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PERFORMANCE EVALUATION OF COMMERCIAL SESAME (*Sesamum indicum* L.) CULTIVARS FOR YIELD AND YIELD RELATED TRAITS IN WOLAITA, SOUTHERN ETHIOPIA

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ABSTRACT

Sesame (*Sesamum indicum* L.) is cultivated in Ethiopia as a cash crop, export commodity, and raw material for sesame oil industries. It has surged up as a silver line regarding its contribution to the export earnings for Ethiopians. Sesame cultivation was not widely known in Wolaita area although the area could be a potential cultivation location for wider production of sesame in the country. Therefore, to evaluate performance in terms of yield and yield related traits for selection of the best performing cultivars to enhance productivity and larger production, ten sesame cultivars were laid out in a randomized complete block design with three replications at two districts (Humbo and Kindo-Koysha) for two years (2017-2018). Analysis of variance showed that cultivars *Mehado*-80 (154 cm), *Adi (*153 cm)*,* and *Tate* (149 cm) have grown to significantly higher heights over the rest of the cultivars. *Mehado*-80 and *Tate* had a significantly higher number of primary branches (mean values across locations 9.3, 8.7 and 8.6, respectively). The cultivar *Tate* had the highest number of capsules (97.9) per plant, which had also the highest genotypic variation (428.54). The highest genotypic coefficient of variance (45.58%) was recorded for seed yield. Days to 50% flowering and 90% maturity exhibited the lowest phenotypic coefficient of variation, 7.16%, and 3.69%, respectively. Heritability in a broad sense (h^2_b) ranged from 13.32% for plant height to 32.43% for thousand seed weight. The interaction effects had showed no significant difference (P>0.05) for most of the studied traits. Cultivars *Tate* (1200 kg/ha), *Serkamo* (917 kg/ha) and *Kelafo*-74 (875 kg/ha) scored significantly higher seed yield at Kindo-Koysha site whereas *Tate* (1208 kg/ha, *S* (1042 kg/ha) and *Mehado*-80 (1021 kg/ha) scored significantly higher seed yield at Humbo site. Hence these cultivars could, respectively, be used as a potential cultivar for Kindo-Koysha and Humbo districts of Wolaita zone, while cultivar *Tate* exhibited the highest seed yield at both locations and hence recommended for Wolaita zone, southern Ethiopia.

Key words: Commercial cultivars, Seed yield, Sesame, Traits, Wolaita, Yield components

INTRODUCTION

Sesame (*Sesamum indicum* L.), also called *Selit* in Amharic, is a flowering plant in the genus *Sesamum* of the Pedaliaceae family. The chromosome number of cultivated sesame is 2n = 26 [1]. Botanically, sesame is 0.60 to 1.20 m tall with an erect, pubescent, branching stem and mostly with indeterminate inflorescence. The leaves are broad ovate to lanceolate or oblong. The lower leaves are trilobed and the upper leaves are undivided, irregularly serrated and pointed [2]. The fruit is an oblong, mucronate, pubescent capsule containing numerous small oval-shaped yellow, white, red, brown, or black seeds [3].

India and East Africa were considered to be early origins of sesame [4]. Africa has got great weight as its centre of origin because there are numerous wild relatives of sesame in the continent relative to India [5]. Sesame diversity centers have been identified in India, China, Central Asia, the Near East, and Ethiopia [6]. It is widely naturalized in tropical regions of the world [7].

Sesame is one of the oldest oilseed crops cultivated for its edible seeds, which are used whole or processed to produce oil and meal, made into porridges and soups [1, 7]. The seeds contain 40–60% oil of very high quality and 17–29% protein, and are rich in minerals (calcium, phosphorus, iron, copper, magnesium, zinc, and potassium), vitamins (E, A and B complex), carbohydrate and ash [8]. Sesame oil is used for cooking dishes and medicinal purposes [9]. From the composition of sesame oil, oleic and linoleic fatty acids are 85 % and they make the oil to have a long shelf-life because these fatty acids have a high degree of resistance against oxidative rancidity. The quality of the oil is determined by the fatty acid compositions of the total oil. The linoleic acid of sesame is known to lower cholesterol content in human blood. Some antioxidants such as sesamolin and sesamin are used as active ingredients in antiseptics, bactericides, viricides, disinfectants, moth repellants, and anti-tubercular agents [10].

