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Screening of linseed germplasm for resistance against *Alternaria* spp. cause blight disease in linseed (*Linum usitatissimum* L.)

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Abstract
A field study was conducted during *Rabi*, 2015-16 crop seasons at Nwabganj Farm (2014-15) and Oilseed Farm, Kalyanpur, C. S. Azad University of Agriculture and Technology, Kanpur to test the resistance of 200 germplasm against *Alternaria* spp. under artificial epiphytotic conditions. Each germplasm was sown in second week of November in single row of one meter length. Variety Raj 4015 was used as check and was sown after every 20 genotypes. Pure culture of pathogen was inoculated on genotypes by using cleaned sprayer, at evening. Disease data was recorded using double digit scale based on per cent blighted area on flag leaf and one leaf just below. Out of 200 genotypes, disease free (F) and highly susceptible (HS) germplasm were not found, 7 genotypes were found resistant (R), 66 were moderately resistant (MR), 102 were moderately susceptible (MS) and 25 were found susceptible (S) against blight disease of linseed.

Keywords: germplasm, *Alternaria, Linum usitatissimum* L

Introduction
Flaxseed or Linseed (*Linum* is *usitatissimum* L.) is known as founding crop [1] which is being evaluated as a crop platform for the production of bio-industrial and nutraceutical products [2]. It is the sixth largest oilseed crop in the world and is one of the oldest cultivated plants [3]. Flaxseed is grown as either oil crop or a fiber crop [4]. Linseed is a *Rabi* crop in India which is a member of family Linaceae. Linseed is an annual dicotyledonous plant [5]. Canada is the world's largest producer of flax (38% of total production) [5]. India contributes about 14.88% and 6.57% to world area and production, respectively. Productivity of Rajasthan state (1351 kg/ha) of India is surpassing the productivity of Asia (728kg/ha) as well as of world (986 kg/ha) [6]. The plant is native to west Asia and the Mediterranean.
Linseed is one of the richest sources of α- linolenic acid (ω-3 fatty acid) and soluble mucilage. An analysis of brown Canadian flax showed about 41% fat, 20% protein, 28% total dietary fibre, 7.7% moisture and 3.4% ash, which is the mineral-rich residue left after samples are burned [7]. Seed contain 20% protein[8] but Indian cultivar Khategaon had a protein content of 21.9% [9]. Flax is glutenfree. Linseed oil have ω-3 (57%), ω-6 (16%), monosaturated fatty acid (18%) and saturated fatty acid (9%) in its composition [10]. The components present in flaxseed attract the food technologists and nutritionists to explore its activities in health sector [11].
Linolenic acid, eicosapentaenoic acid (EPA) and docosahexanoic acid (DHA) are three types of omega-3 fatty acids and are nutritionally important because they reduce the risk of cardiovascular disease [7]. Flaxseed protein was effective in lowering plasma cholesterol and triglycerides (TAG) compared to soy protein and casein protein [12]. Flaxseeds, which also contain PUFA and dietary fiber, are therefore a promising food to help decrease the risk of lifestyle related diseases [13]. The antioxidant activity of the flaxseed has been shown to reduce total cholesterol [14] as well as platelet aggregation [15].
Flaxseed can be incorporated into diet through oil, milled or ground flaxseeds or through eggs, meat produced by animals fed flax meal [16]. The seeds are now widely used as bakery [17]. One table spoon of ground flax per serving can be incorporated into morning hot cereal after cooking. We can also sprinkle ground flax over a salad, cooked vegetables or cold breakfast cereals. Flaxseed is used for the preparation of flaxseed chutney powder [18]. Linseed tea [19] also made up from linseed. Total fibers (cellulose, lignine and hemicellulose) content varies between 22-26 per cent [20].
Linseed is adversely affected by different diseases. Out of 15 fungal diseases of linseed, most important pathogens as *Alternaria linicola* (blight), *Fusarium* spp. (wilt), *Botrytis cinerea* (gray mould) and *Oidium lini* (powdery mildew) [21], *Ascochyta linicola* (foot rot), *Melampsora*

lini (Rust), *Rhizoctona solani* (Rhizoctonia seedling blight), *Pythium megalacanthum* (scorch), *Septoria linicola* (pasmo), *Polyspora lini* (browning or stem break) and *Colletotrichum linicolum* (anthracnose) which are affected by seed-treatment and certification, breeding for resistance.

Alternaria blight is a major disease which causes heavy loss in terms of quality and quantity of fiber and seed of linseed. Alternaria blight of linseed was first reported by Dey [22] from Kanpur, Uttar Pradesh in 1933. Later Siddiqui (1963) [23] reported the occurrence of Alternaria blight on linseed cultures at IARI, New Delhi and other parts of the country. The fungus was named as *Alternaria lini* after the first report of this disease in 1933 [22].

Alternaria blight causes heavy loss from 28 to 60 per cent depending upon the variety/genotype and date of sowing [24, 25]. To the point of disease, chemical minimization in crop and environmental safety it becomes essential to evaluate large number of available germplasm lines for seed yield alongwith the prevailing diseases of the area. In view of this fact, 200 lines were evaluated for Alternaria blight incidence to find out genotypes resistant to this disease which may be used as resistant donor in linseed breeding programme.

