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Identification of novel late blight resistance source in wild potato species and interspecific somatic hybrids, and their distinctness, uniformity and stability (DUS) characterization

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Abstract

Forty potato genotypes, including wild *Solanum* species and interspecific somatic hybrids were characterized for late blight resistance and distinctness, uniformity and stability (DUS) descriptors. Thirty-two genotypes (14 wild species + 18 somatic hybrids) were found highly resistant to late blight, whereas 4 were resistant and 1 was moderately resistant compared to the control varieties *viz*., Kufri Jyoti (susceptible), Kufri Bahar (highly susceptible), and Kufri Girdhari (highly resistant). All wild species were high resistant to late blight. Further, morphological characterization based on 51 DUS descriptors showed phenotypic variation in the genotypes studied. Thus, we identified late blight-resistant potato wild species and somatic hybrids, which could serve as a potential source for late blight resistance breeding.

Keywords: DUS traits, Late blight resistance, Potato, Wild species, Somatic hybrids.

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Introduction

The genus *Solanum* is the richest source of potato biodiversity and possesses immense potential for its genetic enhancement. Study shows that only a small fraction of wild/semi-cultivated and cultivated species have been utilized in potato improvement via breeding and biotechnological tools (Bradshaw *et al.* 2006). Hence, most wild species remain untapped, especially for transferring resistance genes, for example, late blight resistance- the most devastating disease of potato (Lal *et al.* 2013). Wild tuber-bearing Solanum species are widely distributed from the south-western USA to central Argentina and Chile (South America). This extensive geographical range has resulted in adaptation to a broad range of climatic and soil conditions. In the course of evolution, wild species have also developed resistance/tolerance to different pathogens and pests (Chakrabarti *et al.* 2017). Much of this effort has involved examining wild species for various resistance traits and agronomical influence on the growth and yield of potato (Bhatt *et al.* 2020).

Late blight is the most serious disease of potatoes worldwide. Hence, the utilization of wild species in potato breeding is important to confer durable resistance against this disease. To overcome the sexual-incompatibility barriers between wild and cultivated potatoes, wild species have been used in protoplast fusion and as a result interspecific potato somatic hybrids were developed for late blight resistance worldwide, including India (Sarkar *et al.* 2011;

Chandel *et al.* 2015). Further, these somatic hybrids have been used as parents in developing new potato varieties. We have demonstrated successful development of interspecific somatic hybrids between *Solanum tuberosum* dihaploid C-13 and *S. pinnatisectum* (Sarkar *et al.* 2011); C-13 and *S. cardiophyllum* for late blight resistance (Chandel *et al.* 2015); and C-13and *S. tuberosum* for potato virus Y resistance (Tiwari *et al.* 2010). This has enabled us to widen the genetic base of cultivated potato by utilizing these somatic hybrids in breeding as parental lines to develop new varieties. Further, somatic hybrids have been evaluated in the field for various traits and promising clones were selected for improvement through breeding (Luthra *et al.* 2016), and advance stage hybrids have been developed using these somatic hybrids (Tiwari *et al.* 2018a). Besides, several other potato somatic hybrids have been produced during the past four decades (Tiwari *et al.* 2018b). Follow the correct citation pattern. Any variety of plant before being entered to the national list of cultivars or plant breeder›s right (PBR) to be granted, should undergo one of the tests named (DUS) stands for distinctness, uniformity and stability. According to this any new variety should be distinct, uniform and stable compared to all the known varieties subjected to PBR, commercially available or with any published description (UPOV 2002). The UPOV (The International Union for the Protection of New Varieties) of plants has many country members and it provides system of DUS testing for plant varieties. Since the potato is native to Lima, Peru (South America), all potato germplasm are obtained at the institute from International gene banks like the International Potato Centre, the USA and the Netherlands etc. The present study aimed at the characterization of wild potato species and interspecific somatic hybrids available at the institute for DUS characters and late blight resistance.

Materials and Methods

Plant materials

All materials were used from the institute germplasm repository. The wild species were obtained earlier at the institute from the international gene banks (Potato Introduction Station, NRSP-6, Sturgeon Bay, Wisconsin, USA; and the Centre for Genetic Resources, Wageningen University and Research, the Netherlands). *In-vitro* plants were maintained and multiplied in the Division of Crop Improvement, Indian Council of Agricultural Research – Central Potato Research Institute, Shimla, Himachal Pradesh, India.

DUS characterization

Plants were grown in the earthen pots (in three replicates) following standard practices at Kufri, Shimla, Himachal Pradesh, India. Fifty-one phenotypic traits were recorded as per the DUS guidelines on potato of PPV & FRA, Govt. of India. These 51 traits are associated with various plant parts like light sprout, plant foliage structure, stem color, stem cross-section, plant height, plant wings, leaf, flowers, plant maturity and tubers. DUS characterization was done and data was collected for two consecutive years.