Sesame is an important cash crop for farmers in several developing countries. Sesame produced in Ethiopia has an excellent demand in the international market and is utilized by domestic oil production for the country's consumption. Currently, it is the second-largest export crop of the country. Sesame is the second most important agricultural commodity next to coffee in foreign exchange earnings to more than $449 million. It has surged up as a silver line regarding its contribution to the export earnings among the edible oilseeds [11]. The major constraints associated with sesame production include instability in yield and adaptability problem of cultivars due to lack of available research data on recommended rates of fertilizers, lack of improved cultivars seeds, shattering problem, sowing date and knowledge of the cultivation of the crop in some areas of the country and so on [12].

The production of sesame of World increased from 1.94 million tonnes in 1971 to 6.8 million tonnes in 2020 growing at an average annual rate of 2.91% [13]. Ethiopia is the 6^{th} largest sesame producer in the world and third in Africa next to Tanzania and Uganda, respectively. The production of sesame in Ethiopia increased from 15,634

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tonnes in 2000 to 262,654 tonnes in 2019 growing at an average annual rate of 20.63% [14]. It grows in Tigray, Amhara, Gambella, Benshangul Gumuz, Somalia, SNNP and Oromia regions of the country. However, productivity of sesame is very low due to several reasons. Low research and knowledge of crops cultivation are among the major challenges for sesame production in Ethiopia. Hence, the national productivity of sesame is 730 kg/ha [15]. In Wolaita, sesame cultivation was not widely known although the area could be potential cultivation location for wider production of sesame in the country. This necessitates performance evaluation of commercial sesame cultivars in terms of yield and yield related traits for selection of the best performing cultivars to enhance productivity and larger production in the selected areas (Kindo-Koysha and Humbo districts) of Wolaita zone, Southern Ethiopia.

MATERIALS AND METHODS

Experimental sites

The performance evaluation was carried out at Kindo-Koysha and Humbo districts (experimental sites) of Wolaita Zone, Ethiopia. The Kindo-Koysha experimental site is located at a latitude of 07.01.105 N, a longitude of 037.53.442 E and an altitude of 1170 masl. The average annual rainfall and average temperature of this site were 924 mm and 21°C, respectively. The Humbo experimental site is located at a latitude of 6.73.125 N and a longitude of 37.74.742 E and an altitude of 1800 masl. The average annual rainfall and average temperature of this site were 1295 mm and 20°C, respectively. The soil texture of both sites was sandy loam.

Treatments and experimental design

Ten commercial sesame cultivars (*T-85*, *Kelafo-74*, *E*, *S*, *Mehado-80*, *Abasena*, *Argene*, *Adi*, *Serkamo* and *Tate*) (Table 1), which were obtained from Werer Agricultural Research Center, Ethiopia, were laid out in randomized complete block design (RCBD) with three replications, having net plot size 2.4 m x 2 m (4.8 m^2). The cultivars were evaluated for performance for two years (2017-2018) at the two sites (Kindo-Koysha and Humbo).

Land preparation, sowing time and crop management

During preparation of fine seedbed, the soil was pulverized; the land was labelled and disc harrow was run. Then, the seeds of sesame cultivars were sown in well-drained loose soil on flat ground. The treatments were managed in such a way to separate each treatment and replication easily. Sowing was done on August 30th at each site in the year 2017 and repeated in the year 2018, in six-row plots using manual drilling method. The rows were spaced 40 cm and thinned after emergence to maintain a plant-to-plant distance of 10 cm apart. Weeding is conducted manually as required. Inorganic fertilizers in the form of diammonium phosphate and urea were applied as recommended [16].

Morphological traits and data collection

Data on days to heading was recorded as number of days from sowing to the stages when 50% of plants in the plot have started flowering. Days to maturity was scored as number of days from the date of sowing to a stage at which 90% of the plants in the plot have reached physiological maturity. Plant height from the ground upto the tip of the plant was measured from randomly selected five plants in each plot in centimetres at time of maturity. Number of primary branches on the main stem and number of capsules per plant were counted at maturity. Biomass (kg/ha) in each plot weighed when harvested and converted to kg/ha by inferring the plot area of 4.8 m^2 to the hectare basis that is, $\text{Biomass (kg/ha)} = \frac{\text{Biomass per plot (kg)}}{\text{Plot area m2}} * 10000$.

