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Performance of golden flax for genetic variability and heterosis under *utera* & rainfed situation

Sadhna Saha, Nandan Mehta, Amrita Giri and Sonal Upadhyay

Abstract
An experiment was conducted at the Research cum Instructional Farm of AICRP on Linseed, Department of Genetics and Plant Breeding, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh during *Rabi* season 2019-20 and 2020-21 comprising forty (40) accessions including checks *viz;* golden flax (37) & brown flax (3) (checks RLC-143, RLC-148, RLC-153 and Surabhi). Genetic variability and heterosis estimation were done by growing these lines in two situations in randomized complete block design with three replications during *rabi* 2019-20 and *rabi* 2020-21 under *utera* and rainfed situation. Observations were recorded on seed yield and contributing traits (Days to 50 percent flowering, days to maturity, plant height, technical plant height, no. of capsule per plant, no. of seed per capsule, 1000 seed weight, oil content, seed yield per plant). Among all traits number of capsule, capsule size, number of seeds in capsule and seed yield per plant were observed with high GCV, PCV and high heritability with high genetic advance in both situations (*ytera* and rainfed) and hybrid Crosse combinations *viz*., YLS-17 x RLC-143, YLS-18 x RLC-143 & YLS-2 x RLC-143 were found promising to develop golden flax improved varieties as they shown vigor for yield contributing character.

Keywords: Linseed, heritability, genetic advance, heterosis, genotypes

Introduction

Linseed (*Linum usitatissimum* L.) is an important oilseed crop having 2n = 30 chromosome number belongs to the genus *Linum* of the family *Linaceae* and order *Geraniale* having genome size of ~370 Mb and is the species in the family, which is of economic significance. The cultivated flax is supposed to have originated from *The Central Asiatic Centre, The Near-Eastern Centre, The Mediterranean Centre and The Abyssinian Centre* (Vavilov 1926) [14].
Linseed is an important oilseed crop not only for India but all over the world as flaxseed is a source of carbohydrates, fats, proteins, vitamins, and minerals. (Source: USDA Nutrient Database, 2018) [13]. There are two primary industrial use of flaxseed, first one is for seed production and another one is processing of flaxseed for obtaining linseed oil and linseed meal. Linseed oil can be used as a drying oil in paints, varnishes, lacquers, enamels, oilcloth, linoleum, oil clothing, tarpaulins, tenting, patent leather, textiles, printing inks, soap, shoe polish and other specialty items. Linseed meal is a by-product of flaxseed after it is crushed for linseed oil. The product is used as a high-protein animal and poultry feed. (Flax Council of Canada, 2018) [7]. Flaxseed comes in two basic varieties - brown and yellow or golden (also known as yellow linseeds). Most types have similar nutritional characteristics and equal numbers of short-chain omega-3 fatty acids. The exception is a type of yellow flax called solin (trade name Linola), which has a completely different oil profile and is very low in omega-3 fatty acids. Golden linseed is found to be high in oil content and quality. According to Great Plains Flax society has been keenly developed for food market because of its buttery taste and thus offers a great thrust in edible food market.Although a recent comparison of golden flax with brown seed flax shows golden and brown seeds are very closely matched in the oil content (on a dry matter basis) but a minute difference has been observed is that golden seed contained between 43-44 per cent oil and 51 percent omega-3 in comparison of 44 percent oil and almost 59 percent in omega-3 in brown flax seed. There is an imbalance between demand and supply in edible oils due to low productivity of oil seeds. Oil seeds are energy rich crops, but are grown in energy starved conditions. More than 85% of the area under oilseeds is rainfed, often cultivated with low input and poor management practices. Oil seed crops are raised in marginal and sub marginal lands which are having poor fertility status and subjected to the vagaries of the monsoon resulting in lower yields as compared to irrigated crops (Choudhary, 2013) [3]. Despite of increased output and productivity, there is a demand-supply

