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Screening of onion (*Allium cepa* L.) three-way hybrids and their parents for foliage characteristics

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Abstract
Foliage study has been considered as an important trait for the onion with respect to predilection of insect-pests. Leaves colour (Green to dark green) and character (Glossy to waxy) has been highly correlated to nourishing of pest like thrips. Onion thrips prefer dark green to light green foliage with wax coating then the glossy to semi glossy leaves having green and light green colour. The screening of hybrids developed through three-way cross and their parents for favourable leaves appearances and dislike by onion pest, would be helpful for identifying the best genotype(s) and minimize the infestation. Forty-four genotypes were evaluated at research experimental plot of Indian Institute of Horticultural Research, Bengaluru (India). They were categorized based on foliage colour scale and waxiness scale. Twenty-six genotypes were grouped under glossy to semi glossy appearance and eighteen were included as waxy. There were 9, 19 and 16 genotypes were observed for green, light green and dark green, respectively, foliage expression. The crosses L1 x T4, L1 x T5, L2 x T4 and L2 x T5 were possessed light green leaves and semi-glossy foliage's and least preferred by the thrips for feeding leaves. The results were indicated that semi-glossy phenotype may protect foliage from this pest. Therefore, these crosses could be grown for healthy vegetative growth and conceivably high bulb size and yield of onion.

Keywords: onion, screening three-way, glossy, waxy, thrips

Introduction
Onion (*Allium cepa* L.) is a biennial crop (annual for vegetative foliage and bulb production) and commercially grown by seeds through transplanting. Some of the areas, it also grown by direct seeds sowing. It is highly consumed as vegetable and spice in cooking by most of the countries; hence it is popularly known as queen of the kitchen (Germany). The origin of onion is believed to native of Central Asia and characterized under the family Alliaceae. It is broadly used for treating the health problems like body pains, cataract, arthritis and heart disease. Onion has important place in export market other than its culinary and medicinal properties. The production of bulbs, seeds and fresh green leaves (scallion) is affected by abiotic stresses and biotic stresses (purple blotch, *Stemphylium* blight, thrips, *etc.*).
Onion thrips, *Thrips tabaci* Lind. Belongs to family Thripidae and order Thysanoptera was considered a devastating pest of *Allium* spp., which is observed almost in all over the onion growing countries. Habitually, this is polyphagous pest, which has more multiplicative ability either sexually or parthenogenesis in a short period with high endurance. Both the adults and larvae of this pests causes profuse losses either directly or indirectly. The yield and quality of onion bulbs and seeds were found to be decreases significantly due to heavily consumption of its foliage by thrips [8, 12, 13, 16, 25].
Foliage colour and waxiness character directly associated with suckling preference of thrips [11, 17]. Many researchers reported that the occurrences of wax on the leaf surface is a desirable feature as it protects from the abiotic stress like air drying of leaves [3, 18], excess water intake [1] and reflecting disturbance of ultraviolet and photosynthetic wavebands [15]. Attraction or repulsion of insect-pests is correlated with wax deposition and its quality on the leaves surface [10]. In *Allium*, wax deposition and it contains observed on leaves surface directly impacts on thrips numbers [4, 7, 27].
The hybrids developed through three-way approach were performed better for many characters such as yield, quality, resistance/tolerant to biotic and abiotic stresses in tomato, chilli,

sorghum, maize etc. Developing the cultivars or hybrids with semi glossy and light green foliage's to protect from this insect-pests require breeding of long duration and more focus. Therefore, the consideration of all the difficulties and perquisitions, the present advance approach with purposes of three-way hybrids and their parent's evaluation for the foliage characteristics was undertaken to identify the cultivar and/or hybrids with less preferences by the thrips infestation.

Materials and Methods

The hybrids developed from parents and genotypes collected from different sources were finally screened for foliage colour and foliage character and also for thrips infestation level. Forty-four genotypes including 30 hybrids crossed in three-way pattern, three F_1 hybrids (used as female parent for crossing), ten male parents and one check are mentioned in Table 1. All the research work has been carried out at experimental plot of the Division of Vegetable Crops, Indian Institute of Horticultural Research, Hessaraghatta, Bengaluru, India. The sufficient bulbs were grown in previous season to obtain enough quantity and high-quality seeds. The seeds of all the accessions were sown and transplanted in the cropping season of the year 2018.

