of leguminous crops, including chickpea, breeding programme was established at the AICRP unit R.L.B.C.A.U., India in the light of the present research findings, it is proved that this breeding programme can be carried out in a very easily and fast way under the field conditions without the requirement of large labor force and a lot of time and money can be saved.

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