gap in the oilseeds in India, particularly in Edible oils. Currently, India is world's largest importer of edible oil. The demand supply gap is such huge that India has 60-65% import dependency in case of edible oils (Narayan, 2016). In 2019, India imported around 15 million tons of edible oils worth approximately Rs 7,300 crore, which accounted for 40% of the agricultural imports statement and three per cent of the overall import bill of the country. Rainfed agriculture is a type of farming that relies on rainfall for water, because of increased weather variability, climate change is expected to make rain-fed farmers more vulnerable to climate change. Rainfed crop requires early sowing. Early sowing also helps the crop to escape form powdery mildew, wilt and bud fly. However, the productivity of linseed has increased from 574 kg/ha to 671 kg/ha during 2019-20 (Anonymous-I) [2]. In *utera* condition, sowing of crop was done before the harvesting of preceding crop, in our case, crops were grown in rice field, on other hand rainfed crop grown in rainfed situation, means totally depend on rainfall and irrigated condition, hence they need irrigation only in their critical stage. In India, linseed area occupied under rainfed (63%) and utera (25%). *Utera* is the most traditional practices followed in rice fields where sowing by broadcasting linseed in standing rice fields just before 15 to 20 days of rice harvest when last irrigation is given. During such time the field were wet (bunded-medium black soil, *bharri* soil). Linseed is mostly preferred for *utera* because of mucilaginous seed coat which does not stick on rice plant. The future of linseed is very much bright because as its demand is increasing day by day. Thus, it is necessary to improve the current production and productivity of flaxseed in horizontal and vertical form. In this paper our focus is on to study about heterosis and genetic variability for isolating hybrids which can be used further.

Material and Method

The investigation was conducted at the Research cum Instructional Farm of AICRP on Linseed, Department of Genetics and Plant Breeding, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh during *Rabi* season 2019-20 and 2020-21. Forty (40) accessions including checks *viz;* golden flax (37) & brown flax (3) (checks RLC-143, RLC-148, RLC-153 and Surabhi) were collected from All India Coordinated Research Project on Linseed, Department of Genetics & Plant Breeding, College of Agriculture, IGKV, Raipur, These lines were grown on two situations in randomized complete block design with three replication during *rabi* 2019-20 and *rabi* 2020-21 under *utera* and rainfed situations. Analysis of Genetic variability and heterosis for seed yield and its attributing traits was done by help of observations taken on seed yield and contributing traits, which are, (Days to 50 percent flowering, days to maturity, plant height, technical plant height, no. of capsule per plant, no. of seed per capsule, 1000 seed weight, oil content, seed yield per plant)

Mean and Range

Mean and range performance for different characters for *utera*, and rainfed situations were summarized in the Table 1 and 2 which stated that in *utera* condition, days to 50% flowering ranged from 52 to 72 days with an average of 59.46 days. Days to 50% maturity varied from 110.5 to 126.2 days with mean of 118.28 days. The degree of dispersion for the plant height ranged between 40.2 cm to 63.8 cm with an average performance of 54.04 cm. Height of technical plant varied from 3.09 cm to 5.86 cm with mean of 3.82 cm. Number of capsules per plant varied from 3 to 46.6 with an average of 20.06. Number of seeds per capsule showed a mean value of 7.98 and varied from 5 to 9. Weight of 1000 seed had an average of 5.52 g with a minimum of 3.7g and maximum of 6.7g. Seed yield per plant had a range of 0.82 g to 2.25 g with an average performance of 1.42 g. Oil content% varied from 31.88 to 39.12% with mean 33.86%. Similarly, in rainfed condition; days to 50% flowering ranged from 52 to 72 days with an average of 58.55 days. Days to 50% maturity varied from 111 to 126 days with mean of 117.62 days. The plant height ranged between 30.2 cm to 63.8 cm with an average performance of 52.15 cm. Technical plant height varied from 3.1 cm to 5.9 cm with mean of 3.8 cm. Number of capsules per plant varied from 6.00 to 46.6 with an average of 30.12 capsules. Number of seeds per capsules showed a mean value of 7.3 and varied from 5.3 to 8.9 seeds. 1000 seed weight had an average of 5.44 g with a minimum of 3.74 g and maximum of 6.67 g. Seed yield per plant had a range of 1.47 g to 4.53g with an average performance of 2.36 g. Oil content% varied from 31.88 to 39.12% with mean 33.86%.

