Parameters for evaluation of defense trade-offs for selection of *Solanum lycopersicum* cultivars in IPM against *Tuta absoluta* Meyrick

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Introduction

(i) Plants develop constitutive and induced defense in their interaction with phytophagous arthropods.

(ii) Tomato leaf miner (*T. absoluta*) is implicated for 80 t0 100% losses in tomato production: invasive and noxious resistant to IRAC insecticides, cryptic feeding nature, high fecundity, multivoltine (Fig. 1).

(iii) In surviving herbivore attack, plants suffer resource reallocation to facilitate prioritization of defense responses compromising growth, reproduction and yield.

(iv) Breeding technology maximises production by balancing the trade-off between growth/development and pest defenses.

(v) Surrogate parameters estimating plant fitness include growth, chlorophyl content (photosynthesis), seed vigour (reproduction), and defense traits: trichomes and cellular components deterring leaf mining.

(vi) Screening *S. lycopersicum* cultivars' fitness for herbivory defense without comprising growth, and development will increase efficacy of IPM strategies and limit application of synthetic pesticides.

Research Aims

(i) Evaluate the association between germination, and growth indices with defense traits in *S. lycopersicum* cultivars.

(ii) Assess potential of *S. lycopersicum* cultivars to deter oviposition, hatchability and leaf mining behaviour of *T. absoluta.*

Pest status and damage

Fig 1. *T. absoluta* damage, invasion status and distribution in Africa

(iii) Assess the interaction of germination, growth, and defense parameters for fitness of *S. lycopersicum* cultivars in IPM of *T. absoluta.*

Materials and methods

1. Standard petri-dish germination test

Fig 2. Germination test for germination percentage, meant germination time (MGT), seedling vigour, time to 50% germination (T_{50}) of 11 commercial *S. lycopersicum* cultivars grown in Kenya.

2. Tomato cultivars' growth parameters

Fig 3. Assessment of seedling growth parameters on potted plants at day 5, 10, 15, and 20 post-transplanting for number of leaves, shoot diameter, chlorophyll content, shoot and root length, shoot dry weight.

3. Trichome counts and no choice bioassay

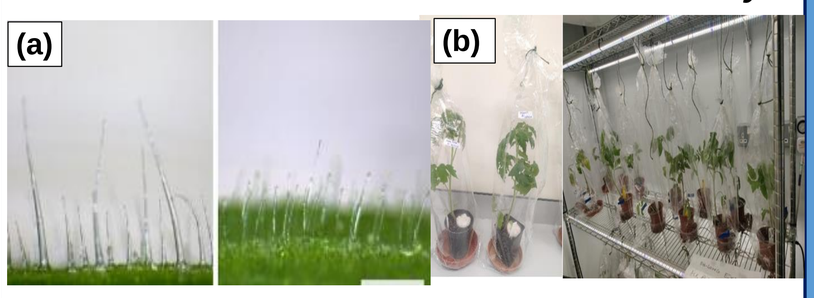


Fig 4. (a) Light microscope observation of glandular and non-glandular trichomes (b) Bread bag No-choice bioassay test for susceptibility to *T. absoluta* infestation.

Results

1. Germination indices and traits across cultivars

- The germination percentage and mean germination time (MGT) negatively affected all damage traits.
- There was a trade-off of between Time to 50% germination (T_{50}) and all growth parameters (shoot length, diameter, root length, and leaf area (Fig. 5).

