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WIDE HYBRIDIZATION AND CHARACTERIZATION OF HYBRIDS OF *Linum usitatissimum* L. FOR CROSSABILITY, AGRO-MORPHOLOGICAL TRAITS AND RUST RESISTANCE

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SUMMARY

Four inter and eight intraspecific hybrids, obtained after crossing 6 cultivated and 2 wild species of *Linum*, were evaluated in detail for assessment of crossability and evaluation of various agro-morphological traits along with the screening for linseed rust resistance. In this study interspecific hybridization between *Linum* species with different chromosome numbers (*L. grandiflorum*) failed to produce hybrids whereas species with equal chromosome (*L. angustifolium)* numbers responded well. Analysis of variance revealed significant differences among entries for all the traits. The intraspecific hybrids (T-397 x HimAlsi-1) revealed higher seed yield over the interpsecific hybrids due to involvement of both elite cultivated parents. The interspecific hybrids were observed to superior for yield contributing traits i.e. T-397 x *L. angustifolium* for primary and secondary branches, HimAlsi-2 x *L. angustifolium* for capsules and biological yield per plant, Kangra Local x L. angustifolium for seeds per capsule and harvest index. The hybrids having wild species *L. angustifolium* as one of the parents appeared to be important for the improvement of the cultivated linseeds as T-397 x *L. angustifolium* recorded highest crossability. All hybrids were rust resistant highlighting the importance of wild species as a potential source of rust resistant genes for breeding programs..

Key words: *Linum***,** linseed, hybridization, crossability, rust

Key findings: This research has yielded a wide array of *Linum* germplasm which will serve as a potential source of rust resistance gene(s).

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INTRODUCTION

Linseed (*Linum usitatissimum* L.) is among the oldest crop plants cultivated for more than 6000 years in Mediterranean and Southwest Asia, for the purpose of oil and fibre (Millam *et al.*, 2005). It belongs to the genus *Linum* and family Linaceae. It has been a rich source of 2 essential fatty acids, alpha-linolenic acid (Lorgeril *et al.*, 1999; Foulk *et al.*, 2002) and linoleic acid (Bloedon and Szapary, 2004; Lorgeril *et al.*, 1999), which on metabolism lead to the synthesis of DHA (docosa hexaeenoic acid), an indispensible metabolite for the optimal development of nervous system and maturation of visual acuity (retina) in infants (Neuringer and Connor, 1986; Uauy *et al.*, 1996). Studies on early civilizations like Greeks and Egyptians reveal its use as food as well as laxative (Berglund, 2002). Besides, linseed is the richest source of lignans (antioxidants). Its seed provides 800 times more lignans than any other plant seed (except sesame seeds which has 47 times less lignan than flax seed). Linseed is preferred not only for human use but is also an important feed supplement. The genus *Linum* has a large number of diploid species that exhibit a remarkable diversity in chromosome number including *n* = 8, 9, 10, 12, 14, 15, 16, 18, 30, and > 30 (Darlington and Wylie, 1955; Gill, 1987). Diversity in chromosome numbers may be due to polyploidy and aneuploidy (Chennaveeraiah and Joshi, 1983).

Although only, a minor crop, linseed is grown in a wide range of countries in Asia, Australia, North America and Europe acquiring approx. 22,703,500 hectare area with the production of 2,238,940 tons having productivity of 986.2 kg per hectare, owing to its adaptability and product diversity. In India, its area is limited to 338 thousand hectares and production 147 thousand tons with the productivity of 434.9 kg per hectare (Anonymous, 2013).

Despite its several advantages, cultivated area of linseed is drastically reducing because of its low productivity. Besides this, diseases like rust and powdery mildew (Saharan 1988; Saharan and Mehta, 2002) also pose serious constraints. Moreover, long course of selections for desirable traits have narrowed down the genetic base of the cultivated crops. A recent comparative study of genetic diversity of the stearoyl-ACP desaturase II (*sad2*) locus from *L. usitatissimum* (2n = 30) and *L. angustifolium* (2n = 30) showed reduced diversity in the cultivated species (Allaby *et al.*, 2005). Hence to develop high yielding cultivars with wider adaptability and resistance to abiotic as well as biotic stresses, genetic backgrounds of the elite cultivars have to be diversified with the incorporation of disease resistance from the wild progenitors especially for rust (Misra, 1966; Seetharam, 1972; Madill *et al*,. 1964). To generate diversity among the elite cultivated species, wild progenitors and wild relatives offer an immense reservoir of genes. However speciation and adaptive radiation has lead to the development of reproductive barriers among the wild and cultivated species. Interspecific hybridization is another interesting supplementary technique in plant breeding which can help to generate diversity. The introgression breeding can play a significant role in addressing these issues, whereby desirable genes from different sources are taken into the background of cultivated varieties.