Genotypic and phenotypic coefficient of variation (%)

Genotypic and phenotypic coefficient of variation for yield and its attributing traits are presented in table 1 and 2. The phenotypic variance was found higher in magnitude than genotypic variance for all the traits in the present investigation. Number of capsules per plant recorded with high genotypic coefficient of variation (25.55%**)** in *utera* condition followed by seed yield per plant (15.09%) and plant height (10.06%). Genotypic coefficient variation was found low for 1000 seed weight (8.93%), days to 50% flowering (6.25%) and number of seeds per capsules (5.89%), technical plant height (5.18), oil content% (4.97%) and days to 50% maturity (3.62). In rainfed condition, high genotypic coefficient of variation was recorded for number of capsules per plant (30.9%), followed by seed yield per plant (13.03%) and technical plant height (11.88%), whereas low genotypic coefficient of variation found for days to flowering (7.16%), number of seeds per capsules (6.68%), plant height (6.49%), 1000 seed weight (6.29%), oil content (4.97%) and days to 50% maturity (2.99%). The high value of phenotypic coefficient of variation was recorded in *utera* situation, for number of capsule per plant (29.08%) followed by seed yield per plant (20.23%), 1000 seed weight (10.93%) and plant height (10.54%) while low values of phenotypic coefficient of variation was noted for number of seed per capsule (8.65%), technical plant height (7.38%), days to 50% flowering (6.65%) oil content (4.97%) and days to 50% maturity (3.78%). On other hand, number of capsules per plant **(**32.7%) showed high phenotypic coefficient of variance in rainfed condition followed by seed yield per plant (15.54%) and number of seeds per capsules **(**8.78%**)** while, low phenotypic coefficient of variance was noted for 1000 seed weight **(**8.59%), plant height (8.09%), days to 50% flowering (7.47%), technical plant height (5.53), oil content (4.97%) and days to 50% maturity (3.13%). In this investigation similar result was found by the some researcher's *viz*., Dabalo *et al*. (2020) [4]. Dogra *et al.* (2020) [6]. Terfa and Gurmu (2020) [12] for number of capsules per plant Dogra *et al.* (2020) [6]. Kumar *et al.* (2019 [9]. Dhirhi and Mehta (2018) [5]. while, low GCV and PCV manifested for oil yield (kg per ha) and days to 50% maturity in the statement of Terfa and Gurmu (2020) [12] and Dabalo *et al*.(2020) [4].

Heritability (bs) (%)

The heritability (bs) was computed for each of the character for the various components for estimating their relative magnitudes of genotype and phenotypic variability contributed through environmental factors. The estimates of heritability in broad sense for yield and its component characters presented in table 1 & 2. Broad sense heritability was classified as high (>70%), moderate (50 -70%) and low (<50%). High heritability estimate was recorded for number of capsule per plant (98.824%) followed by seed yield per plant (98.527%), capsule size (82.252%), number of seeds per capsule (81.34%) and days to 50% flowering (77.841%) in *utera* condition. For rainfed condition, number of capsule per plant (98.642%) was found with high heritable followed by seed yield per plant (96.813%), capsule size (86.607%), 1000 seed weight (84.478%), days to 50% flowering (75.205%) and number of seeds per capsules (74.172%) while, number of capsule per plant (97.059%) followed by seed yield per plant (96.485%), technical plant height (86.225%) capsule size (84.538%) and plant height (76.333%) were observed with high heritability for irrigated condition. Similarly, low heritability was recorded for seed size (22.178%), days to 50% maturity (14.814%) and oil content (6.237%) in *utera* condition. In rainfed condition seed size (17.955%), oil content (7.989%) and days to 50% maturity (3.802%) showed low heritability.

Genetic advance as percentage of mean (%)

Genetic advance as percentage of mean classified in high (>20%), medium (10-20%) and low (<10%). Estimate of genetic advance as percentage of mean given in table 1 and 2. It's ranged from 0.88% to 92.72% in *utera* condition and in rainfed condition mean ranged from 0.45% to 90.8%. The highest genetic advance as percentage of mean was recorded for seed yield per plant (92.7%), number of capsules per plant (89.3%), capsule size (28.7%), number of seeds per capsules (24.77%) and days to 50% flowering (20.29%) in *utera* condition. In rainfed condition, number of capsules per plant (90.7%), seed yield per plant (78.8%), capsule size (29.7%), 1000 seed weight (23.3%) and days to 50% flowering (20.8%) recorded with high genetic advance as percentage of Mean.