Seed index (1000 seed weight) was measured by using sensitive balance and seed yield per plot (kg/ha) was weighed (g) and calculated based on the weight of plants threshed to get an average weight of seeds per plot and converted to seed yield per hectare (kg/ha) by inferring the plot area of 4.8 m^2 to the hectare basis, that is,

$$\text{Seed yield per hectare (kg/ha)} = \frac{\text{Seed yield per plot (kg)}}{\text{Plot area m2}} * 10000$$

Statistical Analysis

The agro-morphological data were subjected to statistical analysis using SAS version 9.3 [17]. Analysis of variance was computed by PROC GLM procedure of SAS. Treatment means were compared using the least significant difference (LSD) at a 5 % probability level. The cultivar location interaction analysis was done following the procedure forwarded by Gauch and Zobel [18]. The genetic parameters were estimated to identify the genetic variability among the cultivars and to find out the extent of environmental effect on various characters. Variance components due to genotype, environment, and phenotype were calculated by adopting the following formula suggested by Burton and Devane [19]. Genotypic variance (δ^2g) = (MSG-MSE)/r; δ^2e for environmental variance, which was MSE and phenotypic variance (δ^2p) = $\delta^2g + \delta^2e$; where MSG - mean squares for the cultivars, MSE-mean square of error and r is replication. The genotypic and phenotypic coefficients of variations were estimated using the formulas suggested by Singh [20]. Genotypic coefficient of variation (GCV %) = $\sqrt{\delta^2g}/ x * 100$ and phenotypic coefficient of variation (PCV %) = $\sqrt{\delta^2p}/ x * 100$, where x is the grand mean value of the particular trait of interest.

Heritability in a broad sense (h^2_b %) was estimated for each trait as a ratio of genotypic variance to phenotypic variance by using the formula of Allard [21] as Heritability in a broad sense (h^2_b %) = δ^2g/δ^2p*100; where δ^2g is genotypic variance and δ^2p is phenotypic variance. The genetic advance was calculated to compare the extent of predicted advances of different traits under selection, using the formula given by Falconer and Mackey [22] as follows: Genetic advance (GA) = $Ks_ph^2_b$, δp is the standard deviation of phenotypic variance, h^2_b is a broad sense heritability and k is the selection differential at a particular selection intensity, in this case, we used 2.06 at 5% selection intensity suggested by Falconer [23].

RESULTS AND DISCUSSION

Phenological parameters

Days to 50% flowering and 90% maturity: Days to 50% flowering and the number of days to 90% maturity were affected by cultivars and locations (Table 2). The cultivar *E* took the longest days (62.6) to flowering and maturity (83.0), while *Serkamo* took the

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shortest days to flowering (58.2) and maturity (80.2). The average performance of cultivars over locations significantly differed for both the number of days to flowering and maturity. Days to flowering and maturity were relatively prolonged at Humbo site, indicating that there was a favorable climatic factor for the vegetative growth phase of sesame. With the exception of *Serkamo* and *Tate*, the others took more than 60 days to flower at Humbo site. Except for *E,* others took less than 60 days of flowering at Kindo-Koysha site. A difference of 7.8 days was seen between the longest and shortest days to flowering at the locations. The days to maturity of the sesame cultivars included in this study corresponds to other reports [24]. Highly significant differences among sesame cultivars for the days to flowering and maturity were reported by other authors [25-26]. However, it was also reported that some sesame cultivars exhibited non-significant differences in days to flowering and maturity [27]. The differences could be likely attributed to their inherent variations or environmental difference.

Growth traits

Plant height and number of primary branches: The mean heights of sesame cultivars indicated that *Mehado-80* was the tallest plant (154 cm) while *Argene* was recorded the shortest plant height (139 cm) (Table 2). Similarly, significant variation in plant height among different sesame cultivars was reported by Thakur and Borulkar [28] and Rao *et al.* [29]. The number of branches per plant varies from cultivar to cultivar. Cultivar *Kelafo-74* produced the largest number of primary branches per plant (9.3) while cultivar *Abasena* produced the smallest number of primary branches per plant (5.7). Similar to this, previous research outputs indicated that the number of branching is affected by seed rate, rainfall, location, growing seasons and cultivar [3]. Generally, this study showed a positive relationship between plant heights and the numbers of branches per plant, which were in agreement with earlier explanation [5].