While proceeding for introgressive wide hybridization, the variability in chromosome number among the *Linum*. spp. should be taken into account. As linseed has been domesticated for > 5000 years, it can be artificially crossed with several wild relatives and produce fertile progeny (Gill and Yermanos, 1967a; Yermanos and Gill, 1967; Bari and Godward, 1970; Seetaram, 1972). While interspecific hybridization has not been documented for the most cultivated species, hybridization of flax with other n = 15 species suggests successful crossing may occur. *Linum lewisii*, n = 9, seems less likely to hybridized with cultivated flax (Gill, 1987).

The assessment of the potential for gene flow to wild relatives is one of many components of an environmental risk assessment before the release of a new crop variety with alien chromatin. Other concerns are the movement of transgenes via pollen to conventional crops, seed and volunteer mediated gene flow, influences on non-target species, and the potential harm to biodiversity. Details on the specific traits and the consequence of its expression are required before determining whether the transgene could have an impact on wild species.

Taking all of the above issues into consideration, the research investigation was carried out to determine the crossability among the wild and cultivated species of *Linum* and relative performance of their hybrids over parents various agro-morphological traits and resistance to linseed rust.

MATERIALS AND METHODS

This study was carried out in the Experimental Farm of the Department of Crop Improvement CSKHPKV, Palampur, Himachal Pradesh, India (32°8´ N, 76°3´ E) represents humid sub-temperate climate zone with annual rainfall of 2500 mm and acidic soil with pH of 5.0 to 5.6. The experimental material consisting of 6 cultivated and 2 wild species (Table 1), selected on the basis of previous studies (Basandrai *et al.*, 1994), were staggered sown at 7 days interval with row to row and plant to plant distance of 30 cm and 10 cm respectively with row length of 3 meter was maintained by thinning. Standard cultural practices were carried out as recommended for linseed.

During *rabi* 2012-13, inter and intra-specific hybridization programme was carried out. In each cross combination 100 flowers were manually emasculated in the evening (4 to 6pm) and pollinated in the next morning

(6:30am to 8:00 am) and seed set was recorded.

The crossability (%) was calculated by using the formula:

$$\textit{Crossability (\%)} = \frac{\text{No. of seed carrying capsules}}{\text{No. of flowers pollinated}} \times 100$$

Average seed set per capsule was calculated using the formula:

$$\textit{Average seed set per capsule} = \frac{\text{Total number of seeds}}{\text{Seed carrying capsule}}$$

In next season (2013-14) F_1 seeds (intraspecific and interspecific) obtained from all the crosses along with their parents were raised in randomized complete block design with 3 replications using standard package of practices for analyzing different agro-morphological traits. Data were recorded on 5 randomly selected plants in each replication for plant height(cm), technical height (cm), recorded from the ground surface to the point from where the primary branches start at the stage of physiological maturity primary branching, secondary branching, capsules per plant, seeds per capsule, biological yield (g), straw yield (g), seed yield per plant (g), 1000 seeds weight (g) and harvest index (%).The recorded data was subjected to analysis of variance (Panse and Sukhatme, 1985).

Table 1. Wild species and different varieties of cultivated species with their chromosome number and pedigree.

Wild species	Chromosome number	Pedigree
L. *angustifolium*	30	Wild Species
L.*grandiflorum*	16	Wild Species
Cultivated varieties of *L. usitatissimum*		
T-397	30	T-491 x T-1193-2
Chambal	30	Local × RR 45
Kangra Local	30	Local variety
HimAlsi-1	30	K-2 x TLP-1
Nagarkot	30	New River x LC-216
HimAlsi-2	30	EC-21741 x LC-216

Screening of linseed rust

One set of F_1 along with their respective parents was sown at Shivalik Agricultural Research and Extension Centre, Kangra, Himachal Pradesh, India (32^{o}9' N, 76^{o}22' E), amongst which T-397 was used as check. Rust inoculum was collected from the Kangra and Mandi districts, plant material was inoculated by placing an infected leaf at the margin of a glass slide and brushing the spores onto the terminal leaves by brush and the inoculated plants were atomized with water. The material was screened for linseed rust on 0 to 4 scales given by Flor, 1954 (Table 2).