Heritability coupled with Genetic advance

Estimate of heritability with genetic advance presented in table 1 and 2. High heritability coupled with high genetic advance as percentage of mean noted for the traits in different condition *viz;* number of capsules per plant (98.8%, 89.3%) followed by seed yield per plant (98.5%, 92.7%) in utera condition and number of capsules per plant (98.6%, 90.7%) and seed yield per plant (96.8%,78.8%) in rainfed condition. High heritability coupled with low genetic advance as percentage of mean for days to 50% flowering (77.8%, 20.3%) and number of seeds per capsule (81.3%, 24.8%) in *utera* condition. In rainfed condition; days to 50% flowering (75.2%, 20. 8%) and number of seeds per capsule (74.2%, 19.7%), whereas, high heritability coupled with high genetic advance as percentage of mean noted for the traits *viz;* number of capsules per plant and seed yield per plant in *utera* condition and in rainfed condition number of capsules per plant and seed yield per plant was noted with high heritability coupled with high genetic advance as percentage of mean. High GCV and PCV found in plant height, technical plant height, number of capsules per plant, number of seeds per capsules and seed yield per plant. Similar result found by Dabalo *et. al*. (2020) [4]. Dogra *et. al*. (2020) [6]. Terfa and Gurmu (2020) [12]. Patial *et al*. (2020) [10] and Kumar *et. al*. (2019) [9]. Hence can be clearly seen that high genotypic and phenotypic coefficient of variation showed by number of capsules per plant followed by seed yield per plant (g), capsule size (mm) and plant height (cm) in *utera* condition. In rainfed condition, high genotypic and phenotypic coefficient of variation found for number of capsules per plant followed by capsules size (mm) & seed yield per plant (g). In irrigated condition, high genotypic and phenotypic coefficient of variation observed for number of capsules per plant followed by capsules size (mm) & number of seeds per capsules. And the highest genetic advance as percentage of mean was recorded for seed yield per plant (g) followed by number of capsules per plant, capsule size (mm), number of seeds per capsules and days to 50% flowering in *utera* condition. In rainfed condition, high genetic advance as percent of mean was recorded by number of capsules per plant followed by seed yield per plant (g), capsule size (mm), 1000 seed weight (g) and days to 50% flowering. In irrigated condition; number of capsules per plant, seed yield per plant (g), technical plant height (cm) and capsule size (mm) recorded as high genetic advance as percentage of mean.

Table 1: Genetic Parameters of variability for seed yield & its components in *utera*

Parameters	Mean	Min.	Max.	GCV%	PCV%	h^2 (bs)	GA	GA as% of Mean
Days to 50% flowering	59.46	54	72	6.25	6.65	77.84	11.81	20.29
Days to maturity	118.28	109.5	131.4	3.62	3.78	14.81	2.39	2.05
Plant height (cm)	53.38	39.26	61.45	10.06	10.54	62.13	6.44	13.21
Technical plant height (cm)	3.82	3.45	4.43	5.18	7.38	69.43	1.38	18.09
Number of capsules per plant	20.06	10.13	30.80	25.55	29.08	98.82	18.28	89.25
Number of seeds per capsules	7.74	6.53	8.80	5.89	8.65	81.34	1.79	24.77
1000 seed weight (gm)	5.51	4.8	7.64	8.93	10.93	61.45	0.80	14.67
Seed yield per plant	1.30	0.82	1.95	15.09	20.23	98.53	0.76	92.73
Oil content (%)	33.86	31.88	39.12	4.97	4.97	6.24	0.31	0.88
Capsule size (mm)	0.62	0.47	0.87	15.35	16.92	82.25	0.17	28.67
Seed size (mm)	0.31	0.30	0.33	3.33	7.07	22.17	0.01	3.23

Table 2: Genetic Parameters of variability for seed yield & its components in rainfed