Late Blight Resistance

Total 40 genotypes including wild species, somatic hybrids including controls (Kufri Jyoti: susceptible, Kufri Girdhari: highly resistant, Kufri Bahar: highly susceptible) were tested for late blight resistance in controlled conditions by challenge inoculation of whole plants as methods described by Tiwari *et al.* (2015). In brief, plants were grown in earthen pots (in three replicates) in Shimla, Himachal Pradesh. Nearly two months old plants were shifted in the controlled chamber (18 ± 2°C temperature and 80–90% relative humidity) for late blight resistance assay. The pathogen inoculum of *Phytophthora infestans* isolate A2 mating type was prepared on highly susceptible control Kufri Bahar. Then plants were challenge inoculated with the pathogen. Late blight symptoms were observed after 3 days and observations were recorded accordingly at 3, 5, 7 and 9 days after pathogen inoculation. The area under disease progressive curve (AUDPC) was calculated and wild species were classified based on the AUDPC value [HR: < 50; R: 50–100; MR: 100–150; and S: > 150; HR=highly resistant, R=resistant, MR=moderately resistant, and S=susceptible] (Singh and Birhman 1994).

Results and Discussion

Solanum species is the reservoir of genetic diversity of potato and has immense potential to widen the genetic base of cultivated potato by using these non-crossable wild species. These diploid wild species are not crossable with cultivated tetraploid potato due to the difference in ploidy and endosperm balance number. Hence, interspecific somatic hybrids were developed via protoplast fusion using wild species with cultivated potatoes for the use in breeding. Total 40 potato genotypes were tested against late blight resistance by artificial inoculation of pathogen under controlled conditions. Late blight resistance test results showed that 32 genotypes (14 wild species and 18 somatic hybrids) were highly resistant, 4 wild species (ACL38, LES29, STO40 and VEN30) were resistant and 1 wild species (IOP80) was moderately resistant compared to controls (Kufri Jyoti: susceptible; Kufri Bahar: highly susceptible, and Kufri Girdhari: highly resistant; Table 1, Figures 1 and 2). These wild species and somatic hybrids are potential source of late blight resistance breeding in potato. These findings are incongruent with earlier late blight resistance test of wild species (Srivastava *et al.* 2012; Tiwari *et al.* 2015) and somatic hybrids (Tiwari *et al.* 2010; Sarkar *et al.*, 2011; Chandel *et al.* 2015; Tiwari *et al.* 2018a). Further, all 40 genotypes were characterized for 51 DUS traits and presented in Tables 2 and 3.

Table 1: Late blight resistance assay of wild (*Solanum*) species and interspecific somatic hybrids under controlled conditions by artificial inoculation of *Phytophthora infestans*

Sr. No.	*Genotype*	*Species/Acc. ID*	*Late blight incidence (AUDPC value)*			*Class*
			2019	2020	Mean	
1	ACL38	*S. acaule* (CGN17938)	80.38	101.25	90.815	R
2	BER57	*S. berthaultii* (PI265857)	0.00	5.00	2.5	HR
3	CPH62	*S. cardiophyllum* (PI283062)	0	0	0	HR
4	CPH33	*S. cardiophyllum* (PI341233)	0	0	0	HR
5	CHC60	*S. chacoense* (PI197760)	0	0	0	HR
6	IOP80	*S. iopetalum* (PI230480)	108.84	100.75	104.795	MR
7	IOP59	*S. iopetalum* (PI230459)	0	0	0	HR
8	JAM07	*S. jamesii* (PI498407)	0.00	2.50	1.25	HR
9	LES29	*S. lesteri* (CGN24429)	98.34	82.75	90.545	R
10	MCD24	*S. microdontum* (PI218224)	25.00	35.00	30	HR
11	PNT44	*S. pinnatisectum* (CGN17444)	3.50	2.60	3.05	HR
12	PNT43	*S. pinnatisectum* (CGN17443)	2.50	5.50	4	HR
13	PIN45	*S. pinnatisectum* (CGN17445)	5.34	10.75	8.045	HR
14	PLD47	*S. polyadenium* (CGN17747)	0	0	0	HR
15	PLD48	*S. polyadenium* (CGN17748)	8.70	4.50	6.6	HR
16	PLT50	*S. polytrichon* (CGN22350)	0.00	0.00	0	HR
17	STO40	*S. stoloniferum* (SS2740)	43.67	61.25	52.46	R
18	TRF65	*S. trifidum* (PI255565)	0.00	7.50	3.75	HR
19	VEN30	*S. vernei* (PI320330)	74.17	62.75	68.46	R
20	P1	*S. tuberosum* + *S. pinnatisectum*	0	0	0	HR
21	P2	*S. tuberosum* + *S. pinnatisectum*	0	0	0	HR
22	P3	*S. tuberosum* + *S. pinnatisectum*	3.0	5.0	4	HR
23	P4	*S. tuberosum* + *S. pinnatisectum*	0	0	0	HR
24	P5	*S. tuberosum* + *S. pinnatisectum*	2.5	6.0	4.25	HR
25	P6	*S. tuberosum* + *S. pinnatisectum*	2.5	2.00	2.25	HR
26	P7	*S. tuberosum* + *S. pinnatisectum*	7.84	5.50	6.67	HR
27	P8	*S. tuberosum* + *S. pinnatisectum*	5.50	6.50	6	HR
28	P9	*S. tuberosum* + *S. pinnatisectum*	5.4	7.5	6.45	HR
29	P10	*S. tuberosum* + *S. pinnatisectum*	3.4	4.7	4.05	HR
30	P11	*S. tuberosum* + *S. pinnatisectum*	0	0	0	HR
31	P12	*S. tuberosum* + *S. pinnatisectum*	0	0	0	HR
32	P13	*S. tuberosum* + *S. pinnatisectum*	0	0	0	HR
33	P14	*S. tuberosum* + *S. pinnatisectum*	3.00	3.50	3.25	HR
34	Crd6	*S. tuberosum* + *S. cardiophyllum*	0.00	0	0	HR
35	Crd10	*S. tuberosum* + *S. cardiophyllum*	0	0	0	HR
36	Crd16	*S. tuberosum* + *S. cardiophyllum*	2.0	5.00	3.5	HR
37	Crd23	*S. tuberosum* + *S. cardiophyllum*	10.34	18.50	14.42	HR
38	Kufri Jyoti (control, S)	*S. tuberosum*	186.34	208.75	197.545	S
39	Kufri Girdhari (control, HR)	*S. tuberosum*	0.00	0	0	HR
40	Kufri Bahar (control, highly susceptible)	*S. tuberosum*	256.67	288.00	272.335	S
CD ($p < 0.05$)			16.80	24.53	20.66	