Table 2. Disease scale for linseed rust (*Melampsora lini*).

Score	Reaction type	Characterization
0	R	No uredial development
1	R	Uredia minute to small, distinct and scattered, leaf distortion
2	R	Uredia small to medium, always associated with necrosis of adjacent leaf tissue. Stunting and distortion of leaf.
3	S	Uredia medium size, surrounded by chlorotic areas. No necrosis of leaf distortion
4	S	Uredia large and compound, little chlorosis of adjacent tissue

RESULTS

Crossablity

The crossability was assessed on the basis of seed setting. The wild species *L. grandiflorum* was not crossable with any of the cultivar used in the study whereas, *L. angustifolium* was crossable with all the cultivars. The seed set frequency of *L. angustifolium* ranged from 69 to 78 per cent with HimAlsi-2 and T-397, respectively whereas, maximum average seed set per capsule (7.5) was also observed with HimAlsi-2. In case of intraspecific hybridization the range of crossability varied from 88 to 94% in Kangra Local x Nagarkot and T-397 x HimaAlsi-1 crosses, respectively with an average of 90.8%.The mean of average seed set per capsule was 6.9 and its range varied from 5.3 to 7.9 in the crosses of Him Alsi-1 with Chambal and T-397 respectively (Table 3).

Table 3. Crosses attempted between and within *Linum* species and their crossability(%).

Crosses	No. of flowers pollinated	No. of seed(s) carrying capsules obtained	Total number of seeds set	Average seed set/ capsule	Crossability (%)
Interspecific					
T-397 x *L.angustifolium*	100	78	425	5.5	78
Chambal x *L. angustifolium*	100	73	407	5.6	73
Kangra Local x *L. angustifolium*	100	71	402	5.7	71
HimAlsi-2 x *L.angustifolium*	100	69	520	7.5	69
T-397 x *L.grandiflorum*	100	0	0	0	0
Chambal x *L. grandiflorum*	100	0	0	0	0
Kangra Local x *L. grandiflorum*	100	0	0	0	0
HimAlsi-2 x *L. grandiflorum*	100	0	0	0	0
Mean		*36.4*	*219.3*	*3.03*	*36.4*
SE ±		*14.7*	*89.6*	*1.3*	*14.7*
Intervarietal					
T-397 x Nagarkot	100	89	659	7.4	89
T-397 x HimaAlsi-I	100	94	747	7.9	94
Chambal x Nagarkot	100	91	541	5.9	91
Chambal x Him Alsi-I	100	90	480	5.3	90
Kangra Local x Nagarkot	100	88	644	7.3	88
Kangra Local x HimAlsi-I	100	92	674	7.3	92
HimAlsi -II x Nagarkot	100	90	639	7.1	90
HimAlsi-II x HimAlsi-I	100	92	657	7.1	92
Mean		*90.8*	*630.1*	*6.9*	*90.8*
SE (m) ±		*0.7*	*31.3*	*0.3*	*0.7*

Assessment of hybrids with their parents

The analysis of variance revealed significant difference among the parents and their F_1 hybrids for all the traits except seeds per capsule (Table 4).The hybrids developed during the process were evaluated with their parents for yield and quality related traits. The salient features of external morphology of the F_1hybrids were also compared with their respective parents. Emphasis was laid on important key characters of diagnostic value in describing the species and hybrids on the basis of the mean performance (Table 5).

Seed yield is most important character for crop improvement. In this study among parents, Nagarkot was observed to be the highest yielder with 3.9 g, whereas *L. angustifolium* was found to be lowest (2.2 g) seed yield per plant.Whereas in case of hybrids, Chambal x Nagarkot (5.7 g) was on the top, followed by HimAlsi-2 x *L. angustifolium* (5.5 g) and HimAlsi-2 x HimAlsi-1 (5.4 g). Crop yield is directly affected by seed weight and considerable variation was observed for 1000 seed weight in this study. A maximum average 1000 seed weight of 8.1 g was recorded in HimAlsi-1 cultivar. Only 2 hybrids with Nagarkot i.e. T-

397 x Nagarkot (7.4 g) and HimAlsi-2 x Nagarkot (6.6 g) were observed to be better than their respective parents.