Seed yield and components of yield

The biomass yield was affected by cultivars and locations. Significantly higher biomass yield was recorded at Humbo site (8250 kg/ha) than that of at the Kindo-Koysha site (4438 kg/ha). *Mehado-80* provided significantly greater biomass yield (7979 kg/ha) followed by *Tate* (7021 kg/ha) whereas *Adi* provided the lowest biomass yield (5229 kg/ha). Location mean by cultivars interaction resulted in a significant difference in biomass yield, indicating how the environmental differences affect the biomass yield of the sesame cultivars. Similarly, the number of capsules significantly differed in response to locations and cultivars (Table 3). Location mean values indicated that cultivars produced more capsules per plant at Kindo-Koysha site (78.4) than at Humbo site (54.7). The highest number of capsules per plant (97.9) was recorded for *Tate* followed by *Mehado-80* (73.0) whereas the least number of capsules per plant (52.4) was obtained from *Adi*. This variation in capsule numbers with respect to cultivars and location indicated that the sesame cultivars responded differently in the two sites. The environment has its own effect on the number of capsules and other phonological traits of sesame [30]. A significant difference was detected due to effect of cultivars on seed yield. The highest mean seed yield (1204 kg/ha) was recorded for *Tate* followed by *S* with a mean seed yield of 917 kg/ha. The lowest mean seed yield (521 kg/ha) was obtained from *Adi*. *Tate* exhibited the highest performance at both sites but *Serkamo* and *Kelafo-74* at Kindo-Koysha site and *S* and *Mehado-80* at Humbo site showed superiority over other cultivars. The lowest seed yield was recorded by *Adi* at both experimental sites (Table 3).

The combined analysis of variance, which was done in order to identify high yielding and stable sesame cultivars across locations, showed that the cultivars were significantly different ($P < 0.05$) for all of the studied parameters. The interaction effects were shown no significant effects ($P > 0.05$) for most of the growth and yield-related traits, implying that most of the evaluated sesame cultivars can perform similarly in both locations over years (Table 4). These results were in agreement with the results reported by other authors [30, 31].

Genetic components

The genetic components such as phenotypic and genotypic variances, coefficient of variations, heritability, and genetic advance are presented in Table 4. The highest δ^2g (428.54) was recorded for the number of capsules while the least δ^2g was 0.03 for seed yield. The highest δ^2p was recorded for the number of capsules per plant (2594.71) whereas the lowest δ^2p was recorded for seed yield (0.13 kg/ha). Genotypic coefficient of variation (GCV) varied from the highest (45.58%) for seed yield to the lowest (2.05%) for days to maturity. Days to maturity exhibited the lowest PCV (3.69%). Plant height exhibited moderate PCV (13.85%) whereas traits such as number of primary branches, number of capsules, seed index (TSW), biomass, and seed yield had high PCV. The GCV or PCV were categorized as high if it is greater than 20%, moderate if it is between 10% to 20% and low if it is below 10% [30]. Genotypic coefficient of variation (GCV) and PCV was used to measure the variability that exists in a given population under consideration [22]. Higher magnitude of difference between phenotypic and genotypic coefficients of variation was observed for the number of capsules per plant and primary branches per plant, indicating that there was the greatest influence of environmental factors for the phenotypic expression of these traits. In consistency with this, PCV was greater than that of GCV for most of the sesame traits [32].

Different characters have different levels of heritability that can contribute to yield improvement in breeding programs. In this study, heritability in a broad sense (h^2_b) ranged from 13.32% for plant height to 32.43% for thousand seed weight. Heritability estimated as low (< 30%), moderate (30-60%) and high (> 60%) [33]. Days to flowering, days to maturity, number of primary branches per plant, and TSW exhibited moderate h_b^2. Plant height, the number of primary branches per plant, biomass, and seed yield exhibited low h^2_b, which may limit the possibility of including the traits to select desirable genotypes due to the higher influence of environment for the expression of phenotypic variation than genotypic variation. The most important function of the heritability in the genetic study of quantitative characters is its predictive role to indicate the reliability of the phenotypic value as a guide to breeding value [21].

Genetic advance as a percentage of the mean (GAM) was ranged from 2.67% for days to maturity to 44.74% for seed yield (Table 4), indicating that selecting the top 5% of the genotypes could result in an advance of 2.67% to 44.74% over the respective population mean. The GAM was classified as low (<10%), moderate (10-20%) and high (>20%) [29]. Traits such as number of primary branches per plant, number of capsules per plant, TSW, and seed yield had high genetic advances, implying that progress on improving the studied sesame cultivars could be achieved through simple selection of these traits.

