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STUDIUL CARACTERELOR CE CONTRIBUIE LA RANDAMENTUL GENOTIPURILOR PENTRU AMELIORARE A NĂUTULUI (*CICER ARIETINUM* L.)

STUDY THE YIELD CONTRIBUTING CHARACTERS IN CHICKPEA (*CICER ARIETINUM* L.) BREEDING GENOTYPES

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Rezumat. *Prezenta investigație a fost efectuată asupra genotipurilor de năut (12 linii consangvinizate recombinante și 2 soiuri Botna și Ichel) în perioada anilor 2023-2024. Zece caractere cantitative și anume, numărul de zile până la 50% de înflorire, durata fazei reproductive, numărul de zile până la maturitate, numărul de ramuri primare per plantă, numărul de ramuri secundare per plantă, înălțimea plantei, numărul de păstăi și semințe per plantă, numărul de semințe per păstaie și greutatea a o sută de semințe au fost studiate pentru a evidenția productivitatea de semințe per plantă. Studiile de corelație au demonstrate că randamentul de semințe a fost într-o asociere pozitivă semnificativă cu numărul de păstăi per plantă (r=0,639) și numărul de semințe per plantă (r =0,702). Analiza descriptivă a arătat că 4 caractere, adică numărul de păstăi și semințe per plantă, numărul de semințe per păstaie și greutatea a o sută de semințe au avut efecte directe pozitive semnificative asupra producției de semințe. Regresia a confirmat faptul că randamentul de semințe a înregistrat o relație pozitivă și liniară cu numărul de păstăi per plantă (R^2=0,409) și numărul de semințe per plantă (R^2= 494). Pe baza rezultatelor a 3 analize ale caracterelor s-a constatat că numărul de păstăi per plantă, numărul de semințe per plantă, greutatea a o sută de semințe și numărul de semințe per păstaie trebuie luate în considerare pentru optimizarea randamentului.*
Cuvinte-cheie: *năutul, caractere associate cu productivitatea, corelația, analiza descriptivă, regresia.*

Abstract.*The present investigation was carried out in chickpea genotypes (12 Recombinant inbred lines and 2 varieties Botna & Ichel) in 2023-2024. Ten quantitative characters viz., days taken to 50% flowering, duration of reproductive phase, days taken to maturity, No. primary branches per plant, no. secondary branches per plant, plant height, no. pods and seeds per plant, seeds per pod and hundred seeds weight were studied to influence on seeds yield per plant. Correlation studies revealed thatseed yield was in significant positive association with number pods per plant (r=0.639) and number seeds per plant (r=0.702). Path analysis revealed that 4 characters viz. no. pods and seeds per plant, no. seeds per pod und hundred seeds weight had significant positive direct effects on seed yield. Regression showed that seed yield had positive and linear relationship with no. pods per plant (R^2=0.409) and no. seeds per plant (R^2= 494). Based on the results of 3 analyses the characters no. pods per plant, no. seeds per plant, hundred seeds weight and seeds per pod should be taken in consideration for yield improvement.*
Keywords: *chickpea, yield attributing characters, correlation, path analysis, regression.*

Introduction

Chickpea (*Cicer arietinum* L.) is diploid species with 2n = 14, belongs to the *Fabaceae* family, and is considered the first most crucial pulse in the world is widely grown in many subtropical and warm temperate regions. It is usually grown as a rain fed cool-weather crop or as a dry climate crop in semi-arid regions. Chickpea (*Cicerarietinum* L.) is a highly nutritious crop containing 24% protein, 60-65% carbohydrate, 6% fat and also good source of many minerals and vitamins [4].

