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Accessing the Performance of Promising Germplasm of Chickpea (*Cicer arietinum* L.) under Red and Black Soil Conditionss

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

About 550 germplasm accessions were evaluated in Rani Lakshmi Bai Central Agricultural University Jhansi Research farm for quantitative traits during rabi 2019-20, among them twenty germplasm accessions were selected based on their seed yield. During rabi 2020-21, these selected germplasm accessions are raised in red and black soil conditionss for accessing their performance through direct (variability, heritability, and genetic advance) and indirect selection parameters (correlation and path coefficient analysis). About seventeen quantitative traits were studied in both soil conditions Under red and black soil conditions, chlorophyll content, pods per

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plant, 100 seed weight, biological yield, and seed yield showed high Phenotypic and Genotypic Coefficient of Varience. In red soil conditions, chlorophyll content, plant height, 100 seed weight, biological yield, and seed yield showed high heritability and genetic advance, while in black soil conditions leaf area index, chlorophyll content, primary branches, and 100 seed weight showed high heritability coupled with genetic advance. By considering indirect selection parameters in the red soil conditions leaf area index, the number of primary branches and biological yield per plant were the major direct contributors to seed yield. Similarly, under black soil conditions leaf area index, leaflet size, and biological yield per plant were the major direct contributors to seed yield. By comparing the performance of twenty genotypes most of the genotypes perform well under red soil conditionss than black soil conditions.

Keywords: Chickpea; red soil; black soil; heritability; genetic advance; indirect selection parameters.

1. INTRODUCTION

Chickpea *(Cicer arietinum* L.*)* is one of the most important and earliest cultivated legumes, known for cultivation for the last 7500 years [1]. It ranks second among the world's food legumes in terms of area. India is the largest producer (12.61 million tonnes) of chickpea's with an average yield of 1077 kg ha^{-1} [2]. Chickpea shares about 34% area and 48% of the production of the total pulses in our country. In India, chickpea is grown on about 10.56 million ha that is spread over mainly in Madhya Pradesh, Maharashtra, Rajasthan, Karnataka, Uttar Pradesh, Andhra Pradesh, Chhattisgarh, and Jharkhand. The average productivity of chickpea in Bundelkhand is 1320 kg ha^{-1} which is more than the national average with a total production of 1.08 million tonnes (mt) from an area of 0.79 million ha [3]. A large number of varieties of desi and Kabuli chickpea have been developed for different agro-ecological zones or states. Its grains are rich in protein (22%), carbohydrates (60%), fat (4.5%), Ca (280 milli gram/100g), Fe (12.3 milli gram/100g) and P (301 milli gram/100 g) besides dietary fibre [4].

Chickpea is pulse crop can be grown very well in many soil conditions. Generally chickpea is grown as rainfed crop in black loamy soil, but also with some life saving irrigation it can be grown very well in red soil also. The aim of our investigation is to identify suitable germplasm that can perform very well in black and red soil, and use them in crop improvement program to relase suitable varieties in the particular area.

Cultivars with a narrow genetic base emerged due to the extensive use of few and closely related germplasm lines in the crop improvement program. Diverse genetic backgrounds of parental lines provide the allelic variation necessary to create favourable new gene combinations. Genetically diverse germplasm is therefore needed in breeding programs to enhance the productivity and diversity of cultivars. The introduction of germplasm remains a major strategy to enhance genetic diversity. The knowledge of genetic variability present in targeted material is essential for better understanding the worth of the germplasm material introduced and its utilization in the crop improvement program. Out of the several promising donors/genotypes, one should identify the genotype/donor having a combination of useful traits (Agronomically superior) for use in the breeding programme.

2. MATERIALS AND METHODS

This investigation was carried from rabi 2019-20 to *rabi* 2020-21 in Rani Lakshmi Bai Central Agricultural University Jhansi Research farm. During *rabi* 2019-20, 550 germplasm accessions of chickpea were evaluated for qualitative and quantitative traits, among them twenty genotypes were selected based on their seed yield. In the next year, these selected twenty genotypes were raised in randomized block design, with three replications using four checks (RVG 202, RVG 203, JG 36 and RLBGK 1) in two sets viz., red and black soil conditions. All these accessions were evaluated for about 17 quantitative traits viz., days to 50% flowering, days to maturity, chlorophyll fluorescence, leaf area index, leaf-let size, chlorophyll content, plant height, primary branches per plant, secondary branches, pods per plant, seeds per pod, pod length, peduncle length, 100 seed weight, biological yield per plant, harvest index and seed yield per plant. And these data were subjected to analysis of variation, and other biometrical methods were followed to estimate the phenotypic coefficient of variance, genotypic coefficient of variance, heritability, genetic advance, and correlation and path analysis