Materials and Methods

The experiment was conducted at Oilseed farm, Kalyanpur of C. S. Azad University of Agriculture and Technology, Kanpur (U.P.) India during crop season Rabi, 2015-16. Seeds of 200 genotypes were collected from All India Co-ordinated Research Project on Linseed, C. S. Azad University of Agriculture and Technology, Kanpur. Each genotype was sown (second week of November) in single row of one meter length at a distance of 30 cm row to row and 5 cm plant to plant. One row of susceptible variety (Chamble) to linseed blight was sown as border rows around all the sites of experiment. The ten days old pure culture of *Alternaria* spp. multiplied on Potato Dextrose Agar (PDA) was used for inoculating on entries. The spore suspension was prepared in sterilized distilled water having a spore load of 50-75 per microscopic field (10x). This suspension was sprayed at 30 DAS by using hand atomizer. Inoculation was sprayed after noon. After inoculation, the entries were regularly watched for recording the observations of disease severity. The first observations were made after ten days of inoculation on ten plants selected randomly. The disease score of each selected plants were recorded by using 0-5 scale [26] (Table 1) based on per cent blighted area of leaf. The maximum disease score of each genotype was recorded finally.

Table 1: 0-5 scale adapted to indicate degree of resistance against *Alternaria* blight of linseed

Scale	Disease Intensity	Disease Rection
0	Free from disease	Free (F)
1	1-10% infection	Resistant (R)
2	10.1-25% infection	Moderate Resistant (MR)
3	25.1-50% infection	Moderate Susceptible (MS)
4	50.1-75% infection	Susceptible (S)
5	75.1-100%	Highly Susceptible (HS)

Result and discussion

Use of resistant variety is a cheapest and most economical method of disease control. Two hundred varieties (Table 2) were screened under field conditions by double digit scale based on per cent blighted area on the flag and flag-1 leaf at hard Dough stages. Out of which, disease free (F) and highly susceptible (HS) germplasm were not found, 7 genotypes *viz*., 9×12, ARNY, BS-2, NP-8, NP-25RRSK, NP-48, NP Hyb-29 were rated as resistant (R), 66 germplasm *viz.,* 68-10-3276, 164/1, A-434, C-429-3, CC-12, RL-975, EC-1187, EC-1410, EC-2268, EC-848, EC-22850, EC-41577, EC-41656, EC-41733, EC-99029, ES-115178, ES-1534, GS-204, GS-206, Gunawal Local, Gangroochi, H-8, EC-384154, Ayogi, H-25, Hanuman Sagar, FCI-6387, Karambanda, L-43, L-48, L-53, L-108, LCK-152, NP-23K, NP-59, NP-88, NP Hyb-39, NP Hyb-48, NP(RR)-9, NP(RR)-1153, NP(RR)-267, NP(RR)-268, NP(RR)-271, NP(RR)-429, NP(RR)-442, R-552, RL-4-6, RLC-49, RR-454, S-91-22, S-91-31, S-91-45, T-82, UP Type, T-397, SJKO-1, SJKO-5, SJKO-21, SJKO-36, SJKO-39, SJKO-49, SJKO-55, SJKO-61, RSJ-10, RSJ-31, RSJ-34 were rated as moderately resistant (MR), 102 germplasm *viz.,* 191×RR-912, 1541, 5620A, 59126, A-10-2-2, A-49, A-170, A-180, A-199, A-375, A-385, A-388, A-396A, A-404, A-417, BAU-111-1, BAULK, BR-1, BR-14, BR-3-62, Bengal-23, Behrampur, Baupur Local, Bilaspur, CI-540, CI-765, CI-1427, CI-15-B, CI-1554, CI-IT97, CI-1968, CI-1972, CI-2056, CI-J-5635, EC-561, EC-564, EC-569, EC-589, EC-1389, EC-1433, EC-1434, EC-1529B, EC-1639B, EC-22592, EC-41561, EC-41627, EC-41704, EC-99009, EC-99025, ES-16381, EX-6-3, PB3No.3, FR-11, G-2C-1-2, GS-121, GS-134, GS-219, GS-337, GS-401, H-11, Hyb-603-2, IC-15888, ICI-14577, ILS-150, ILS-153, Jabalpur-367, KL-169, Kanpur Local, L-4, L-14, L-18, L-21, LC-1044, LCK-254, LCK-3532, LCK-87312, LCK-88311, LMH-379, NP-89, NP-103, NP-114, NP-115, NP-121, NP Hyb-38, NP(RR)-28, NP(RR)-402, NP(RR)-494, AHUDOBA, P-650, Polf-6, RL-28-1, RL-43-5, RLC-37, RLC-48, RLC-52, RR-76, S-91-55, T-126, SJKO-71, SJKO-72, RSJ-12, RSJ-24 were rated as moderate susceptible (MS) and 25 germplasm *viz.,* A-23-1-1, A-210, A-449, A-459, A-495, Bengal-63, Bengal-70, Baupur Local, CI-2010, CI-2067, CR-M-6×22-9, Begnoadi, BC-523B, EC-22583, EC-9832, EC-99080, EC-12077B, EX-131-10, GS-178, GS-183, GS-194, GS-280, LS-1, OLS-42, OLC-48 were rated as susceptible (S) for linseed blight disease under field conditions. Das [27] also evaluate the performance of promising lines/varieties of linseed against Alternaria blight disease. Four hundred forty linseed germplasm lines accessions and three improved check varieties (Neelam, T 397 and Kiran) screened to identified to extent of promising genotypes at the yield level against Alternaria blight. Of these germplasm lines 8 genotypes A-225B, A-75, A-226, A-364, A-232, A-66, A-202 and A-184 showed lowest per cent disease intensity of disease of 12.67, 21.50, 22.34, 22.54, 23.25, 24.25, 24.77 and 25.00 per cent, respectively. These lines also showed better response to seed yield and can be used as good donor to improvement for resistant varieties against Alternaria blight in linseed breeding programme [28].