Parameters	Mean	Min.	Max.	GCV%	PCV%	h^2 (bs)	GA	GA as% of Mean
Days to 50% flowering	58.55	52.67	71	7.16	7.47	75.21	11.94	20.79
Days to maturity	117.62	111	124.83	2.99	3.13	3.802	0.52	0.45
Plant height (cm)	52.15	45.30	58.90	6.49	8.09	68.38	7.63	15.41
Technical plant height (cm)	3.8	3.26	5.02	11.88	5.53	65.24	1.21	15.42
Number of capsules per plant	29.10	18.11	59.50	30.90	32.70	98.64	27.91	90.77
Number of seeds per capsules	7.3	6.20	8.44	6.68	8.78	74.17	1.47	19.66
1000 seed weight (gm)	5.44	4.34	6.21	6.29	8.59	84.47	1.27	23.29
Seed yield per plant	2.36	0.90	3.15	13.03	15.54	96.81	0.79	78.86
Oil content (%)	33.86	31.88	39.12	4.97	4.97	7.98	0.39	1.11
Capsule size (mm)	0.62	0.47	0.87	15.49	16.65	86.61	0.18	29.71
Seed size (mm)	0.31	0.30	0.33	2.67	6.29	17.95	0.01	2.33

Heterosis

Heterosis investigations on heterosis provides fundamental information regarding the utility of the cross combinations and its use for commercial exploitation. The magnitude of heterosis for seed yield, yield components and quality traits depend to a large extent on genetic variation, genetic base and adaptability of parents. The presence of significant amount of non-additive gene action is a prerequisite for the commercial exploitation of heterosis in many crops. The Heterosis over mid parent (Relative heterosis), over better parent (heterobeltiosis) and over standard check (standard heterosis/ useful heterosis) was estimated for all the characters under study. The estimates of mid parent, better parent and standard heterosis are given in table 4. The results of heterosis are stated that for days to 50 percent flowering the mid parent heterosis ranged from -0.43% (YLS-2 x RLC-148) to -15.39% (YLS-32 x RLC-153). All hybrids showed non- significant negative relative heterosis. The heterobeltiosis ranged from -2.16% (YLS-2 x RLC-148 and YLS-2 x RLC-143) to -23.94 (YLS-32 x RLC-153). Again, all hybrids, showed - significant negative better heterosis. The standard heterosis (over) ranged from -11.27% (YLS-2 x RLC-153 and YLS-17 x RLC-153) to to -23.94 (YLS-32 x RLC-153). All hybrids, showed significant negative heterosis for the trait days to flowering. The negative heterotic effects indicating that the hybrids give early flowering than their mid, better and standard parents. Negative heterosis is desirable for days to flowering because this will make the hybrids to mature earlier as compared to parents. For the trait days to 50% maturity the mid parent heterosis ranged from -1.77% (YLS-18 x RLC-148) to -3.10% (YLS-17 x RLC-148). The heterobeltiosis ranged from -2.49% (YLS-2 x RLC-153) to -6.09 (YLS-11 x RLC-143). The standard heterosis (over) ranged from -0.32% (YLS-11 x RLC-153) to -6.78 (YLS-32 x RLC-143). All hybrids, showed non - significant negative heterosis for mid, better and standard parent for the trait days to 50% maturity. The negative heterotic effects indicating that the hybrids showed early maturity than their mid, better and standard parents. For the trait plant height, the mid parent heterosis ranged from -2.93% (YLS-18 x RLC-153) to 2.20% (YLS-2 x RLC-148). The heterobeltiosis ranged from -3.73% (YLS-18 x RLC-153) to -17.21% (YLS-11 x RLC-148). The standard heterosis (over) ranged from -2.10% (YLS-32 x RLC-148 and YLS-17 x RLC-148) to -2.74 (YLS-2 x RLC-148). All hybrids, showed non-significant negative heterosis for mid parent and standard parent except hybrid YLS-2 x RLC-148, it shows non - significant positive heterosis over mid parent and standard parent. For the better parent all hybrids showed non-significant negative heterosis. The negative heterotic effects indicating that the hybrids showed dwarfness than their mid, better and standard parents. For the trait technical plant height mid parent heterosis ranged from -1.08% (YLS-17 x RLC-153) to 13.85% (YLS-18 x RLC-153). Among hybrids, seven hybrids showed highly significant positive relative heterosis while six hybrids showed significant negative relative heterosis and two hybrids showed non-significant relative heterosis for this trait. The heterobeltiosis ranged from -0.26% (YLS-2 x RLC-153 and YLS-32 x RLC-153) to -19.64% (YLS-2 x RLC-143). Among hybrids, eleven hybrids showed highly significant negative heterobeltiosis while four hybrids showed significant positive heterobeltiosis for this trait. The standard heterosis (over) ranged from -0.26% (YLS-2 x RLC-153, YLS-11 x RLC-148 and YLS-32 x RLC-153) to 17.59 (YLS-18 x RLC-153). All hybrids, showed eleven hybrids showed significant. The negative heterotic effects indicating that the hybrids were shorter than their parents and positive heterotic effects showed that hybrids were taller with their parents. Crosses YLS-2 x RLC-143, YLS-11 x RLC-153, YLS-17 x RLC-153, YLS-18 x RLC-143, YLS-18 x RLC-148 and YLS-32 x RLC-143 showed highest