Table 1: Name of the parental lines and three- way cross hybrids used in present experiment

Sl. No.	Genotype names	Denoted names	Sl. No.	Genotype names	Denoted names
1	Arka Kirthiman (F_1)	L1	23	Arka Kirthiman x N-2-4-1	L1 x T10
2	Arka Lalima (F_1)	L2	24	Arka Lalima x Arka Bindu	L2 x T1
3	Super Flare (F_1)	L3	25	Arka Lalima x Arka Pitambar	L2 x T2
4	Arka Bindu	T1	26	Arka Lalima x Arka Pragathi	L2 x T3
5	Arka Pitambar	T2	27	Arka Lalima x Arka Niketan	L2 x T4
6	Arka Pragathi	T3	28	Arka Lalima x Arka Kalyan	L2 x T5
7	Arka Niketan	T4	29	Arka Lalima x P-178	L2 x T6
8	Arka Kalyan	T5	30	Arka Lalima x Bhima Red	L2 x T7
9	P-178	T6	31	Arka Lalima x Bhima Raj	L2 x T8
10	Bhima Red	T7	32	Arka Lalima x Bhima Super	L2 x T9
11	Bhima Raj	T8	33	Arka Lalima x N-2-4-1	L2 x T10
12	Bhima Super	T9	34	Super Flare x Arka Bindu	L3 x T1
13	N-2-4-1	T10	35	Super Flare x Arka Pitambar	L3 x T2
14	Arka Kirthiman x Arka Bindu	L1 x T1	36	Super Flare x Arka Pragathi	L3 x T3
15	Arka Kirthiman x Arka Pitambar	L1 x T2	37	Super Flare x Arka Niketan	L3 x T4
16	Arka Kirthiman x Arka Pragathi	L1 x T3	38	Super Flare x Arka Kalyan	L3 x T5
17	Arka Kirthiman x Arka Niketan	L1 x T4	39	Super Flare x P-178	L3 x T6
18	Arka Kirthiman x Arka Kalyan	L1 x T5	40	Super Flare x Bhima Red	L3 x T7
19	Arka Kirthiman x P-178	L1 x T6	41	Super Flare x Bhima Raj	L3 x T8
20	Arka Kirthiman x Bhima Red	L1 x T7	42	Super Flare x Bhima Super	L3 x T9
21	Arka Kirthiman x Bhima Raj	L1 x T8	43	Super Flare x N-2-4-1	L3 x T10
22	Arka Kirthiman x Bhima Super	L1 x T9	44	Satara Garva	Check

The design of experimental plot was complete randomized block design (CRBD) with three replications having individual plot size of 2 x 1.8m and spacing of 10 x 15cm. The standard package of practice including recommended dose of fertilizer and intercultural operations were followed during cropping period. The chemicals for plant protective measures or insecticides have not been applied with respect to screening of all the genotypes for foliage study and also thrips infestation level.

The scale of leaf colour and leaf waxiness for onion (*Allium cepa* L.) was standardized in the year 2018 by Dr. Veere Gowda R. and Mr. Ajay Kumar Pandav at Division of Vegetable Crops, IIHR, Hessarghatta, Bengaluru (India). The details of standardised scale are mentioned in the Table 2 and visual symptoms of the foliage's characters given in Figure 1. The visual symptoms of plant leaves at experimental plot were followed for screening of onion three-way hybrids and their parents for foliage characteristics and for thrips infestation level (*Thrips tabaci* Lindeman) also. Infestation level of thrips were recorded and plants scored after thirty days from transplanting because at that period, all the plant were enough matured with proper growth of foliage's. The infestation was categorised in five different level *viz.*, very low, low, medium, high and very high.