Table 2: Reaction of linseed germplasm against Alternaria blight caused by *Alternaria* spp during *Rabi*-2015-16

Scale	Disease Intensity	Disease Reaction	No. of germplasma	Name of germplasma
0	0% infection	Disease Free (F)	Nil	Nil
1	1-10% infection	Resistant (R)	07	9×12, ARNY, BS-2, NP-8, NP-25RRSK, NP-48, NP Hyb-29

2	10.1-25% infection	Moderately Resistant (MR)	66	68-10-3276, 164/1, A-434, C-429-3, CC-12, RL-975, EC-1187, EC-1410, EC-2268, EC-848, EC-22850, EC-41577, EC-41656, EC-41733, EC-99029, ES-115178, ES-1534, GS-204, GS-206, Gunawal Local, Gangroochi, H-8, EC-384154, Ayogi, H-25, Hanuman Sagar, FCI-6387, Karambanda, L-43, L-48, L-53, L-108, LCK-152, NP-23K, NP-59, NP-88, NP Hyb-39, NP Hyb-48, NP(RR)-9, NP(RR)-1153, NP(RR)-267, NP(RR)-268, NP(RR)-271, NP(RR)-429, NP(RR)-442, R-552, RL-4-6, RLC-49, RR-454, S-91-22, S-91-31, S-91-45, T-82, UP Type, T-397, SJKO-1, SJKO-5, SJKO-21, SJKO-36, SJKO-39, SJKO-49, SJKO-55, SJKO-61, RSJ-10, RSJ-31, RSJ-34
3	25.1-50% infection	Moderately Susceptible (MS)	102	191×RR-912, 1541, 5620A, 59126, A-10-2-2, A-49, A-170, A-180, A-199, A-375, A-385, A-388, A-396A, A-404, A-417, BAU-111-1, BAULK, BR-1, BR-14, BR-3-62, Bengal-23, Behrampur, Baupur Local, Bilaspur, CI-540, CI-765, CI-1427, CI-15-B, CI-1554, CI-IT97, CI-1968, CI-1972, CI-2056, CI-J-5635, EC-561, EC-564, EC-569, EC-589, EC-1389, EC-1433, EC-1434, EC-1529B, EC-1639B, EC-22592, EC-41561, EC-41627, EC-41704, EC-99009, EC-99025, ES-16381, EX-6-3, PB3No.3, FR-11, G-2C-1-2, GS-121, GS-134, GS-219, GS-337, GS-401, H-11, Hyb-603-2, IC-15888, ICI-14577, ILS-150, ILS-153, Jabalpur-367, KL-169, Kanpur Local, L-4, L-14, L-18, L-21, LC-1044, LCK-254, LCK-3532, LCK-87312, LCK-88311, LMH-379, NP-89, NP-103, NP-114, NP-115, NP-121, NP Hyb-38, NP(RR)-28, NP(RR)-402, NP(RR)-494, AHUDOBA, P-650, Polf-6, RL-28-1, RL-43-5, RLC-37, RLC-48, RLC-52, RR-76, S-91-55, T-126, SJKO-71, SJKO-72, RSJ-12, RSJ-24,
4	50.1-75% infection	Susceptible (S)	25	A-23-1-1, A-210, A-449, A-459, A-495, Bengal-63, Bengal-70, Baupur Local, CI-2010, CI-2067, CR-M-6×22-9, Begnoadi, BC-523B, EC-22583, EC-9832, EC-99080, EC-12077B, EX-131-10, GS-178, GS-183, GS-194, GS-280, LS-1, OLS-42, OLC-48
5	75.1-100% infection	Highly Susceptible (HS)	Nil	Nil

Conclusion

The screening of some selected linseed genotypes for resistant performance against blight disease pathogen of linseed. Economic and environment safety point of view, use of resistant variety is a cheapest and best method of disease control. This is also part of Integrated Disease Management (IDM) strategy. Although the selected varities/ germplasm/ genotypes of linseed were unable to completely inhibit the pathogens but they could be used in IDM practices to minimize the use of fungicides. The finding of the present investigation could be an important step towards the possibilities of using resistant variety in plant disease control.

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