Plant height and Technical height are the indirect contributors of yield and fibre quality, respectively. The maximum plant height of 79.7 cm was recorded in HimAlsi-2 cultivar whereas minimum of 44.8 cm in *L. angustifolium* while range of technical height among parents varied from 1.9 to 40.9 cm in parents T-397 and HimAlsi-2, respectively. In case of hybrids 2 hybrids T-397 x *L. angustifolium* (56.9 cm and 23.5 cm) and Chambal x Nagarkot (79.8 cm and 40.6 cm) showing higher plant and technical height respectively over their respective parents.

The primary and secondary branches help in determining the number of capsules on the plant. The wild species *L. angustifolium* had only 6.6 and 5.8 in contrast to T-397 cultivar which on an average had 14.3 and 11.9 primary and secondary branches per plant, respectively. T-397 x Nagarkot was the only hybrid which had low primary as well as secondary branches per plant whereas rest of the of the hybrids were more vigorous than their respective parents except HimAlsi-2 x Nagarkot for primary branches and HimAlsi-2 x HimAlsi-1 for secondary branches. Linseed straw is an indicator of fibre quantity and it was observed from present investigation that the lowest straw yield was observed in *L. angustifolium* (3.3 g) and also in its hybrids with Kangra Local and HimAlsi-2, whereas highest straw yield was observed in HimAlsi-2 (6.6 g) and hybrid T-397 x Nagarkot (7.3 g).

Crop yield depends upon number of capsules and seeds per capsule.The Kangra Local exhibited minimum of 45.4 capsules per plant but a maximum of 8.9 seed per capsules. The wild species *L. angustifolium* bore a maximum of 74.3 capsules per plant whereas HimAlsi-2 had revealed minimum of 6.9 seed per capsules. *L. angustifolium* seems to be important from the view point of capsules per plant. However, only 2 hybrids of Kangra Local with Nagarkot and HimAlsi-1 showed heterosis with increased capsules per plant whereas three hybrids of HimAlsi-2 with *L. angustifolium*, HimAlsi-1, and Nagarkot appeared to have more seeds per capsule than their parents. Amongst hybrids, HimAlsi-2 x HimAlsi-1 was better for both capsules per plant and seeds per capsule.

Biological yield is the determinant of plant vigour,the parental range varied from 6.2 to 11.7 g in *L. angustifolium* and Nagarkot, respectively. All hybrids were observed to be vigorous for biological yield except the hybrids of Kangra local with Nagarkot and *L. angustifolium.* Harvest index is an indicator of the source-sink relationship. The maximum average harvest index was observed in T-397 (40.3%) but its hybrids with Nagarkot and HimAlsi-1 were not found to be better than its respective parents.

Reaction to rust

The species and the hybrids were tested against the linseed rust (*Melampsora lini)* under natural conditions. Both the wild species were found to be resistant to the rust. The parental lines viz. T-397, Chambal and Kangra Local were found to be susceptible with a value of 4, 3 and 3, respectively on the disease scale. All the hybrids were resistant to the linseed rust.

Table 4. Mean square values for various agro-morphological traits of linseed.

No.	Traits	Source	Replication	Genotypes	Error
		df	2	18	36
1	Seed yield per plot (g)		0.3	3.9**	0.02
2	1000 Seed Weight (g)		0.8	7.07**	0.04
3	Plant Height (cm)		4.9	329.6**	1.32
4	Technical Height (cm)		3.8	137.0**	1.32
5	Primary branch		1.1	21.7**	0.10
6	Secondary branch		0.8	13.7**	0.06
7	Straw yield per plant(g)		0.3	4.7**	0.05
8	Capsuls per plant		6.3	192.6**	1.30
9	Seeds per Capsule		1.3	1.7	0.08
10	Biological Yield per plant(g)		1.6	21.4**	0.09
11	Harvest Index(%)		0.4	66.2**	1.63

***** $P \leq 0.005$ and **$P \leq 0.001$

Table 5. Comparative various agro-morphological traits of the parents and their hybrids.