3. RESULTS AND DISCUSSION

3.1 Variability Studies

Analysis of variance showed that all the traits studied underboth soil types exhibited highly significant differences (Table 1 and 2). Genetic parameters of yield and their components are studied and given in Table 3 and 4. Under red soil conditions, high Genotypic and Phenotypic Coefficient of Variance were reported for chlorophyll fluorescence (23.27 and 36.72), chlorophyll content (48.14 and 61.06), 100 seed weight (35.75 and 36.08), biological yield per plant (27.57 and 32.97), and seed yield per plant (23.44 and 29.18). While under black soil conditionss, leaf area index (36.7 and 44.03), chlorophyll content (58.13 and 74.85), peduncle length (22.41 and 26.5), 100 seed weight (31.58 and 31.97), biological yield per plant (35.17 and 51.43) and seed yield per plant (38.15 and 55.92) showed high GCV and PCV value. The presence of high Genotypic and Phenotypic coefficient of Varience for 100 seed weight, seed yield per plant, was earlier reported by Banik et al*.* [5], Jain et al*.* [6], and Kishor et al*.* [7]. High Genotypic and Phenotypic Coefficient of Variance for 100 seed weight, seed yield per plant, and biological yield per plant were also reported earlier by Mohan et al*.* [8]. Under both soil conditionss value of Phenotypic Coefficient of Variance is higher than the Genotypic Coefficient of Variance which reveals the presence of high environmental influence on these traits.

High heritability coupled with genetic advance was reported for chlorophyll content, plant height, pods per plant, pod length, 100 seed weight, biological yield per plant, and seed yield per plant under red soil conditionss. Similarly, under black soil conditionss leaf area index, chlorophyll content, primary branches, secondary branches, peduncle length, and 100 seed weight exhibited high heritability and genetic advance. And remaining traits showed a high to moderate level of heritability and genetic advance (Table 3 and 4). Similarly, Ali et al*.* [9] and Johanson et al*.* [10] reported high genetic advance in chlorophyll content, grain yield, pods per plant, 100 seed weight. Similar results of high genetic advance were reported by Hagoes et al*.* [11] for the number of pods per plant, and 100 seed weight. Later kishor et al*.* [7] reported high genetic advances for primary branches per plant, pods per plant, biological yield per plant, and seed yield per plant which is similar to our result.

3.2 Character Association Studies

In red soil conditions, Seed yield per plant had a highly significant and positive association with leaf area index (0.813**), chlorophyll fluorescence (0.563**), primary branches (0.707**) and biological yield per plant (0.799**). It showed a significant negative correlation with chlorophyll content (-0.6512). Biological yield per plant had a highly significant and positive association with chlorophyll fluorescence (0.588**), leaf area index (0.74**), primary branches (0.663**), seed yield (0.7998**). Similarly, 100 seed weight, had a highly significant and positive association with leaf-let size (0.809**), pod length (0.680**) and peduncle length (0.551**). Pods per plant had a highly significant and positive association with primary branches (0.498*). Seed yield per plant is significantly positively correlated with leaf area index, primary branches, biological yield per plant (Table 5). Similar results were also reported by Kumar et al. [12]; Tesfamichael et al. [13]; Kumar et al*.* [14]; Hagoes et al*.* (2015); Mohan et al*.* [8]; Jan et al. (2015); Vaghela et al*.* [15]; Sohil et al*.* [16].