Determination of importance and effectiveness of yield components is main target. Besides, relationship between yield characters and yield may change in various trials and agronomical and breeding programs. Determining and processing effective yield components and relationships between them causes significant yield increase and leads better results [2]. Correlation analysis enables the determination the strength and direction association between variables. Path analysis is used to determine the direct and indirect effects of each of the characters on seed yield per plant. Regression analysis allows to graphically representing the relationship between 2 characters/parameters. Moulya et al. studied 100 germplasm lines collected from different sources and stated that seed yield was in positive association with number of pods per plant, plant height and hundred seed weight and should be taken in consideration in yield improvement programs [5]. Kumar et al. by studying 12 agro-morphological characters of 204 chickpea lines revealed that correlation and path studies showed that biological yield per plant (r-0.91), number of pods per plant (r-0.680), number of secondary branches per plant (r-0.46), number of seeds per pod (r-0.32) and 100 seed weight (0.29) turned out to be the main components for seed yield per plant in chickpea [3]. Doda and Nepir, at their investigation in Ethiopia noted that among the phenotypic traits considered, number of pods per plant (r=0.25) and number of seeds per plant (r=0.25) had positive correlation with seed yield could be used for indirect selection of increased seed yield. It can be concluded that seed yield in chickpea can be improved by selecting the plant that have greater number of pods per plant and number of seeds per plant [1]. Yadav et al. reported that at the phenotypic level, the following variables demonstrated a positive and significant correlation with seed yield per plant: harvest index, number of seeds per pod, number of major branches per plant, number of pods per plant, and 100-seed weight. These correlations showed that enhancing aforementioned traits can increase seed output [7].

The purpose of this study was to determine relationship between yield and yield attributing characters/components and the effect of yield components on yield using 3 statistical analyses.

Material and methods

The experimental material comprised 14 genotypes of chickpea (12 RILs and 2 varieties *Botna* and *Ichel*). Recombinant inbred lines derived from interspecies hybrid combination ♀MDI02432×♂MDI02419. The experiment was conducted at the experimental field of Institution in 2023-2024. Planting was laid out in a RCBD with three replications, each 3 m^2. Ten quantitative characters viz., *days to 50% flowering* (from sowing), *reproductive phase* (from pod setting initiation to maturity), *days to maturity* and plant data were collected for: *primary branches per plant*, *secondary branches per plant*, *height plant*, *pods and seeds per plant*, *seeds per pod*, *100 seeds weight* and *seed yield per plant* as resultant were measured and subjected analyses. For plant data from each plot were selected randomly 7 plants at harvest time.

The mean performance is subjected to correlation, path and regression analyses. To perform path analysis was used the methodology by Wright S., for seed yield per plant as resultant variable and its components as independent variables [6]. Correlation and regression analysis were calculated/ processed in programs Statistics10 and *Excel*.

Result and discussion

Name of investigated genotypes, 2 varieties *Botna*, *Ichel* and 12 recombinant inbred lines and their type and pigmentation of seed are presented in Table 1. By type of seeds only v. *Botna* is different to others genotypes having *kabuli* or intermediate type. By seed pigmentation genotypes presented in 4 groups: beige, dark-beige, brown and reddish-brown.

Table1. Genotypes and their type and pigmentation of seeds

Geno-types	Type of seeds	Color	Geno-types	Type of seeds	Color	Geno-types	Type of seeds	Color
Botna	desi	brown	LC23	k-g	d-beige	LC24	k-g	d-beige
Ichel	kabuli	beige	LC17	kabuli	beige	LC22	k-g	d-beige
LC3	d-g	r-brown	LC90/2	kabuli	beige	LC152	k-g	brown
LC5	d-g	r-brown	LC72/3	gulabi	yellow	C152b	kabuli	beige
LC14ab	kabuli	beige	LC14b	k-g	d-beige	-	-	-

Abbr.: r-brown = reddish brown, d-beige=dark beige, g = *gulabi* or pea shaped

Mean performance of yield attributing characters, their range, general mean and variation are presented in Table 2. At this amount of data especial is variability of characters. Least variability had character *days to maturity* (1.7%) followed by *days to flowering* (2.29%). Close to each other's by variability arecharacters: *reproductive phase* (4.45%), *primary* (4.84%) and *secondary branches per plant* (4.12%). Character *seed yield per plant* (4.87%) is close to *100 seed weigh* (5.1%) and *number pods per plant* (5.9 %). Relatively more variable are *plant height* (7.55%), *number seeds per plant* (7.3%) and *seeds per pod* (7.1%).