significant negative estimates of relative, better parent and standard checks which indicate that this cross can be used for breeding dwarf traits. For no. of capsule per plant the heterobeltiosis ranged from -55.87% (YLS-2 x RLC-148) to -80.32% (YLS-11 x RLC-148). All hybrids showed significant negative heterobeltiosis for this trait. The standard heterosis (over) ranged from -35.67% (YLS-2 x RLC-148) to 17.59 (YLS-32 x RLC-143 and YLS-32 x RLC-148). All hybrids, showed significant negative standard heterosis for this trait. The negative heterotic effects indicating that the hybrids having low number of capsules than their parents. For the trait number of seeds per capsule, mid parent heterosis ranged from -0.27% (YLS-32 x RLC-153) to 20.49% (YLS-11 x RLC-143). All hybrids showed non-significant negative relative heterosis for this trait. Among all hybrids eleven hybrids showed positive average heterosis and remaining all showed negative average heterosis, while heterobeltiosis ranged from -1.17% (YLS-2 x RLC-153) to 18.13% (YLS-11 x RLC-143). All hybrids showed non- significant heterobeltiosis for this trait. Among all hybrids seven hybrids showed negative heterobeltiosis and remaining all showed positive heterobeltiosis. Similarly, the standard heterosis (over) ranged from -0.26% (YLS-32 x RLC-143) to 4.43 (YLS-17 x RLC-148). All hybrids, showed non-significant standard heterosis for this trait. Eleven hybrids showed negative standard heterosis remaining showed positive heterosis for this trait. For the trait 1000 seed weight, mid parent heterosis ranged from from -49.34% (YLS-18 x RLC-148) to 61.78% (YLS-2 x RLC-143). Among all only two hybrids showed significant positive relative heterosis and thirteen hybrids showed negative average heterosis for this trait and for the heterobeltiosis, this trait ranged from -53.32% (YLS-18 x RLC-153 and YLS-32 x RLC-153) to 62.61% (YLS-18 x RLC-143). Among all only one hybrid showed significant positive heterobeltiosis and remaning all showed negative heterobeltiosis for this trait. Similarly the standard heterosis (over) ranged from -51.53% (YLS-18 x RLC-148) to 55.12 (YLS-17 x RLC-143). Among all hybrids only one hybrid showed significant positive standard heterosis and remaining all showed significant negative standard heterosis for this trait. The trait thousand seed weight is an important yield component in the final yield, as the bold grained varieties normally out yield the other types. So, for this trait most promosing cross were YLS-17 x RLC-143, YLS-18 x RLC-143 and YLS-2 x RLC-143. For the trait seed yield per plant, mid parent heterosis ranged from -66.48% (YLS-18 x RLC-153) to 61.78% (YLS-2 x RLC-143). All hybrids showed significant negative relative heterosis for this trait. After that the heterobeltiosis ranged from -53.32% (YLS-18 x RLC-153 and YLS-32 x RLC-153) to 62.61% (YLS-18 x RLC-143). All hybrids showed significant negative heterobeltiosis for this trait. Similarly the standard heterosis (over) ranged from -45.45% (YLS-18 x RLC-153) to -76.36 (YLS-32 x RLC-148). All hybrids showed significant negative standard heterosis for this trait. The trait thousand seed weight is an important yield component in the final yield, as the bold grained varieties normally out yield the other types. So, for this trait most promosing genotypes were YLS-17 x RLC-143, YLS-18 x RLC-143 and YLS-2 x RLC-143. Seed yield is a complex trait that is multiplicative end product of several attributes of yield. Hybrid showing significant negative heterosis for seed yield per plant. Furthermore, significant heterosis over better parent for different crosses have been reported for seed yield per plant and number of seeds per capsule Singh *et al.* (2006). for number of capsules per plant Abdel Moneam (2014) [1]. Kumar *et al.* (2014) [8] and Reddy *etal.* (2013) [11]. So, the final conclusion of heterosis was that, 1000 seed weight (g) showed significant and positive relative heterosis for only two hybrids, similarly only one hybrid was found good for heterobeltiosis & standerd heterosis. So, for this trait most promising crosses were YLS-17 x RLC-143, YLS-18 x RLC-143 & YLS-2 x RLC-143 respectively. Conclusion: The emphasis should be given on the character of seed yield per plant followed by number of capsules per plant, capsule size, number of seeds per capsules days to 50% flowering and plant height in *utera* condition and traits number of capsules per plant followed by capsule size, 1000 seed weight and days to 50% flowering. followed by & seed yield per plant in rainfed condition for future improvement and in case of hybrid crosses YLS-17 x RLC-143, YLS-18 x RLC-143 & YLS-2 x RLC-143 were found promising to develop golden flax improved varieties as they shown vigor for yield contributing character.