Category of late blight resistance was based on the AUDPC value: HR: < 50; R: 50–100; MR: 100–150; and S: > 150; HR=highly resistant, R=resistant, MR=moderately resistant, and S=susceptible

Table 2: DUS characterization of wild potato species

DUS Char #	*ACL38*	*BER57*	*CPH62*	*CPH33*	*CHC60*	*IOP80*	*IOP59*	*JAM 07*
1	Red-purple	Purple	Purple	Purple	Purple	Purple	Purple	Red purple
2	Cylindircal	Spherical	Spherical	Spherical	Spherical	Cylindrical	Cylindrical	Conical
3	Light	Light	Dark	Dark	Light	Dark	Dark	Light
4	Light	Light	Medium	Medium	Light	Dark	Dark	Medium
5	Weak	Weak	Weak	Weak	Weak	Weak	Weak	Weak
6	Small	Small	Small	Small	Small	Small	Small	small
7	Compact	Semi-compact	Semi-compact	Open	Compact	Open	Open	Semi-compact
8	Hollow	Solid	Solid	Solid	Solid	Hollow	Solid	Hollow
9	Round	Angular	Angular	Angular	Round	Angular	Angular	Angular
10	Short	Short	Tall	Short	Medium	Short	Medium	Short
11	Green	Green	Green	Green	Green	Green	Dark purple	Green
12	Purple	Red brown	Green	Purple	Purple	Green	Green	Red brown
13	Through out lightly scattered	Through out lightly scattered	Through out highly scattered	Through out highly scattered	Through out highly scattered	Through out highly scattered	Through out highly scattered	Through out highly scattered
14	Poorly developed	Poorly developed	Poorly developed	Highly developed	Highly developed	Highly developed	Poorly developed	Poorly developed
15	Straight	Straight	Straight	Wavy	Straight	Wavy	Straight	Straight
16	Intermediate	Intermediate	Intermediate	Open	Intermediate	Open	Intermediate	Open
17	Absent	Present	Present	Absent	Absent	Absent	Present	present
18	Present throughout	Present throughout	Present throughout	Absent	Absent	Absent	Present throughout	Present only at base
19	Small	Small	Small	Small	Medium	Small	Small	Small
20	Medium	Narrow	Narrow	Narrow	Medium	Narrow	Narrow	Narrow
21	Ovate lanceolate	Ovate lanceolate	Ovate lanceolate	Ovate	Ovate	Narrow lanceolate	Ovate lanceolate	Narrow lanceolate
22	Weak	Strong	Weak	Weak	Weak	Weak	Medium	Weak
23	Weak	Medium	Weak	Weak	Weak	Weak	Medium	Weak
24	Present	Present	Present	Present	Present	Present	Present	Present
25	Present	Absent	Present	Present	Present	Present	Present	Absent
26	Present	Absent	Present	Present	Present	Present	Present	Present
27	Present	Absent	Present	Present	Present	Present	Present	Present
28	Above the middle	Above the middle	Above the middle	Above the middle	Below the middle	Below the middle	Below the middle	Above the middle
29	White	White	Blue-violet	Blue violet	White	White	White with blue tinch	White
30	Small	Small	Small	Small	Small	Small	Small	Small
31	Small	Large	Medium	Medium	Small	Medium	Medium	Medium
32	Absent	Absent	Present	Present	Absent	Present	Present	Absent
33	Absent	Absent	Medium	Medium	Absent	Medium	Medium	Absent
34	Yellow	Yellow	Yellow	Orange	Yellow	Yellow	Yellow	Yellow
35	Normal	Normal	Normal	Irregular	Normal	Normal	Normal	Normal
36	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
37	Longer	Longer	Longer	Longer	Longer	Longer	Longer	Longer
38	Round	Round	Lobed	Lobed	Round	Round	Round	lobed
39	Bi-lobed	Bi-lobed	Bi-lobed	Bi-lobed	Bi-lobed	Uni-lobed	Uni-lobed	Bi-lobed
40	Present	Absent	Absent	Absent	Present	Present	Present	Absent
41	Medium	Medium	High	High	Medium	Medium	Medium	Medium
42	Medium	Late	Late	Late	Late	Late	Late	late
43	Brown	Brown	White cream	White cream	Brown	White cream	White cream	Brown
44	Absent	Brown	Absent	Absent	Absent	Purple	Reddish purple	Absent
45	Absent	Splashed	Absent	Absent	Absent	Splashed	Splashed	Absent
46	Rough	Rough	Smooth	Smooth	Rough	Smooth	Smooth	Rough
47	Round	Oblong	Round	Round	Round	Irregular	Irregular	Oblong
48	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow
49	Cream	Yellow	Cream	Cream	Cream	Cream	Cream	White
50	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
51	Absent	Absent	Outer cortex	Absent	Absent	Absent	Absent	Absent