Table2. Mean values of investigated characters (2023-2024)

Genotypes	DFF	RPh	DM	NPBP	NSBP	PH	NPP	NSP	SPod	HSW	SYP
v.Botna	66	32	105	1.9	6.8	45.7	28.87	33.2	1.15	27.1	9.0
v.Ichel	67	32	107	1.8	6.5	58.3	33.57	32.9	0.98	28.9	9.5
LC3	69	33	109	2.0	6.2	61.5	32.74	31.1	0.95	31.5	9.8
LC5	69	33	109	2.0	6.2	59.8	34.63	32.9	0.95	30.1	9.9
LC14ab	67	34	110	1.8	6.5	60.2	33.67	33.0	0.98	29.1	9.6
LC23	72	32	111	1.9	6.3	62.3	34.38	33.7	0.98	28.5	9.6
LC17	67	32	107	1.8	6.6	59.5	38.26	37.5	0.98	28	10.5
LC90/2	68	31	107	1.8	6.4	58.1	34.95	33.9	0.97	27.7	9.4
LC72/3	68	33	108	1.7	5.8	58.6	32.39	31.1	0.96	28.3	8.8
LC14b	68	35	111	1.8	6.5	62.5	33.47	31.8	0.95	29.9	9.5
LC24	67	35	110	1.9	6.1	62.9	33.92	32.9	0.97	29.2	9.6
LC22	69	30	110	1.9	6.1	62.7	34.07	40.2	1.18	26.1	10.5
LC152	70	31	111	2.0	6	64.5	34.06	32.7	0.96	30.3	9.9
C152b	67	33	108	1.8	6.4	58.4	35.41	34.7	0.98	27.1	9.4
Min	**66**	**30**	**105**	**1.7**	**5.8**	**45.7**	**28.87**	**31.1**	**0.95**	**26.1**	**8.8**
Max	**72**	**35**	**111**	**2**	**6.8**	**64.5**	**38.26**	**40.2**	**1.18**	**31.5**	**10.5**
Mean	**68.1**	**32.6**	**108.8**	**1.86**	**6.31**	**59.6**	**33.9**	**33.7**	**0.99**	**28.7**	**9.6**
CV, %	**2.29**	**4.45**	**1.7**	**4.84**	**4.12**	**7.55**	**5.9**	**7.3**	**7.1**	**5.1**	**4.87**

DFF– days taken to 50% flowering, RPh – duration of reproductive phase, DM - days taken to maturity, NPBP – No. primary branches per plant, NSBP – No. secondary branches per plant, PH – Plant height(cm), NPP and NSP – No. pods and seeds per plant, SPod – seeds per pod, HSW – 100 seeds weight(g.), SYP – seeds yield per plant(g.).

Correlation coefficient analysis: *days taken to flowering* exhibited significant values with days *taken to maturity* (0.651) and *height plant* (0.570). *Reproductive phase* showed only one but negative significant values with *seeds per plant* (-0.572). Significant positive relationship had character *days taken to maturity* with *plant height* (0.847). Character *primary branches per plant* have had no significant values with any character. *Secondary branches per plant* reveled significant negative value with *height plant* (-0.596). Character *height plant* displayed significant association with character *pods per plant* (0.571). Character *pods per plant* exhibited significant positive correlation with *grain yield per plant* (0.639). *Grain per plant* showed significant positive values with characters *grain per pod* (0.624) and *grain yield per plant* (0.702), but significant negative value with *weight of 100 seeds* (-0.698). Character *grain per pod* coupled with *weight of 100 seeds* has been in significant negative relationship (-0.701), Table 3.

Table 3. Phenotypic correlations among investigated characters in chickpea

Traits	RPh	DM	NPBP	NSBP	PH	NPP	NSP	SPod	HSW	GYP
DFF	-0.309	0.651*	0.462	-0.487	0.570*	0.165	-0.007	-0.176	0.282	0.261
RPh		0.249	-0.179	0.056	0.114	-0.093	-0.572*	-0.505	0.459	-0.340
DM			0.310	-0.494	0.847*	0.213	-0.061	-0.287	0.424	0.319
NPBP				-0.164	0.180	-0.134	-0.029	0.089	0.458	0.404
NSBP					-0.596*	-0.062	0.133	0.233	-0.235	-0.023
PH						0.571*	0.071	-0.467	0.421	0.508
NPP							0.456	-0.407	-0.027	0.639*
NSP								0.624*	-0.698*	0.702*
SPod									-0.701*	0.152
HSW										0.016