Under black soil conditions, seed yield per plant is positively correlated with leaf area index (0.842**), leaf-let size (0.446**), primary branches (0.956**), secondary branches (0.094**), peduncle length (0.642**), 100 seed weight (0.479**) and biological yield per plant (0.979**). While it is a significantly negative correlation with days to maturity (-0.544**). A similar report of highly significantly positive correlation was also reported by Noor et al*.* [17]; Arshad et al*.* [18]; Babbar et al. [19]; Bayahi et al*.* [20]; Tsehaye et al. [21]. Days to maturity showed a negative correlation with seed yield which was also reported earlier by Kumar et al. (2020); Kumar et al*.* [14]; Hagoes et al*.* [11]; Jain et al. [6]; Talebi et al*.* [22]; Ali et al. [23]; Tadesse et al. [24]; Jivani et al. [25]. The harvesting index had a highly significant and negative association with days to 50% flowering (-0.707**), days to maturity (-0.792**), and pod length (-0.54**). Biological yield per plant showed a significant negative correlation with days to 50% flowering (-0.181**). Chlorophyll content had significant positive correlation with leaf area index (0.421*), plant height (0.503*), peduncle length (0.678**), and 100 seed weight (0.647**)(Table 5). And leaf area index had significant positive correlation with leaf-let size (0.546**), chlorophyll content (0.421*), primary branches (0.929**), secondary branches (0.824**), peduncle length (0.692**),

Table 1. ANOVA for red soil conditions

Sources of variation	DF	DF50	DM	CF	LAI	LS	CC	PH	PB	SB	PPP	SPP	PDL	PL	100SW	BYPP	SYPP	HI
Replication	2	2.04	15.72	0.81	0	0.16	0.21	10.53	0.9	2.22	20.42	0.086	0.14	2.11	11.60***	48.7	3.72	0.002
Genotype	23	201.7***	40.8**	0.63*	0.01*	4.5**	3.8***	271.8***	0.26**	13.18***	717.7***	0.130**	19.22***	4.10*	117.4***	261.8***	42.63***	0.015***
Error	46	4.56	7.21	0.21	0	0.87	0.64	4.89	0.17	3.63	77.79	0.050	0.84	1.88	0.72	32.85	6.60	0.004

Table 2. ANOVA for black soil conditions

Sources of variation	DF	DF50	DM	CF	LAI	LS	CC	PH	PB	SB	PPP	SPP	PDL	PL	100SW	BYPP	SYPP	HI
Replication	2	5.18*	47.5**	0	0.38	1.96	0.072	17.5	0.23	0.15	162.6	0.037	526.2	11.1	3.99	1.69	3.55	0.017
Genotype	23	88.08**	57.8***	0.01*	1.16**	6.94***	4.63***	52.1**	1.44**	35.62**	356***	0.15***	562.13*	26**	100.5***	74.8***	2.85***	0.014*
Error	46	1.07	4.33	0	0.15	1.15	0.83	8.94	0.18	6.13	90.9	0.054	504.7	3	0.82	20.59	6.32	0.006

and indicate 5% and 1% level of significance*

DF50=Days to 50% flowering; DM=Days to maturity; CF=Chlorophyll fluorescence; LAI=Leaf area index; LS=leaf-let size; CC=Chlorophyll content; PH=Plant hight; PB=Primary branches; SB=Secondary branches; PPP=Pods per plant; SPP=Seeds per pod; PDL= Pod length; Pl= Peduncle length; 100SW= Hundred seed weight, BYPP= Biological yield per plant; SYPP= Seed yield per plant; HI= Harvest index

Table 3 and 4. Estimation of PCV and GCV, heritability, genetic advance, and genetic advance as per mean for various characters in chickpea for red soil and black soil conditions (2020-21)