LES29	*MCD 24*	*PNT 44*	*PNT 43*	*PIN45*	*PLD 47*	*PLD 48*	*PLT 50*	*STO 40*	*TRF 65*	*VEN30*
Red purple	Red purple	Purple	Purple	green	Purple	Green	Green	Green	Red-purple	Purple
Cylindrical	Cylindrical	Spherical	Spherical	Cylindrical	Conical	Cylindrical	Cylindrical	Cylindrical	Conical	Cylindrical
Dark	Dark	Light	Dark	Light	Medium	Light	Light	Light	Medium	Medium
Medium	Medium	Light	Medium	Light	Light	Light	Light	Light	Light	Light
Weak	Weak	Weak	Weak	Weak	Weak	Weak	Strong	Strong	Weak	Weak
Small	Small	Large	Small	Small	Medium	Large	Large	Large	Small	Small
Semi-compact	Compact	Open	Open	Open	Open	Open	Open	Open	Open	Open
Solid	Hollow	Hollow	Hollow	Hollow	Hollow	Hollow	Solid	Hollow	Solid	Solid
Angular	Angular	Angular	Round	Round	Angular	Round	Round	Round	Angular	Round
Short	Short	Tall	Short	Tall	Small	Medium	Short	Short	Short	Tall
Dark purple	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Green	Red brown	Purple	Red-brown	purple	Red –brown	Absent	Purple	Dark purple	Purple	Purple
Only at basal node	Through out highly scattered	Through out lightly scattered	Through out lightly scattered	Through out lightly scattered	Through out lightly scattered	Absent	Through out lightly scattered	Through out highly scattered	Absent	Through out highly scattered
Poorly developed	Highly developed	Poorly developed	Poorly developed	Poorly developed	Poorly developed	Highly developed	Highly developed	Poorly developed	Poorly developed	Poorly developed
Straight	Wavy	Straight	Wavy	Straight	Straight	Wavy	Wavy	Straight	Straight	Straight
Intermediate	Intermediate	Open	Open	Open	Open	Open	Open	Open	Open	Open
Present	Absent	Absent	Absent	Absent	Present	Absent	Absent	Absent	Absent	Absent
Present throughout	Absent	Absent	Absent	absent	present	Absent	Absent	Absent	Absent	Present only at base
Medium	Small	Small	Small	Small	large	Medium	Small	Small	Small	Medium
Medium	Narrow	Narrow	Narrow	Narrow	medium	Narrow	Narrow	Narrow	Narrow	Narrow
Ovate Lanceolate	Oval	Narrow lanceolate	Lanceolate	Narrow lanceolate	Ovate lanceolate	Ovate	Lanceolate	Ovate lanceolate	Lanceolate	Lanceolate
Weak	Weak	Weak	Weak	Weak	weak	Weak	Weak	Weak	Weak	Medium
Weak	Weak	Weak	Weak	Weak	Medium	Weak	Weak	Weak	Weak	Weak
Present	Absent	Present	Present	Present	Present	Present	Present	Present	Present	Present
Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Present
Present	Absent	Absent	Absent	Absent	Absent	absent	White green	Absent	Absent	Present
Present	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Present
Above the middle	Above the middle	At the middle	At the middle	At the middle	Above the middle	Above the middle	At the middle	Above the middle	At the middle	Below the middle
Blue-violet	White	White	White	White	White	White	White	White	White	White
Small	Small	Small	Small	Small	Small	Small	Small	Small	Small	Small
Small	Small	Medium	Medium	Medium	Small	Small	Medium	Medium	Medium	Medium
Present	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Strong	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Yellow	Yellow	Yellow	Yellow	orange	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Normal	Normal	Normal	Normal	Normal	normal	Normal	Irregular	Normal	Normal	Normal
Normal	Normal	Normal	Normal	Normal	Normal	Normal	Irregular	Normal	Normal	Normal
Longer	Longer	Longer	Longer	Longer	Longer	Longer	Longer	Longer	Longer	Longer
Lobed	Round	Round	Round	Round	Round	Round	Round	Round	Lobed	Round
Bi-lobed	Bi-lobed	Bi-lobed	Bi-lobed	Uni-lobed	Bi-lobed	Bi-lobed	Bi-lobed	Bi-lobed	Bi-lobed	Bi-lobed
Present	Present	Absent	Absent	Present	Absent	Absent	Absent	Absent	Present	Present
Low	Low	Low	Low	Medium	Low	Low	Low	Low	Low	Medium
Late	Late	Late	Late	Late	Late	Late	Late	Late	Late	Late
White cream	White cream	Purple	White	Brown	Yellow	Yellow	White cream	White cream	Brown	Brown
Absent	Absent	Absent	Absent	Absent	Absent	Absent	Purple	Purple	Absent	Absent
Absent	Absent	Strippled	Absent	Absent	Absent	Absent	Around eyes	Strippled	Absent	Absent
Smooth	Smooth	Rough	Rough	Rough	Rough	Smooth	Rough	Rough	Rough	Rough
Round	Ovoid	Round	Round	Round	Ovoid	Round	Round	Flattened	Ovoid	Round
Shallow	Shallow	Medium deep	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow
White	White	White	White	Cream	Yellow	Yellow	Yellow	White	White	Cream
Absent	Absent	Red purple	Absent	Cream	Absent	Green	Red purple	Red purple	Absent	Absent
Absent	Absent	Outer cortex	Absent	Absent	Absent	Outer cortex	Outer cortex	Outer cortex	Absent	Absent