CONCLUSION

The studied commercial sesame cultivars showed differences in the performance for seed yield and related traits. The cultivars also performed differently at two districts (experimental sits) for agronomic traits measured with respect to their genetic variability. Based on this result, cultivar *Tate* exhibited higher performance for seed yield with the highest seed yield record at both districts and hence recommended for sesame seed production for both sites and similar agro-ecologies. Cultivar *Tate* could be the 1st alternative for both sites while *Serkamo* and *Kelafo-74* showed specific adaptation to Kindo-Koysha, and hence could be used as potential breeding at Kindo-Koysha whereas the cultivars *Mehado* and *S* performed best at Humbo and hence could be good alternatives to be used for Humbo area and other similar agro-ecologies.

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Table 1: Sesame cultivars that were evaluated for performance

No	Cultivar name	Year of release	Origin
1	*T-85*	1976	INDIA
2	*Kelafo-74*	1976	ETHIOPIA
3	*E*	1978	UGANDA
4	*S*	1978	UGANDA
5	*Nehado-80*	1989	ETHIOPIA
6	*Abasena*	1990	ETHIOPIA
7	*Argene*	1993	ETHIOPIA
8	*Adi*	1993	FAO(ISREAL)
9	*Serkamo*	1993	UPPER VOLTA(CONGRA)
10	*Tate*	2000	ETHIOPIA

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Table 2: Mean performance of sesame cultivars for phonological and growth traits

Location	Cultivars	Days to flowering	Days to maturity	Plant height	Primary branches
Kindo-Koysha	*T-85*	58.2g-i	84.7	133	8.2
	Kelafo-74	58.5g-i	82.7	133	10.8
	E	60.3d-f	81.8	137	8.0
	S	58.8f-h	83.8	138	8.0
	Mehado-80	59.5e-h	85.2	153	9.3
	Abasena	57.8hi	82.5	135	6.5
	Argene	59.2e-h	85.7	133	8.3
	Adi	58.2g-i	83.5	150	7.9
	Serkamo	57.0i	82.3	138	8.5
	Tate	58.7f-i	83.7	143	9.3
Humbo	*T-85*	61.8b-d	79.5	159	7.1
	Kelafo-74	62.0b-d	78.8	154	7.8
	E	64.8a	78.5	152	6.6
	S	62.5bc	78.7	154	7.1
	Mehado-80	60.8c-d	80.2	155	8.1
	Abasena	61.8b-d	79.8	152	4.9
	Argene	63.5ab	80.3	145	6.7
	Adi	64.5a	80.5	157	5.6
	Serkamo	59.8e-g	80.0	146	6.9
	Tate	59.8e-g	79.0	156	7.8
	LSD	1.6	NS	NS	NS
Combined mean across locations	*T-85*	60.0cd	82.1a-c	146a-d	7.6b-d
	Kelafo-74	60.3b-d	80.8cd	143cd	9.3a
	E	62.6a	83.0a	144b-d	7.3d
	S	60.7bc	81.3cd	146a-d	7.5cd
	Mehado-80	60.2b-d	82.7ab	154a	8.7ab
	Abasena	59.8cd	81.2cd	144cd	5.7e
	Argene	61.3b	81.2cd	139d	7.5cd
	Adi	61.3b	82.0a-c	153ab	6.8de
	Serkamo	58.4e	80.2d	142cd	7.7b-d
	Tate	59.3de	81.3b-d	149a-c	8.6a-c
	LSD	1.1	1.3	9.0	1.1
	LSD	0.5	0.6	4.0	0.5
	CV (%)	2.4	2.1	7.5	18.0

Means followed by different letters within a column are significantly different at 5% probability level, NS= not significant

Table 3: Mean performance of sesame cultivars for seed yiled and yield components