S.No	Character	Coefficient of variance		Heritability	Genetic advance	Genetic advance as per mean	S.No	Character	Coefficient of variance		Heritability	Genetic advance	Genetic advance as per mean
		GCV	PCV						GCV	PCV			
1	DF50	9.83	10.17	93.51	16.15	19.58	1	DF50	7.36	7.5	96.41	10.89	14.9
2	DM	2.39	3.07	60.82	5.38	3.85	2	DM	3.77	4.2	80.44	7.8	6.96
3	CF	23.27	36.72	40.16	0.49	30.38	3	CF	8.8	9.21	91.24	0.14	17.31
4	LAI	6.16	6.65	85.67	0.09	11.74	4	LAI	36.7	44.03	69.5	1	63.04
5	LS	8.64	11.34	58.1	1.73	13.57	5	LS	10.8	13.65	62.55	2.26	17.59
6	CC	48.14	61.06	62.15	1.67	78.18	6	CC	58.13	74.85	60.32	1.8	93
7	PH	15.67	16.09	94.79	18.92	31.42	7	PH	7.95	10.12	61.67	6.14	12.86
8	PB	13.27	17.37	58.37	0.78	20.88	8	PB	19.48	23.32	69.78	1.12	33.52
9	SB	9.04	13.24	46.66	2.51	12.72	9	SB	20.82	26.53	61.6	5.07	33.66
10	PPP	14.08	16.45	73.28	25.75	24.83	10	PPP	16.99	24.2	49.29	13.6	24.57
11	SPP	11.74	19.91	34.77	0.2	14.26	11	SPP	13.14	21.04	38.98	0.24	16.9
12	PDL	13.05	13.93	87.87	4.78	25.21	12	PDL	21.03	73.11	3.65	1.72	8.28
13	PL	7.55	14.22	28.18	0.94	8.25	13	PL	22.41	26.5	71.54	4.82	39.05
14	100SW	35.75	36.08	98.16	12.73	72.96	14	100SW	31.58	31.97	97.59	11.74	64.27
15	BYPP	27.57	32.97	69.91	15.05	47.49	15	BYPP	35.17	51.43	46.75	5.99	49.53
16	SYPP	23.44	29.18	64.52	5.73	38.78	16	SYPP	38.15	55.92	46.54	3.3	53.62
17	HI	12.86	18.42	48.72	0.09	18.48	17	HI	9.89	19.17	26.6	0.05	10.5

Table 5. Estimation of the genotypic correlation coefficient for red and black soil. Values below the diagonal represent red soil, and values above the diagonal represent black soil

	DF50	DM	CF	LAI	LS	CC	PH	PB	SB	PPP	SPP	PDL	PL	100SW	BYPP	HI	SYPP
DF50	1 **	0.5493 **	0.0553	-0.5401 **	-0.5945 **	-0.564 **	-0.1383	-0.4262 *	-0.3911	-0.1641	0.8389 **	-0.9501 **	-0.6396 **	-0.5842 **	-0.1813	-0.7073 **	-0.3493
DM	0.3174	1 **	-0.1728	-0.445 *	0.03	0.1388	0.0938	-0.4337 *	-0.3661	-0.4872 *	0.5045 *	-0.6089 **	-0.2729	-0.1185	-0.369	-0.7924 **	-0.5339 **
CF	-0.4153 *	0.1088	1 **	0.243	0.3082	0.2264	0.3818	0.3065	0.3609	0.346	-0.0326	0.2155	0.2607	0.3119	0.4204 *	-0.1222	0.3577
LAI	0.0697	0.2079	0.8484 **	1 **	0.5463 **	0.4214 *	0.3334	0.9294 **	0.8249 **	0.3918	-0.5532 **	0.684 **	0.6923 **	0.6244 **	0.7261 **	0.6036 **	0.8424 **
LS	-0.5945 **	-0.0167	0.2251	-0.0846	1 **	0.803 **	0.7022 **	0.5967 **	0.6915 **	-0.0828	-0.6059 **	-0.3519	0.9114 **	0.7932 **	0.5101 *	-0.2082	0.4465 *
CC	-0.5081 *	-0.1453	-0.0982	-0.6726 **	0.7039 **	1 **	0.6151 **	0.3806	0.4344 *	-0.087	-0.3038	-0.0712	0.6783 **	0.6476 **	0.3925	0.0508	0.3884
PH	-0.041	0.6726 **	0.0828	-0.1158	0.3866	0.5037 *	1 **	0.5024 *	0.6173 **	-0.1593	-0.3281	-0.5158 **	0.5518 **	0.4931 *	0.3641	0.1391	0.3673
PB	-0.1232	0.3464	0.881 **	0.931 **	0.0612	-0.3117	0.1476	1 **	0.9845 **	0.2845	-0.5061 *	-0.3301	0.7756 **	0.6214 **	0.8612 **	0.5697 **	0.9569 **
SB	0.4831 *	0.0295	-0.0148	0.1929	-0.5791 **	-0.0138	0.0118	0.089	1 **	0.0806	-0.4913 *	-0.0453	0.9037 **	0.713 **	0.9761 **	0.2705	0.954 **
PPP	-0.2399	0.1759	0.2049	0.3705	-0.149	0.2614	0.3713	0.4987 *	0.3121	1 **	-0.1463	-0.5004 *	-0.0455	-0.1314	0.1813	-0.0775	0.1311
SPP	0.4687 *	0.1694	-0.3478	-0.1135	-0.4618 *	-0.3487	0.0994	-0.1171	0.3785	-0.1162	1 **	-0.4863 *	-0.6174 **	-0.7174 **	-0.2523	-0.54 **	-0.367
PDL	-0.6134 **	0.0469	0.0583	-0.3531	0.9328 **	0.7796 **	0.5118 *	-0.2072	-0.612 **	-0.035	-0.4676 *	1 **	0.2971	0.9424 **	-0.3927	0.9122 **	0.0283
PL	-0.6638 **	-0.0639	0.0818	-0.2335	0.4835 *	0.6337 **	0.2202	-0.0637	-0.1294	0.0755	-0.6763 **	0.5331 **	1 **	0.8334 **	0.562 **	0.4005	0.6422 **
100SW	-0.5952 **	-0.2403	0.3783	0.1519	0.8096 **	0.3446	0.0967	0.0702	-0.7931 **	-0.251	-0.7941 **	0.6801 **	0.5518 **	1 **	0.4539 *	0.2706	0.479 *
BYPP	0.1467	0.3378	0.5884 **	0.74 **	0.1956	-0.3707	0.1805	0.663 **	-0.1345	-0.2835	-0.0043	-0.0301	-0.2965	0.2534	1 **	0.0185	0.9798 **
HI	-0.2019	-0.5111 *	-0.2259	-0.0479	-0.4023	-0.4879 *	-0.7167 **	-0.1459	-0.0817	-0.0354	0.0063	-0.4628 *	0.0993	-0.1166	-0.5575 **	1 **	0.2366
SYPP	-0.0578	0.0885	0.5635 **	0.8131 **	0.0461	-0.6512 **	-0.1722	0.7077 **	-0.269	-0.2903	0.0026	-0.2488	-0.1749	0.2816	0.7998 **	0.0414	1 **