Table 3: DUS characterization of interspecific somatic hybrids and common varieties of potato

DUS Char #	*P1*	*P2*	*P3*	*P4*	*P5*	*P6*	*P7*	*P8*	*P9*	*P10*
1	White-Green	Red-purple	White-Green	White-Green	Red-purple	White-Green	Red-purple	Purple	Green	Purple
2	Cylindrical	Cylindrical	Cylindrical	Cylindrical	Cylindrical	Cylindrical	Cylindrical	Cylindrical	Cylindrical	Cylindrical
3	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Light	Medium
4	Light	Light	Light	Light	Light	Medium	Medium	Light	Light	Light
5	Weak	Weak	Strong	Weak	Weak	Weak	Weak	Strong	Weak	Weak
6	Long	Long	Long	Long	Long	Small	Small	Long	Large	Small
7	Open	Open	open	Open	Open	Semi-compact	Semi-compact	Open	Open	Open
8	solid	Hollow	Hollow	Solid	Hollow	Solid	Hollow	Hollow	Hollow	Hollow
9	Round	Round	Round	Round	Round	Angular	Round	Round	Angular	Angular
10	Tall	Tall	Tall	Tall	Tall	Tall	Tall	Tall	Tall	Tall
11	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
12	Purple	Purple	purple	Purple	Purple	Purple	Purple	Dark purple	Purple	Purple
13	Through out lightly scattered	Only at basal node	Only at basal node	Only at basal node	Through out lightly scattered	Only at basal node	Only at basal node	Through out lightly scattered	Through out lightly scattered	Only at basal node
14	Poorly developed	Highly developed	Poorly developed	Highly developed	Highly developed	Highly developed	Poorly developed	Highly developed	Highly developed	Highly developed
15	Straight	Wavy	Straight	Wavy	Wavy	Wavy	Straight	Wavy	Wavy	Wavy
16	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open
17	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
18	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
19	Medium	Small	Medium	Small	Medium	Small	Small	Medium	Medium	Small
20	Medium	Narrow	Narrow	Narrow	Narrow	Narrow	Narrow	Medium	Medium	Narrow
21	Lanceolate	Lanceolate	Ovate lanceolate	Ovate lanceolate	Ovate lanceolate	Ovate lanceolate	Ovate lanceolate	Ovate lanceolate	Ovate lanceolate	Ovate lanceolate
22	Weak	Weak	Weak	Medium	Weak	Weak	Medium	Weak	Weak	Weak
23	Weak	Weak	Weak	Medium	Weak	Medium	Weak	Weak	Weak	Weak
24	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present
25	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
26	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
27	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
28	At the middle	At the middle	At the middle	Above the middle	Above the middle	At the middle	Above the middle	At the middle	At the middle	Above the middle
29	White	White	White	White	White	White	White	White	White	White
30	Medium	Medium	Large	Medium	Medium	Large	Medium	Medium	Small	Small
31	Medium	Large	Medium	Medium	Medium	Medium	Medium	Large	Medium	Medium
32	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
33	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
34	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange
35	Normal	Normal	irregular	Normal	irregular	Normal	Normal	Irregular	Normal	Normal
36	Normal	Normal	Normal	Normal	Irregular	Normal	Normal	Normal	Normal	Normal
37	Longer	Longer	Longer	Longer	Longer	Longer	Longer	Longer	Longer	Longer
38	Round	Round	Round	Lobed	Round	Round	Round	Round	Round	Lobed
39	Bi-lobed	Bi-lobed	Bi-lobed	Uni-lobed	Uni-lobed	Bi-lobed	Bi-lobed	Uni-lobed	Uni-lobed	Uni-lobed
40	Present	Present	Present	Present	Present	Present	Present	Present	Medium	Medium
41	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Present	Present
42	Late	Late	Late	Late	Late	Late	Late	Late	Late	Late
43	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	White	White
44	Absent	Absent	Absent	Absent	Purple	Absent	Absent	Absent	Absent	Absent
45	Splashed	Absent	Splashed	Splashed	Splashed	Splashed	Splashed	Splashed	Absent	Absent
46	Rough	Rough	Rough	Rough	Rough	Rough	Rough	Rough	Smooth	Smooth
47	Round	Round	Round	Round	Round	Round	Round	Round	Round	Round
48	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Medium	Shallow
49	White	White	White	White	Cream	White	White	White	White	White
50	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
51	Absent	Absent	absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent

Note: DUS Characters # as given in Table 2

P11	*P12*	*P13*	*P14*	*Card 6*	*Card 10*	*Card 16*	*Card 23*	*Kufri Jyoti*	*Kufri Girdhari*	*Kufri Bahar*
Purple	Purple	Purple	Purple	Purple	Purple	purple	Purple	Red-purple	Red-Purple	Purple
Cylindrical	Cylindrical	Cylindrical	Cylindrical	Spherical	Spherical	Spherical	Spherical	Spherical	Conical	Spherical
Light	Light	Medium	light	Dark	Dark	Dark	Dark	Dark	Medium	Dark
Medium	Medium	Light	Light	Medium	Medium	medium	Medium	Light	Medium	Light
Weak	Weak	Weak	Weak	Weak	Weak	weak	Weak	Weak	Weak	Weak
Small	Small	Small	small	Small	Small	small	Small	Small	Medium	Small
Open	Open	Open	Open	Open	Open	Open	Open	Semi-compact	Open	Open
Hollow	Solid	Hollow	Hollow	Solid	Hollow	Hollow	Hollow	Solid	Hollow	Solid
Round	Round	Angular	Round	Angular	Round	Round	Angular	Round	Angular	Angular
Tall	Tall	Tall	Tall	Medium	Short	Short	Short	Medium	Medium	Short
Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Dark purple	Purple	Dark purple	Absent	Purple	Red brown	Red brown	Purple	Purple	Absent	Absent
Only at basal node	Only at basal node	Through out highly scattered	Absent	Through out lightly scattered	Through out lightly scattered	Through out highly scattered	Through out lightly scattered	Through out lightly scattered	Absent	Absent
Highly developed	Highly developed	Highly developed	Highly developed	Highly developed	Highly developed	Highly developed	Poorly developed	Highly developed	Highly developed	Highly developed
Wavy	Wavy	Wavy	Wavy	Wavy	Wavy	wavy	Straight	Wavy	Wavy	Wavy
Open	Open	Open	Open	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate
Absent	Absent	Absent	Absent	Absent	Absent	absent	Absent	Absent	Absent	Absent
Absent	Absent	absent	Absent	Absent	Absent	absent	Absent	Absent	Absent	Absent
Medium	Small	Small	Small	Small	Small	small	Small	Small	Small	Medium
Narrow	Narrow	Narrow	Narrow	Narrow	Narrow	narrow	Narrow	Narrow	Narrow	Narrow
Ovate lanceolate	Ovate lanceolate	Narrow lanceolate	Narrow lanceolate	Oval	Oval	ovate	Oval	Ovate	Ovate lanceolate	Oval
Weak	Weak	Weak	Weak	Weak	Weak	Weak	Weak	Weak	Weak	Weak
Weak	Medium	Weak	Weak	Weak	Weak	Weak	Weak	Weak	Weak	Weak
Present	Present	present	present	Present	Present	present	Present	Present	Present	Present
Absent	Absent	Absent	Absent	Present	Present	present	Present	Absent	Absent	Absent
Absent	Absent	Absent	Absent	Absent	Present	Absent	Absent	Absent	Absent	Absent
Absent	Absent	absent	absent	Present	Present	present	Present	Absent	Absent	Present
Below the middle	Above the middle	below the middle	Above the middle	Above the middle	Above the middle	Above the middle	Above the middle	Above the middle	At the middle	At the middle
White	White	White	White	Blue violet	Blue violet	Blue violet	Blue violet	White	White	White
Small	Small	Small	Small	Small	Small	Small	Small	Medium	Medium	Small
Medium	Small	Medium	small	Small	Small	Small	Small	Medium	Medium	Small
Absent	Absent	Absent	Absent	Present	Present	Present	Present	Absent	Absent	Absent
Absent	Absent	Absent	Absent	Strong	Strong	Strong	Strong	Absent	Absent	Absent
Orange	Yellow	Yellow	Orange	Orange	Orange	orange	Orange	Yellow	Yellow	Yellow
Irregular	Normal	Normal	irregular	Normal	Normal	Normal	Normal	Normal	Normal	Irregular
Normal	Normal	Normal	Normal	Irregular	Irregular	irregular	Irregular	Normal	Normal	Normal
Longer	Longer	Longer	Longer	Longer	Longer	Longer	Longer	Longer	Equal	Longer
Round	Round	Lobed	Round	Lobed	Lobed	Lobed	Lobed	Lobed	Round	Round
Bi-lobed	Uni-lobed	Bi-lobed	Uni-lobed	Bi-lobed	Bi-lobed	Bi-lobed	Bi-lobed	Bi-lobed	Bi-lobed	Bi-lobed
Medium	Medium	Medium	Medium	High	High	High	High	High	High	High
Present	Present	Present	Present	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Late	Late	Late	Late	Late	Late	Late	Late	Medium	Late	Medium
White	White	White	White	White cream	White cream	White cream	White cream	White	White	Yellow
Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth
Pear	Round	Round	Round	Round	Round	Round	Round	Round	Oblong	Round
Shallow	Medium	Medium	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow
White	White	White	White	Cream	Cream	Cream	Cream	White	Cream	Yellow
Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Green
Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Outer cortex