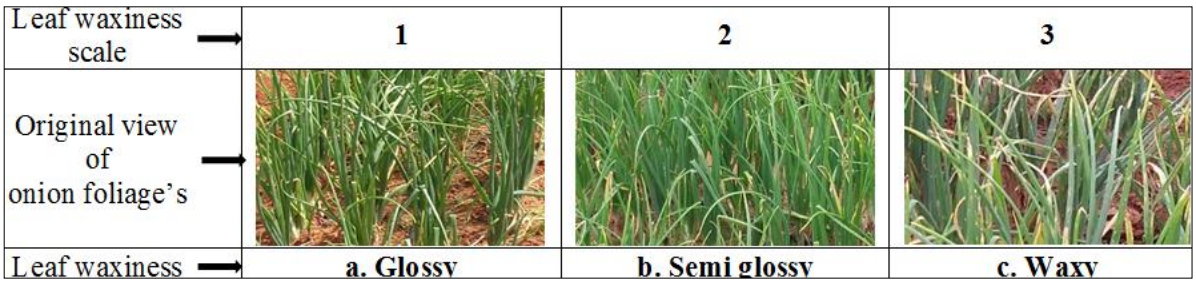

Fig 1: Leaf waxiness for onion (*Allium cepa* L.) a. Glossy, b. Semi glossy and c. Waxy (The pictures of onion foliage's were taken in the year 2018 from experimental field of Vegetable Crops, IIHR, Hessarghatta, Bengaluru (India).

Table 2: Scale for leaf colour and leaf waxiness of onion (*Allium cepa* L.)

Leaf colour scale	Leaf colour	Leaf waxiness scale	Leaf waxiness
1	Light green	1	Glossy
2	Green	2	Semi glossy
3	Dark green	3	Waxy

The recorded data were averaged out from five leaves samples per plant and the subjected for the further analysis. It was statistically analysed by single factor analysis of OPSTAT, an online software developed at CCS HAU, Hisar, India. However, the results were majorly concluded based on colour scale and waxiness scale because the foliage colour and character directly associated with the thrips population.

Results and Discussion

The data of current research are depicted in the Table 3 and revealed that the nine genotypes namely L1, L2, T1, T3, T4, T5, L1 x T3, L2 x T3 and L3 x T3 expressed green foliage's. Sixteen and nineteen genotypes were observed for dark green and light green leaves, respectively. Likewise, eight genotypes (L1, L2, T4, T5, L1 x T4, L1 x T5, L2 x T4 and L2 x T5) were found to be semi glossy foliage's and eighteen genotypes individually observed for glossy and waxy foliage's characteristics. These results recorded for individual traits were not directly governed the thrips population. Therefore, the foliage colour and waxiness were accompanied with thrips infestation level.

The genotypes having dark green and waxy foliage's were highly preferred by the thrips and infestation found at very high level. These types were found in the parents T2, T6 and T7, and TWC hybrids L1 x T6, L1 x T7, L2 x T6, L2 x T7, L3 x T6, L3 x T7 and L3 x T10. The higher amount of wax associated with dark to blue foliage's and more infestation of thrips [9]. Subsequently, the leaves possess light green and wax accumulation on its surface were also favoured by thrips for feeding and shown symptoms of high level of invasion. These infestations were exhibited by the eight genotypes *i.e.* L3, T10, L1 x T2, L1 x T10, L2 x T2, L2 x T10, L3 x T2 and check among forty-four accessions.

The genotypes having more deposition of epicuticular waxes were more supported to thrips for sticking on leaf surfaces and aggravate to damage by suck the sap. Some of the similar findings were shown that thrips also favour blue to green foliage's [6, 14, 19, 20].

Table 3: Screening of onion (*Allium cepa* L.) three-way hybrids and their parents for foliage characteristics and visual symptoms of plant infested by onion thrips (*Thrips tabaci* Lindeman)