		SYP (g)	SW (g)	PH (cm)	TH (cm)	PB	SB	StYP (g)	CP	SC	BYP (g)	HI (%)	RR (0-4)
	Parents												
1	*L.usitatissimum* varieties												
A	T-397	2.5	6.5	52.2	21.9	14.3**	11.9**	3.4	46.4	8.6**	6.3	40.3**	4
B	Chambal	3.3	7.9**	74.9**	38.9**	8.1	7.5	4.6	52.2	7.5	11.2**	29.7	3
C	Kangra Local	2.6	3.5	70.5**	31.4	7.7	6.4	4.4	45.4	8.9**	7.5	34.1	3
D	HimAlsi-2	3.3	6.4	79.7**	40.9**	9.0	7.9	6.5**	50.5	6.9	10.7	30.9	1
E	Nagarkot	3.9	6.6	77.6**	38.4**	8.2	7.2	6.2**	48.8	7.0	11.7**	33.6	0
F	HimAlsi-1	3.2	8.1**	70.8**	40.7**	12.5**	8.9	3.8	51.5	7.6	9.1	35.2	0
2	*L. angustifolium*	2.2	3.7	44.8	22.3	6.6	5.8	3.3	74.3**	7.9	6.2	35.0	0
	Crosses												
1	T-397 x *L. angustifolium*	2.5	6.3	56.9	23.5	16.3**	13.3**	4.4	45.2	8.1	7.3	34.4	0
2	Chambal x *L. angustifolium*	4.8**	7.1**	76.2**	30.1	9.5	8.1	5.4	54.9**	5.9	12.4**	38.9	0
3	Kangra Local x *L. angustifolium*	2.9	3.6	56.5	26.7	9.0	7.5	3.2	65.4**	8.4**	6.1	46.9**	0
4	HimAlsi-2 x *L. angustifolium*	5.5**	5.4	75.0**	36.3**	10.4	8.5	6.0**	67.7**	7.9	13.3**	41.4**	0
5	T-397 x Nagarkot	5.3**	7.4**	60.0	27.9	10.7	9.3	7.3**	47.6	7.5	13.6**	38.8	0
6	T-397 x HimAlsi-1	4.3**	7.9**	61.3	32.9	15.3**	12.9**	5.3	47.9	8.2*	10.8	39.5*	0
7	Chambal x Nagarkot	5.7**	7.7**	79.8**	40.6**	9.2	8.2	6.5**	46.6	7.3	13.1**	42.9**	0
8	Chambal x HimAlsi-1	4.8**	7.0**	71.7**	38.5**	12.9**	11.5**	5.5	49.4	6.8	11.9**	39.9**	0
9	Kangra Local x Nagarkot	3.0	4.6	74.9**	36.4**	9.4	8.2	5.0	51.1	8.3**	8.1	37.4	0
10	Kangra Local x HimAlsi-1	3.1	6.8*	72.0**	38.0**	13.2**	11.1**	4.8	52.6	8.4**	10.1	30.9	0
11	HimAlsi-2 x Nagarkot	4.0*	6.6	78.9**	38.9**	11.0	9.1	6.5**	47.8	7.2	12.9**	30.9	0
12	HimAlsi-2 x HimAlsi-1	5.4**	8.0**	77.9**	41.9**	11.4*	8.7	6.6**	52.5	7.7	13.3**	40.6**	0
	Mean	3.8	6.4	69.0	34.0	10.8	9.1	5.2	52.5	7.7	10.3	36.9	
	SE (m) ±	0.07	0.12	0.33	0.33	0.19	0.14	0.13	0.33	0.16	0.18	0.74	
	CD(5%)	0.20	0.33	0.93	0.93	0.53	0.41	0.37	0.90	0.46	0.51	2.09	
	CD(1%)	0.27	0.44	1.2450	1.24	0.71	0.54	0.49	1.20	0.61	0.68	2.80	

* $P \le 0.005$ and ** $P \le 0.001$

SYP-seed yield per plant; SW-1000 seed weight; PH-plant height; TH- technical height; PB- primary branch; SB- secondary branch; StYP-Straw yield per plant; CP-capsules per plant; SC-seeds per capsule; BYP- biological yield per plant; HI-harvest index and RR-rust reaction