*- significant at level, $P \leq 0.05$

Table 4. Path analysis: direct and indirect effects effective characters on yield

Characters	Direct effect	No. pods / plant	No. seeds /plant	No. seeds/ pod	100 seeds weight
Days to flowering	-0.0074	0.1247	-0.0039	-0.1436	0.2795
Reproductive phase	-0.0169	-0.0706	-0.3054	-0.4110	0.4544
Dais to maturity	0.0285	0.1610	-0.0329	-0.2336	0.4192
No. primary branches/ pl	-0.0105	-0.1012	-0.0156	0.0726	0.4533
No. second. branches/ pl	-0.0042	-0.0472	0.0711	0.1901	-0.2328
Plant height	-0.0153	0.4315	0.0381	-0.3807	0.4163
No. pods per plant	0.7548		0.2436	-0.3313	-0.0268
No. seeds per plant	0.5332	0.3449		0.5082	-0.6903
No. seeds per pod	0.5137	-0.3073	0.3330		-0.6934
Hundred seeds weight	0.7885	-0.0205	-0.3724	-0.5708	

Path analysis: the data pertaining to direct and indirect effects of yield attributes on seeds yield per plant are given in Table 4. Four characters showed significant positive direct effects on grain yield per plant. The highest direct effect exhibited character *100 grain weight* (0.7885) followed by characters *pods per plant* (0.7548), *seeds per plant* (0.5332) and *seeds per pods* (0.5137). Characters such as *days taken to flowering*, *reproductive phase*, *primary* and *secondary branches per plant* and *height plant* exhibited negligible negative direct effects on grain yield per plant; negligible positive direct effect on seeds yield had character days *taken to maturity*. These 6 characters also have no indirect effect on grain yield per plant, Table 4. Character *pods per plant* manifested significant

indirect effects through *height plant* (0.4315) and *seeds per plant* (0.3449) and negative significant effect through *seeds per pod* (-0.3073) on seeds yield. Moderate positive indirect effects *pods per plant* displayed through *days taken to flowering* (0.1247) and *days taken to maturity* (0.1610). Character *seeds per plant* manifested significant positive indirect effects through *grain per pod* (0.333) and *pods per plant* (0.2436), but significant negative indirect effects through weight *of 100 seeds* (-0.3724) and *reproductive phase* (-0.3054).