Table 6. Genotypic Path matrix; direct and indirect effects of various characters on seed yield in chickpea for red soil conditions

	DF50	DM	CF	LAI	LS	CC	PH	PB	SB	PPP	SPP	PDL	PL	100SW	BYPP	HI
DF50	-0.30	0.019	0.074	0.001	-0.142	0.031	-0.005	-0.004	-0.003	0.003	0.030	0.282	-0.011	-0.084	0.152	-0.102
DM	-0.095	0.061	-0.019	0.003	-0.004	0.009	0.078	0.012	-0.000	-0.002	0.011	-0.022	-0.001	-0.034	0.351	-0.259
CF	0.124	0.007	-0.179	0.012	0.054	0.006	0.010	0.031	0.000	-0.002	-0.022	-0.027	0.001	0.053	0.610	-0.115
LAI	-0.021	0.013	-0.152	0.014	-0.020	0.041	-0.013	0.040	-0.001	-0.004	-0.007	0.162	-0.004	0.021	0.768	-0.024
LS	0.178	-0.001	-0.040	-0.001	0.239	-0.043	0.045	0.002	0.003	0.002	-0.030	-0.429	0.008	0.114	0.203	-0.204
CC	0.152	-0.009	0.018	-0.010	0.168	-0.061	0.058	-0.011	0.000	-0.003	-0.022	-0.358	0.010	0.048	-0.385	-0.247
PH	0.012	0.041	-0.015	-0.002	0.092	-0.031	0.115	0.005	-0.000	-0.004	0.006	-0.235	0.004	0.014	0.187	-0.363
PB	0.037	0.021	-0.157	0.016	0.015	0.019	0.017	0.035	-0.001	-0.006	-0.008	0.095	-0.001	0.010	0.688	-0.074
SB	-0.145	0.002	0.003	0.003	-0.138	0.001	0.001	0.003	-0.006	-0.004	0.024	0.281	-0.002	-0.112	-0.140	-0.041
PPP	0.072	0.011	-0.037	0.005	-0.036	-0.016	0.043	0.018	-0.002	-0.011	-0.007	0.016	0.001	-0.035	-0.294	-0.018
SPP	-0.141	0.010	0.062	-0.002	-0.110	0.021	0.011	-0.004	-0.002	0.001	0.064	0.215	-0.011	-0.112	-0.005	0.003
PDL	0.184	0.003	-0.010	-0.005	0.222	-0.047	0.059	-0.007	0.004	0.000	-0.030	-0.460	0.009	0.096	-0.031	-0.234
PL	0.199	-0.004	-0.015	-0.003	0.115	-0.038	0.025	-0.002	0.001	-0.001	-0.044	-0.245	0.017	0.078	-0.308	0.050
100SW	0.178	-0.015	-0.068	0.002	0.193	-0.021	0.011	0.002	0.005	0.003	-0.051	-0.313	0.009	0.141	0.263	-0.059
BYPP	-0.044	0.021	-0.105	0.010	0.047	0.023	0.021	0.024	0.001	0.003	-0.000	0.014	-0.005	0.036	0.934	-0.282
HI	0.061	-0.031	0.041	-0.001	-0.096	0.030	-0.083	-0.005	0.000	0.000	0.000	0.213	0.002	-0.016	-0.579	0.506