Footnote for Tables 2 and 3: DUS Characters #: 1. Light sprout: Predominant colour, 2. Light sprout: Shape, 3. Light sprout: Intensity of anthocyanin colouration at the base of sprout, 4. Light sprout: Intensity of anthocyanin colouration at sprout tip, 5. Light sprout: Pubescence, 6. Light sprout: Length of apical sprout, 7. Plant: Foliage structure, 8. Stem: Solidity, 9. Stem: Cross section, 10. Plant: Height of main stem, 11. Stem: Predominant colouration, 12. Stem: Secondary colouration, 13. Stem: Distribution of secondary colour, 14. Plant : Wings, 15. Plant : Wings type, 16. Leaf : Structure, 17. Leaf :Anthocyanin colouration of rachis, 18. Leaf: Anthocyanin colouration of mid rib, 19. Leaf: Length, 20. Leaf: Width, 21. Leaf: Leaflet shape, 22. Leaflet: Waviness of margin, 23. Leaflet: Glossiness of upper side, 24. Leaflet: Pubescence of blade at apical rosette, 25. Flower: Anthocyanin colouration of bud, 26. Flower: Anthocyanin colouration of floral stalk, 27. Flower: Anthocyanin colouration of pedicle articulation, 28. Flower: Pedicle articulation position, 29. Flower: Corolla colour, 30. Flower: Corolla size, 31. Inflorescence : Size, 32. Flower: Anthocyanin colouration of outer side in white flower, 33. Flower: Intensity of anthocyanin colouration of corolla on inner side, 34. Flower: Anther colour, 35. Flower: Anther cone, 36. Flower: Pistil type, 37. Flower: Stylar length (in comparison to stamen column), 38. Flower: Stigma shape, 39. Flower: Stigma lobe, 40. Flower: Premature bud dropping, 41. Flower: Intensity of flowering, 42. Plant: Time of maturity, 43. Tuber: Predominant skin colour, 44. Tuber: Secondary skin colour, 45. Tuber: Distribution of secondary skin colour, 46. Tuber: Skin type, 47. Tuber: Shape, 48. Tuber: Depth of eyes, 49. Tuber: Predominant colour of flesh, 50. Tuber: Secondary colour of flesh, 51. Tuber: Distribution of secondary colour