Sl. No.	Crosses	Foliage colour rating	Foliage colour	Foliage character rating	Foliage character (Waxy/glossy)	Infestation level of thrips (30 DAT)
1.	L1	2.0	G	2.0	SG'	L
2.	L2	2.0	G	2.0	SG'	L
3.	L3	1.0	LG	3.0	W	H
4.	T1	2.0	G	1.0	G'	M
5.	T2	3.0	DG	3.0	W	VH
6.	T3	2.0	G	1.0	G'	M
7.	T4	2.0	G	2.0	SG'	L
8.	T5	2.0	G	2.0	SG'	L
9.	T6	3.0	DG	3.0	W	VH
10.	T7	3.0	DG	3.0	W	VH
11.	T8	3.0	DG	1.0	G'	M
12.	T9	1.0	LG	1.0	G'	L
13.	T10	1.0	LG	3.0	W	H
14.	L1 x T1	1.0	LG	1.0	G'	L
15.	L1 x T2	1.0	LG	3.0	W	H
16.	L1 x T3	2.0	G	1.0	G'	M
17.	L1 x T4	1.0	LG	2.0	SG'	VL
18.	L1 x T5	1.0	LG	2.0	SG'	VL
19.	L1 x T6	3.0	DG	3.0	W	VH
20.	L1 x T7	3.0	DG	3.0	W	VH
21.	L1 x T8	1.0	LG	1.0	G'	L
22.	L1 x T9	1.0	LG	1.0	G'	L
23.	L1 x T10	1.0	LG	3.0	W	H
24.	L2 x T1	1.0	LG	1.0	G'	L
25.	L2 x T2	1.0	LG	3.0	W	H
26.	L2 x T3	2.0	G	1.0	G'	M
27.	L2 x T4	1.0	LG	2.0	SG'	VL
28.	L2 x T5	1.0	LG	2.0	SG'	VL
29.	L2 x T6	3.0	DG	3.0	W	VH
30.	L2 x T7	3.0	DG	3.0	W	VH
31.	L2 x T8	1.0	LG	1.0	G'	L
32.	L2 x T9	1.0	LG	1.0	G	L
33.	L2 x 10	1.0	LG	3.0	W	H
34.	L3 x T1	3.0	DG	1.0	G'	M
35.	L3 x T2	1.0	LG	3.0	W	H
36.	L3 x T3	2.0	G	1.0	G'	M
37.	L3 x T4	3.0	DG	1.0	G'	M
38.	L3 x T5	3.0	DG	1.0	G'	M

39.	L3 x T6	3.0	DG	3.0	W	VH
40.	L3 x T7	3.0	DG	3.0	W	VH
41.	L3 x T8	3.0	DG	1.0	G'	M
42.	L3 x T9	3.0	DG	1.0	G'	M
43.	L3 x T10	3.0	DG	3.0	W	VH
44.	Check	1.0	LG	3.0	W	H
C.D. at 5%		0.09		0.09		-

Note: G- Green, LG- Light green, DG- Dark green, G'- Glossy, SG'- Semi-glossy, W- Waxy, VL- Very less or no infestation, L- Less, M- Moderate, H- High, VH- Very high and DAT- Days after transplanting

Out of forty-four, there were eleven genotypes namely T1, T3, T8, L1 x T3, L2 x T3, L3 x T1, L3 x T3, L3 x T4, L3 x T5, L3 x T8 and L3 x T9 were expressed for green foliage's having glossy surface and considered for moderate level of losses. The reason may be less accumulation of wax quantity on leaves surfaces, which causes less damage to the foliage's [2, 7, 16, 23, 26].

The genotypes combinedly expressed green with semi- glossy and light green having glossy foliage's were less chosen for feeding and low level of thrips infestation was observed. These kinds of character's were exhibited by ten genotypes including six three-way hybrids (L1 x T1, L1 x T8, L1 x T9, L2 x T1, L2 x T8 and L2 x T9) and four parental lines (L1, L2, T4 and T5) from the total of forty-four genotypes. These types of phenotypes might be found due to accumulation of less epicuticular waxes on its leaf surfaces [16, 22, 24] and less attraction by thrips.

The combine character of light green with semi glossy foliage's having no harmful effect on the plant growth and observed negligible or very low-level infestation of thrips. The four hybrids developed through three- way cross namely L1 x T4, L1 x T5, L2 x T4 and L2 x T5 were exhibited for these combinations. The light green foliage having less attraction as it has been found less wax [5] and some chemical contents in wax accumulated epicuticular region of the leaves [16, 21, 22].

Conclusion

The best genotypes among forty-four accessions including check were observed in four hybrids developed through three-way cross namely L1 x T4, L1 x T5, L2 x T4 and L2 x T5 for combination of light green with semi glossy foliage's having less damaging effect on the plant growth and thrips infestation level. These could be suggested for further improvement in breeding program or directly used for growing.

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