DISCUSSION

The collection and study of wild relatives is an integral part of any breeding programme. Such investigations characterized the materials for their desirable genes which further can be utilized for upgradation of cultivated species. Crossability can act as an important ingredient for successful transfer of those desirable genes. But it is always hindered by number of factors viz. genotypic and environmental (Badiyal *et al.,* 2014). Tammes (1923) successfully synthesized the first interspecific linseed hybrid since then various workers across the globe have been working on this aspect. Limited work on interspecific hybridization has been reported in Indian subcontinent, in particular North-West Himalayan region. So in present investigation crossability of *Linum* was assessed among species and within speices. Wide variation has been observed for crossability, based on the potential of wild progenitors in disease resistance, *L. angustifolium* and *L. grandiflorum* were choosen although no successful hybrid has been reported in case of *L. grandiflorum* and its inclusion was based on its rust resistance property (Seetharam, 1972) and physiological advantages like ease of germination over other wild species. In interspecific hybridization out of 2 wild species *L. angustifolium* and *L. grandiflorum*, the former species exhibited average 73% crossability based on the seed carrying capsule whereas latter species failed to set seeds. The chromosome number of *L. grandiflorum* (2n = 16) is different from cultivated flax *L. usitatissimum* (2n = 30) and karotype of both species is also different, which could be the major cause in failure of seed setting (Bari and Godward, 1970). *L. angustifolium* and *L. usitatissimum* are similar in number as well as morphology of chromosomes except one translocation (Jhala *et al.,* 2008). Present study revealed that T-397 x *L. angustifolium* was the most successful interspecific hybrid emphasizing the importance of gene flow between the wild and cultivated species of genus *Linum* as reviewed by Jhala *et al.* (2008) and earlier reported by Kikuchi (1929), Gill (1966), Gill and Yermanos (1967a). Four interspecific hybrids were obtained by crossing *L. angustifolium* with the released cultivars of the linseed, Ray (1941) and Seetharam (1972) also obtained successful interspecific hybrids with *L. angustifolium.*

The agro-morphological characters of inter- and intra- specific hybrids revealed that some of the combinations performed better over their respective parents. The yield is the prime importance of any crop and it depends upon various related traits. The wide hybridization can help in changing the ideoptype of plant which ultimately contribute in yield. In this investigation, interspecific hybrid T-397 x *L. angustifolium* was superior for primary and secondary branches which indirectly contributed to yield. The highly improved capsules per plant and biological yield per plant was observed in HimAlsi-2 x *L. angustifolium* similarly Kangra Local x *L. angustifolium* was superior for seeds per capsule and harvest index. The wide hybridization can contribute in changing the ideotype of plant hence these hybrids can be used as germplasm for improvement of cultivated linseed. The outstanding intraspecific hybrids T-397 x Nagarkot and Chambal x Nagarkot were superior for straw yield and seed yield per plant, respectively and HimAlsi-2 x HimAlsi-1 was outstanding for 1000 seed weight. Better performance of intraspecific hybrids was the result of presence of superior yield related genes in both cultivated parents which combined on hybridization. The height of linseed plant has significant role in both fibre as well as yield (oil or feed). In case of plant height, Kangra Local x *L .angustifolium* was observed to be of small stature providing tolerance against heavy winds and lodging, whereas Chambal x Nagarkot having long plants are preferred for linseed fibre (Reddy *et al.,* 2013). Technical height is the key trait for assessing the quality of fibre flax. Fibre length is dependent upon the length of unbranched stem (Grauda *et al*., 2004). This investigation revealed that the technical height of HimAlsi-2 x HimAlsi-1 was better than all the hybrids as well as their parents. It can be further utilized to improve fibre in breeding programme.

Rust heavily affects the yield of linseed which ultimately hampers its production. Its inheritance is controlled by either single or multi genes which makes it difficult to study for resistant breeding (Henry, 1930; Flor, 1947). In this investigation agronomically superior cultivars viz. T-397, Kangra Local and Chambal were observed to be susceptible. Whereas their respective hybrids were found to be resistant, indicating involvement of dominant gene(s) in their resistance. Further study is required to establish the nature of the gene(s) controlling the resistance. It can be concluded that *L. angustifolium* can be used as potential source for rust resistance and cultivar improvement breeding programs.

This investigation of inter as well as intraspecific hybrids of *Linum* revealed their superiority over parents for various agronomic traits including resistance against linseed rust. Such finding can open new horizons in the introgression breeding programmes in linseed, worldwide. The interspecific hybrids with wild species as one of the parent can be used as a potential germplasm for resistance breeding. Still further studies are required to establish the inheritance behaviour of various qualitative and quantitative traits contributing towards the development of widely adoptable linseed cultivars.

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