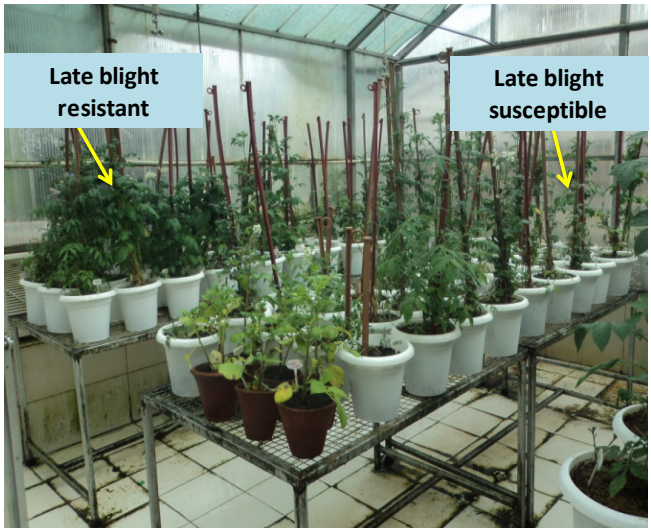

Figure 1: Late blight resistance test of potato genotypes under artificial conditions

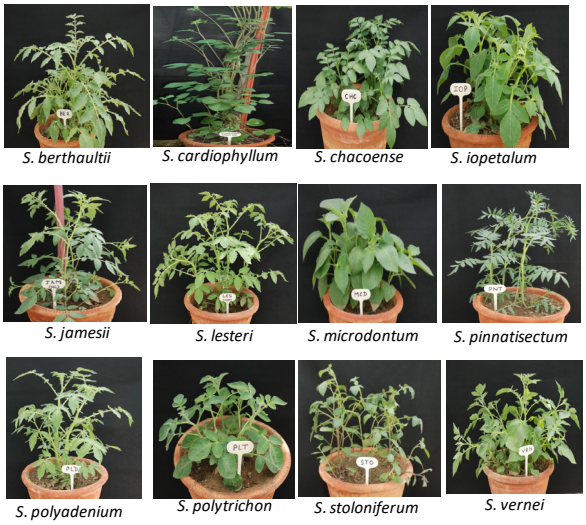

Figure 2: Identification of some late blight resistant wild potato species by artificial screening method and DUS characterization.

DUS characteristics were recorded for two seasons and variations were observed in the genotypes. DUS characters were: Light sprout (Predominant colour, shape, intensity of anthocyanin coloration at the base of sprout, intensity of anthocyanin colouration at sprout tip, Pubescence, Length of apical sprout), Plant (Foliage structure), Stem (Solidity, Cross section), Plant (Height of main stem, Predominant colouration, Secondary colouration, Distribution of secondary color, Wings, Wings type), Leaf (Structure, Anthocyanin colouration of rachis, Anthocyanin colouration of mid rib, Length, Width, Leaflet shape), Leaflet (Waviness of margin, Glossiness of upper side, Pubescence of blade at apical rosette), Flower (Anthocyanin colouration of bud, Anthocyanin colouration of floral stalk, Anthocyanin colouration of pedicle articulation, Pedicle articulation position, Corolla colour, Corolla size, Inflorescence Size, Anthocyanin colouration of outer side in white flower, intensity of anthocyanin colouration of corolla on inner side, anther colour, anther cone, pistil type, stylar length (in comparison to stamen column), Stigma shape, (Stigma lobe, Premature bud dropping, intensity of flowering), Plant (Time of maturity), and Tuber (Predominant skin color, Secondary skin color, Distribution of secondary skin color, Skin type, Shape, Depth of eyes, Predominant colour of flesh, Secondary color of flesh, and Distribution of secondary color). The findings of the study will strengthen the efficient utilization of potato wild species and somatic hybrids in late blight resistance breeding.

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सारांश

आलू के 40 किस्मों (जंगली सोलेनम प्रजातियों एवं अन्तरप्रजाति संकरों) का पिछेती झुलसा रोग के प्रति प्रतिरोधिता और विशिष्टता, एकरूपता और स्थिरता (डी.यूएस.) विवरणकों के लिए अध्ययन किया गया जिसमें 32 किस्में (14 जंगली किस्में एवं 18 अन्तरप्रजाति संकरों) में पिछेती झुलसा रोग के प्रति उच्च प्रतिरोधी पाया गया जबकि 4 प्रतिरोधी थे और 1 मध्यम प्रतिरोधी पाया गया। नियंत्रक किस्मों में कुफरी ज्योति (अति संवेदनशील), कुफरी बहार (अत्यधिक संवेदनशील) और कुफरी गिरधारी (उच्च प्रतिरोधी) पाया गया। सभी जंगली किस्में पिछेती झुलसा रोग के प्रति उच्च प्रतिरोधी पायी गयी। इसके अलावा, सभी 40 किस्मों का 51 डी.यू.एस. डिस्क्रिप्टर का भी अध्ययन किया गया जिनमें बाह्य दृश्य प्रारूप (फेनोटाइपिक) विविधता स्पष्ट हुई। इस प्रकार, झुलसा प्रतिरोधी आलू की जंगली किस्मों और अन्तरप्रजाति संकरों की पहचान की गयी जो पिछेती झुलसा रोग के प्रति प्रतिरोधी थी जिन्हें प्रजनन के लिए एक सम्भावित स्रोत के रूप में उपयोग किया जा सकता है।