Table 3: Heterosis (Over mid parent, better parent and check variety) for seed yield and its components in golden flax.

		Days to 50% flowering			Days to 50% maturity			Plant height (cm)			Technical plant height (cm)			Number of capsules per plant		
S. No.	Parents	RH%	HB%	SH%	RH%	HB%	SH%	RH%	HB%	SH%	RH%	HB%	SH%	RH%	HB%	SH%
1	YLS-2 x RLC-143	-1.84	-2.16	-18.31	-2.05	-4.59	-3.3	-4.16	-6.07	-9.55	-11.44**	-19.64**	-5.51**	-59.19**	-62.33**	-46.39**
2	YLS-2 x RLC-148	-0.43	-2.16	-18.31	-1.95	-4.17	-2.97	2.20	-5.38	2.74	-4.76	-5.41**	-8.14**	-51.66**	-55.87**	-35.67**
3	YLS-2 x RLC-153	-3.29	-11.27	-11.27	-1.89	-2.49	-1.27	-6.59	-10.11	-10.11	1.88**	-0.26**	-0.26**	-54.60**	-58.44**	-49.96**
4	YLS-11 x RLC-143	-4.64	-4.91	-21.13	-2.43	-6.09	-2.54	-6.04	-8.74	-6.76	4.74**	-6.25**	10.24**	-73.52**	-76.39**	-57.11**
5	YLS-11 x RLC-148	-4.99	-6.08	-22.54	-1.92	-5.28	-1.69	-14.69	-17.21	-10.11	4.97**	2.70**	-0.26**	-78.17**	-80.32**	-64.26**
6	YLS-11 x RLC-153	-7.38	-15.49	-15.49	-1.85	-3.64	0.00	-3.53	-4.55	-2.48	-2.86**	-6.30**	-6.30**	-61.93**	-70.48**	-46.39**
7	YLS-17 x RLC-143	-6.91	-7.22	-22.54	-3.10	-5.00	-5.08	-5.11	-8.35	-5.27	0.87**	-9.37**	6.56**	-65.41**	-65.96**	-49.96**
8	YLS-17 x RLC-148	-3.86	-5.53	-21.13	-2.57	-4.15	-4.24	-7.62	-9.84	-2.10	4.26**	2.43**	-0.52**	-70.70**	-70.82**	-57.11**
9	YLS-17 x RLC-153	-3.29	-11.27	-11.27	-2.50	-2.54	-2.54	-10.68	-12.14	-9.18	-1.08**	-4.20**	-4.20**	-56.59**	-63.53**	-46.39**
10	YLS-18 x RLC-143	-2.46	-6.61	-22.54	-2.29	-5.06	-3.39	-5.62	-8.13	-6.57	-17.10**	-20.98**	-7.09**	-65.47**	-66.08**	-49.96**
11	YLS-18 x RLC-148	-6.40	-9.12	-26.76	-1.77	-4.22	-2.54	-7.24	-10.13	-2.48	-7.99**	-12.07**	-6.30**	-75.63**	-75.77**	-64.26**
12	YLS-18 x RLC-153	-3.92	-15.49	-15.49	-2.55	-3.39	-1.69	-2.93	-3.73	-2.10	13.85**	10.34**	17.59**	-56.68**	63.65**	-46.39**
13	YLS-32 x RLC-143	-4.79	-6.61	-22.54	-2.33	-2.90	-6.78	-6.38	-6.84	-10.29	-10.52**	-17.41**	-2.89**	-78.73**	79.91**	-67.83**
14	YLS-32 x RLC-148	-3.39	-3.88	-22.54	-2.33	-3.13	-6.36	-3.99	-9.84	-2.10	1.74**	0.53**	0.00**	-78.97**	79.91**	-67.83**
15	YLS-32 x RLC-153	-15.39	-23.94	-23.94	-2.59	-5.08	-5.08	-3.96	-6.2	-6.20	0.00	-0.26**	-0.26**	-69.77*	-75.45**	-60.69**