Table 7. Genotypic Path matrix; direct and indirect effects of various characters on seed yield in chickpea for black soil conditions

	DF50	DM	CF	LAI	LS	CC	PH	PB	SB	PPP	SPP	PDL	PL	100SW	BYPP	HI
DF50	0.025	0.024	0.005	-0.083	-0.102	0.027	0.014	0.010	0.000	0.023	-0.111	-0.008	-0.016	0.176	-0.174	-0.161
DM	0.014	0.044	-0.015	-0.068	0.005	-0.007	-0.010	0.010	0.000	0.070	-0.067	-0.005	-0.007	0.036	-0.353	-0.181
CF	0.001	-0.008	0.088	0.037	0.053	-0.011	-0.040	-0.007	-0.000	-0.050	0.004	0.002	0.007	-0.094	0.403	-0.028
LAI	-0.013	-0.020	0.021	0.153	0.094	-0.020	-0.035	-0.022	-0.001	-0.056	0.073	0.006	0.018	-0.189	0.695	0.138
LS	-0.015	0.001	0.027	0.084	0.172	-0.049	-0.073	-0.014	-0.001	0.012	0.080	-0.003	0.023	-0.240	0.488	-0.048
CC	-0.014	0.006	0.020	0.064	0.172	-0.048	-0.064	-0.009	-0.000	0.012	0.040	-0.001	0.017	-0.196	0.376	0.012
PH	-0.003	0.004	0.034	0.051	0.121	-0.030	-0.104	-0.012	-0.001	0.023	0.044	-0.004	0.014	-0.149	0.349	0.032
PB	-0.011	-0.019	0.027	0.142	0.102	-0.018	-0.052	-0.024	-0.001	-0.041	0.067	-0.003	0.020	-0.188	0.825	0.130
SB	-0.010	-0.016	0.032	0.126	0.119	-0.021	-0.064	-0.023	-0.001	-0.012	0.065	-0.000	0.023	-0.215	1.030	0.062
PPP	-0.004	-0.021	0.031	0.060	-0.014	0.004	0.017	-0.007	-0.000	-0.143	0.019	-0.004	-0.001	0.040	0.174	-0.018
SPP	0.021	0.022	-0.003	-0.085	-0.104	0.015	0.034	0.012	0.000	0.021	-0.133	-0.004	-0.016	0.217	-0.242	-0.123
PDL	-0.024	-0.027	0.019	0.105	-0.060	0.003	0.053	0.008	0.000	0.072	0.065	0.008	0.008	-0.285	-0.376	0.459
PL	-0.016	-0.012	0.023	0.106	0.156	-0.033	-0.057	-0.018	-0.001	0.007	0.082	0.003	0.025	-0.252	0.538	0.091
100W	-0.015	-0.005	0.028	0.095	0.136	-0.031	-0.051	-0.015	-0.001	0.019	0.095	0.008	0.021	-0.302	0.435	0.062
BYPP	-0.005	-0.016	0.037	0.111	0.088	-0.019	-0.038	-0.020	-0.001	-0.026	0.034	-0.003	0.014	-0.137	0.957	0.004
HI	-0.018	-0.035	-0.011	0.092	-0.036	-0.002	-0.014	-0.014	-0.000	0.011	0.072	0.017	0.010	-0.082	0.018	0.228

pod length (0.684**), 100 seed weight (0.624**), biological yield per plant (0.726**), harvesting index (0.603**) and seed yield per plant (0.842**). Ali et al. [9] reported chlorophyll content is negatively correlated with leaf area index which is similar to our results in black soil conditionss.