Location	Cultivars	Biomass (kg/ha)	Capsules per plant	Seed index (TSW)	Seed yield (kg/ha)
Kindo-Koysha	*T-85*	4563	84.5	5.7	750c-g
	Kelafo-74	4542	80.3	5.5	875b-f
	E	3792	72.5	5.5	667e-h
	S	3958	68.0	4.7	771c-g
	Mehado-80	5208	84.8	4.5	813c-f
	Abasena	4313	67.2	5.3	646e-h
	Argene	4521	73.7	4.9	792c-g
	Adi	4021	71.7	5.2	646e-h
	Serkamo	4625	78.0	5.5	917a-e
	Tate	4854	103.3	6.3	1200ab
Humbo	*T-85*	7646	55.2	5.5	563f-h
	Kelafo-74	7771	56.0	5.5	750c-g
	E	8792	53.3	5.5	854c-f
	S	9521	51.2	4.5	1042a-c
	Mehado-80	10771	61.2	4.5	1021a-d
	Abasena	6771	43.3	5.5	458gh
	Argene	7542	49.7	4.5	688e-h
	Adi	6417	33.2	5.5	375h
	Serkamo	8188	51.5	5.5	708d-h
	Tate	9208	92.5	6.5	1208a
	LSD	NS	NS	NS	339
Combined mean across locations	*T-85*	6000b-d	69.8bc	5.6	646c-e
	Kelafo-74	6167b-d	68.2b-d	5.5	813bc
	E	6292b-d	62.9b-d	5.5	771b-d
	S	6729a-c	59.6b-d	4.6	917b
	Mehado-80	7979a	73.0b	4.5	938b
	Abasena	5542cd	55.3cd	5.4	542de
	Argene	6021b-d	61.7b-d	4.7	729b-e
	Adi	5229d	52.4d	5.3	521e
	Serkamo	6417b-d	64.8bid	5.5	813bc
	Tate	7021ab	97.9a	6.4	1204a
	LSD	1380	17.4	NS	240
	LSD	617	9.3	NS	NS
	CV (%)	26.7	38.4	4.3	37.8

Means followed by different letters within a column are significantly different at 5% probability level, NS= not significant

Table 4: **Mean squares from combined analysis of variance for the agronomic traits**

Source	DF	Days to flowering	Days to maturity	Plant height	Primary branches	No of Capsules	Biomass	TSW	Seed yield
Year	1	374.4*	492.1*	5548.8*	76.8*	16850.7*	99.9*	0.1^{NS}	0.1^{NS}
Location	2	83.3*	23.4*	1360.1*	476.8*	963.3^{NS}	1.2^{NS}	30.0*	12.4*
Cultivar	9	16.5*	9.1*	286.4*	12.5*	1940.2*	1.7*	4.0*	0.1*
Y x C	9	6.9*	3.9^{NS}	146.9^{NS}	1.1^{NS}	164.1^{NS}	1.6^{NS}	0.1*	0.1^{NS}
L x C	9	2.7^{NS}	0.2^{NS}	653.9*	1.6^{NS}	1247.2^{NS}	0.1^{NS}	0.1*	0.1^{NS}
Y x L x C	9	1.9^{NS}	0.7^{NS}	94.7^{NS}	2.9^{NS}	501.9^{NS}	0.1^{NS}	0.1^{NS}	3.0*
Error	72	2.16	2.79	122.9	1.9	654.5	0.7	0.05	0.02

TSW- thousand seed weight; Y x C – the interaction effect between year and cultivar; L x C- the interaction effect between location and cultivar; Y x L x C – The interaction effect among year, location and cultivar; values in level of significance are $P \leq 0.05$ and mean values with > 0.05 are not significantly different

Table 5: Phenotypic and genotypic coefficient of variability, heritability and genetic advance

Trait	σ2p	σ2g	σ2e	PCV (%)	GCV (%)	hb^2 (%)	GA	GA (%)
Days to flowering	18.69	4.79	2.16	7.16	3.62	25.63	2.28	3.78
Days to maturity	11.89	2.10	2.79	3.69	2.05	30.70	2.18	2.67
Plant height	409.26	54.51	122.87	13.85	5.06	13.32	5.55	3.80
No of Primary branches	14.38	3.52	1.92	49.38	24.43	24.48	1.91	24.87
Number of capsules	2594.71	428.54	654.54	76.54	31.11	16.52	17.33	24.04
Seed index (TSW)	4.07	1.32	0.05	38.06	21.68	32.43	1.35	25.47
Biological yield	2.34	0.34	0.66	50.32	1918	14.53	0.46	15.13
Seed yield/ha	0.13	0.03	0.02	94.88	45.58	23.08	0.17	44.74

σ^2p-phenotypic variance; σ^2g-genotypic variance; σ^2e- environmental variance; PCV-phenotypic coefficient of variance; GCV- genotypic coefficient of variance; hb^2- heritability in broad sense; GA- genetic advance

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