Table 4: Heterosis (Over mid parent, better parent and check variety) for seed yield and its components in golden flax.

		Number of seeds per capsules			1000 Seed weight (gm)			Seed yield per plant (gm)		
S.No.	Parents	RH%	HB%	SH%	RH%	HB%	SH%	RH%	HB%	SH%
1	YLS-2 x RLC-143	RH%	HB%	SH%	61.78**	-61.89**	-62.30**	-82.86**	-85.94**	-59.09**
2	YLS-2 x RLC-148	8.09	4.08	-6.78	-52.66**	-53.65**	-54.40**	-88.17**	-89.69**	-70.00**
3	YLS-2 x RLC-153	2.16	-1.88	-4.56	-56.20**	-56.55**	-56.55**	-72.56**	-81.56**	-46.36**
4	YLS-11 x RLC-143	4.26	-1.17	-1.17	-65.42**	-65.52**	-65.89**	-81.12**	-82.50**	-61.82**
5	YLS-11 x RLC-148	20.49	18.13	1.96	58.62**	-59.49**	-60.14**	-81.59**	-81.67**	-60.00**
6	YLS-11 x RLC-153	4.40	-1.47	-4.17	-54.03**	-54.40**	-54.40**	-78.86**	-84.58**	-66.36**
7	YLS-17 x RLC-143	1.47	-5.48	-5.48	-53.96**	-54.63**	55.12**	-82.74**	-84.81**	-62.73**
8	YLS-17 x RLC-148	8.80	1.22	-2.48	-61.13**	-61.50**	-63.02**	-85.04**	-85.93**	-65.45**
9	YLS-17 x RLC-153	7.88	7.37	4.43	-61.17**	-61.94**	-61.94**	-79.47**	-85.56**	-64.55**
10	YLS-18 x RLC-143	-6.77	-8.47	-8.47	-62.27**	62.61**	-63.02**	-86.75**	-87.90**	-72.73**
11	YLS-18 x RLC-148	5.75	1.90	-8.87	-49.34**	-50.09**	-51.53**	-83.13**	-83.47**	-62.73**
12	YLS-18 x RLC-153	7.26	2.95	0.13	-52.64**	-53.32**	-53.32**	-66.48**	-75.81**	-45.45**

13	YLS-32 x RLC-143	5.71	0.13	0.13	-64.34**	-64.79**	-65.17**	-78.10**	-78.60**	-58.18**
14	YLS-32 x RLC-148	13.92	8.20	-0.26	-61.21**	-61.64**	-63.02**	-88.52**	-89.08**	-76.36**
15	YLS-32 x RLC-153	-4.75	-7.24	-9.78	-52.47**	-53.32**	-53.3	-76.62**	-82.33**	-65.45**

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