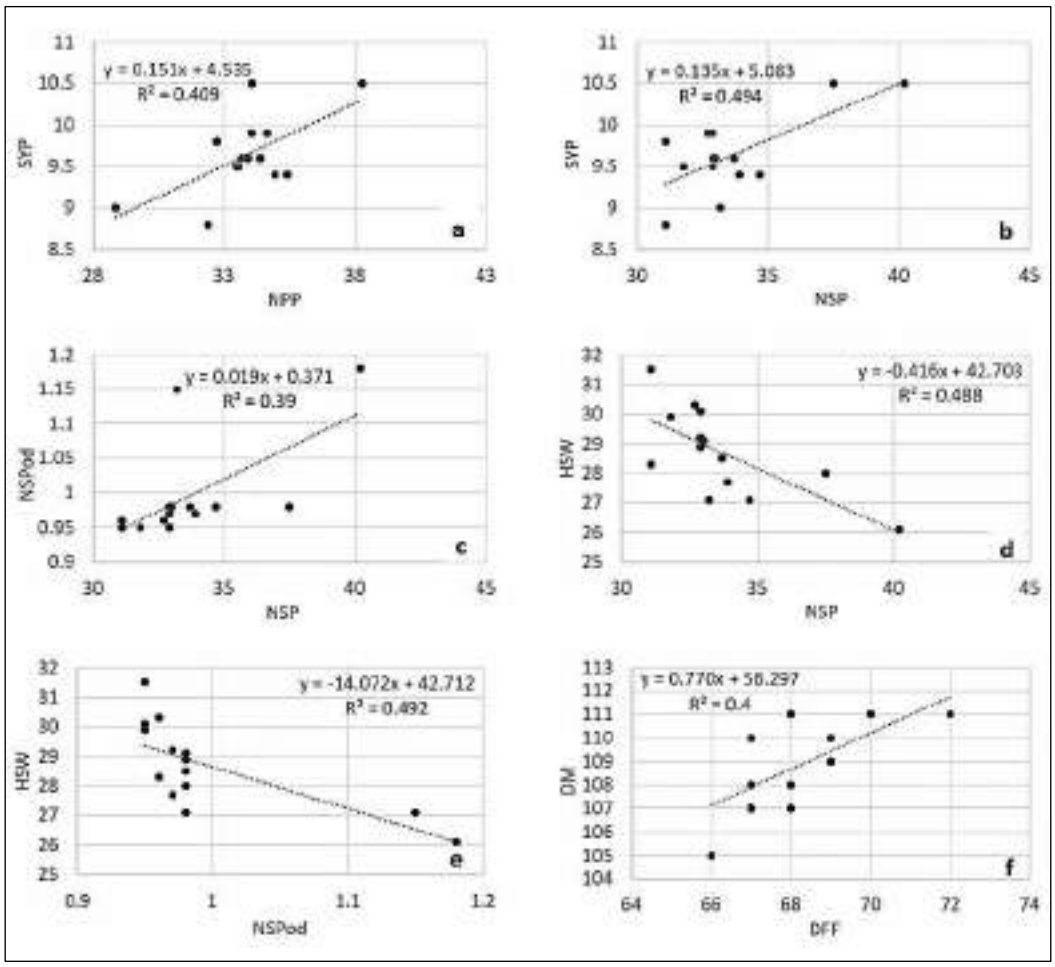


Fig. 1. Relationships between characters: (a) number pods per plant and seeds yield per plant, (b) number seeds per plant and seeds yield per plant, (c) number seeds per plant and number seeds per pod, (d) number seeds per plant and 100 seeds weight, (e) number seeds per pod and 100 seeds weight, (f) days taken to flowering and days to maturity

Character *seeds per pod* displayed significant positive indirect effect through character *seeds per plant* (0.5082) but significant negativeeffects through following characters: *100 seeds weight* (-0.5708), *reproductive phase* (-0.4110), *height plant* (-0.3807) and *pods per plant* (-0.3313), and moderate negative effects through characters *days taken to maturity* (-0.2326) and *days taken to flowering* (-0.1436). Character *100 seeds weight* exhibited significant positive indirect effect on seeds yield through following characters: *reproductive phase* (0.4544), *days taken to maturity* (0.4192), *primary branches per plant* (0.4533) and *height plant* (0.4163), and moderate one through *days taken to flowering* (0.2795). Highly significant negative effects *100 seeds weight* exhibited through *seeds per pod* (-0.6934) and *seeds per plant* (0.6903), Table 4.

Regression analysis: the graphical representation of the regression analysis the 6 couple of characters illustrated in Fig. 1, a, b, c, d, e, f. Conditionally these could be divided into 3 groups: (1) relationship between effective components and seeds yield per plant, (2) relationship among effective component and (3) among non-effective components. Pertaining to 1 group was singled out 2 couple: (a) *number pod per plant* and *SYP*, (b) *number seeds per plant* and *SYP*. For the first pair determination coefficient (DC) is R^2=0.409, for the second pair DC is a little greater R^2= 0.494, both pair characterized as positive linear regression. In the second group was singled 3 couple: (c) *number seeds per plant* and *number seeds per pod* (R^2=0.39), (d) *number seeds per plant* and *100 seeds weight* (R^2=0.488) and (e) *number seeds per pod* and *HSW* (R^2= 0.492), first pair positive linear, second and third one negative linear regression. At third group presented 1couple of characters: (f) *days to flowering* and *days to maturity* (R=0.4) characterized as positive linear regressions (Fig. 1).

Conclusion

As a result of the conducted research and on the basis using of 3 statistical analyses 4 characters were determined as effective on resultant character seeds yield per plant. Bydegree of importance *seeds per plant* and *pods per plant* have some priority over *hundred seeds weight* and *seeds per pod*. Therefore, characters: seeds *per plant*, pods *per plant, hundred seeds weight* and *seeds per pod* should be taken in considerationfor yield improvement.

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