3.3 Path Coefficient Analysis

In the red soil conditions, biological yield per plant (0.934), harvesting index (0.056), 100 seed weight (0.141), plant height (0.115), leaf area index (0.014), primary branches (0.035), and seeds per pod (0.064) exhibited direct positive effect on seed yield. Leaf area index has a positive indirect effect on yield through biological yield per plant (0.768), pod length (0.162), 100 seed weight (0.021), primary branches (0.040), and chlorophyll content (0.041). Biological yield per plant had a positive indirect effect on yield through leaf-let size (0.047), 100 seed weight (0.036), chlorophyll content (0.023), and primary branches (0.024). Chlorophyll fluorescence had a negative direct effect (-0.179) on seed yield. Chlorophyll fluorescence has a positive indirect effect on yield through biological yield per plant (0.610), days to 50% flowering (0.124), leaf-let size (0.054), primary branches (0.031), and leaf area index (0.012). Primary branches had a positive indirect effect on yield through biological yield per plant (0.688), pod length (0.095), plant height (0.017), chlorophyll content (0.019), leaf-let size (0.015), leaf area index (0.016) (Table 6).

The highest direct effect on seed yield per plant was exhibited by biological yield per plant, followed by the harvesting index, plant height, 100 seed weight, leaf area index, and days to maturity, and the same results are also reported by Arshad et al. [18]; Jivani et al. [25]; Khan and Gul [26]; Hagos et al. [11]; Paneliya et al. [27]; Kumar et al. [14]. And days to 50% flowering, chlorophyll content, secondary branches per plant, pods per plant, and seeds per pod showed the negative indirect effect on seed yield, and similar direct negative effects are also reported by Talebi et al. [22], and Shafique et al. [28].

Under black soil conditions, biological yield per plant (0.957), harvest index (0.228), leaflet size (0.172), leaf area index (0.153), peduncle length (0.025), chlorophyll fluorescence (0.088), days to 50% flowering (0.025) and days to maturity (0.044) exhibited direct positive effect on seed yield. Leaf area index has a positive indirect effect on yield through biological yield per plant (0.695), harvesting index (-0.138), leaf-let size (0.094), and chlorophyll fluorescence (0.021). Leaf-let size has a positive indirect effect on yield through biological yield per plant (0.203), 100 seed weight (0114), days to 50% flowering (0.178), and plant height (0.045). Primary branches had a positive indirect effect on yield through biological yield per plant (0.825), harvesting index (0.130), leaf-let size (0.102), leaf area index (0.142), pod length (0.020), and seeds per pod (0.067). Secondary branches had a negative direct effect (-0.001) on seed yield. Secondary branches had a positive indirect effect on yield through biological yield per plant (0.943), leaf area index (0.126), leaf-let size (0.119), chlorophyll fluorescence (0.032), seeds per pod (0.065), and harvesting index (0.062). 100 seed weight, had a negative direct effect (-0.302) on seed yield. 100 seed weight had a positive indirect effect on yield through biological yield per plant (0.435), leaf-let size (0.136), leaf area index (0.095), seeds per pod (0.095), and harvest index (0.062) (Table 7). The direct effect on seed yield per plant was exhibited by biological yield per plant, followed by harvesting index, days to 50% flowering. These results are also reported by Vaghela et al. [15]. Agarwal et al. (2018) reported days to 50% flowering showed an indirect positive effect on yield through days to maturity, plant height, and 100 seed weight which is similar to the results of our set 2 [29,30]. Pods per plant showed an indirect positive effect on yield through plant height, and seeds per pod, which was reported earlier by Yadav et al. [31].

4. CONCLUSION

The genotypes used in the present investigation exhibited wide variability and association among themselves for various traits under study. In the present study, the characters like leaf area index, primary branches, biological yield per plant, and 100 seed weight were identified as main selection criteria for improving seed yield in chickpea, as these characteristics exhibited strong positive correlation as well as high positive direct effects with seed yield per plant. Performance of the promising germplasms are accessed under two soil conditionss viz., red and black soil conditions. By considering the mean yield of these genotypes in the replicated design, it is concluded that performance of the most of the genotypes is better in red soil than in the back soil. Under red soil conditions among the

twenty germplasm highest yield per plant was observed for accession EC547398 (22.44 gram/plant) over the best check RVG 203 (21gram/plant). Under black soil conditions, among the twenty germplasm highest yield per plant was observed for EC54381 (17.84 gram/plant) over the best check RVG 202 (11.44gram/plant).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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