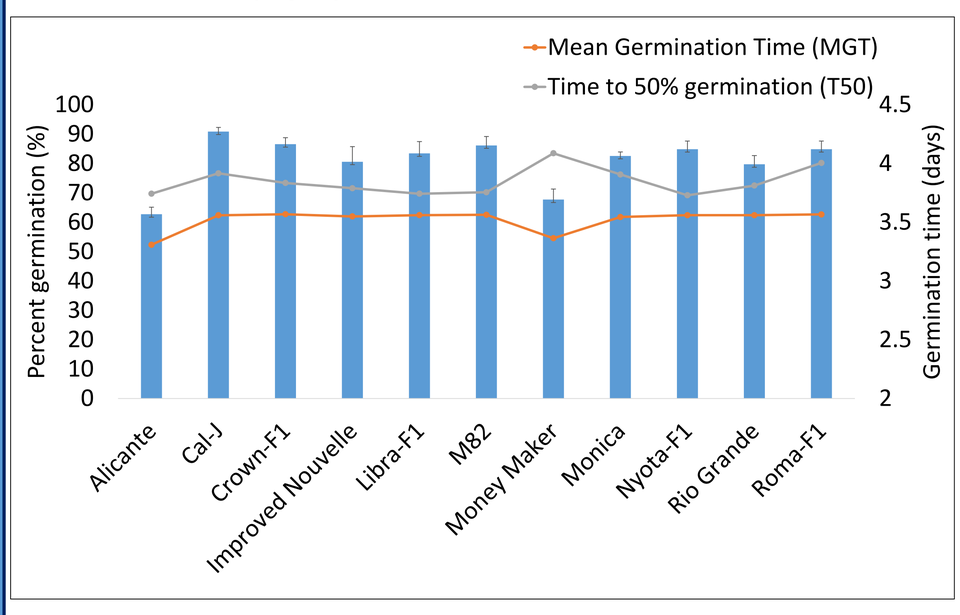


Fig 5. Variation in the trade-off between Mean germination time (MGT-days), time to germination in 50% of the viable seeds (T50) against percent germination rate for the eleven tomato cultivars

2. Seedling growth parameters across cultivars

- The leaf chlorophyll content was associated positively with shoot biomass (r= 0.435) and root length (r= 0.317).
- No trade-off was observed between leaf area and shoot diameter, leaf chlorophyll (r=0.600), shoot biomass (r=0.496), and root length (0.359) across cultivars.
- Leaf area, chlorophyl content negatively affected all damage traits; oviposition rate (r= -0.404), number of larvae (r= -0.548), and damage on the leaf: number and size of mines (r= -0.309).
- Higher Seedling vigour exhibited by Crown-F1, and Cal-J positively influenced mean glandular trichomes on the leaves, oviposition rate, size of lesions on leaves and number of mines.
- Shoot length showed negative association with time to 50% germination (T50) (r= -0.310) (P<0.001), oviposition rate (r= -0.445), number of mines on the leaf (r= -0.392), and number of larvae (r= -0.604).
- Presence of type VI glandular trichomes deterred leaf mining (r= -0.453), size and type of lesions on the leaf (r= -0.394) and number of mines on apical buds (r= -0.423).

3. Variation in glandular and non-glandular trichomes counts

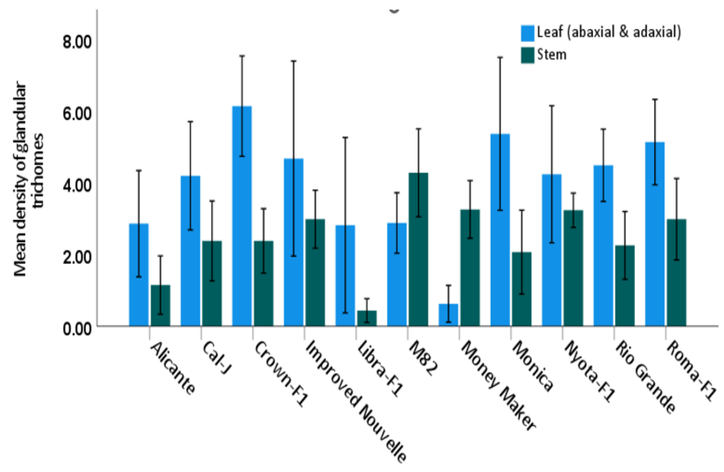


Fig 6. Differences in mean density of glandular trichomes across *S. lycopercium* commercial cultivars.

4. Deterrence to leaf mining and oviposition

Table 1. Overall damage (leaf, leaflet, and lesion size) on tomato cultivars exposed to *T. absoluta* infestation in no-choice bioassay experiments on day 5, 10, 15, and 20 post-infestation

	Overall percent plant damage			
	Sampling period			
Tomato cultivars	5	10	15	20
Alicante	17.7±4.26^{b}	36.8±5.04^{c}	51.3±4.41^{a}	77.2±5.67^{cd}
Cal-J	2.0±0.67^{a}	12.0±3.77^{a}	12.1±2.01^{a}	35.0±1.18^{a}
Crown-F1	5.5±1.94^{a}	12.9±4.16^{ab}	26.8±13.16^{a}	30.8±13.68^{a}
Improved Nouvelle	8.9±1.44^{ab}	31.0±3.70^{abc}	41.86±7.44^{a}	66.2±6.20^{bcd}
Libra-F1	1.8±0.96^{ab}	16.8±2.77^{a}	36.5±9.01^{a}	45.9±5.15^{ab}
M82	4.5±4.51^{a}	13.7±5.19^{ab}	24.2±11.89^{a}	37.9±5.40^{ab}
Money Maker	12.5±1.01^{ab}	30.8±4.54^{abc}	42.0±9.75^{a}	84.9±2.89^{d}
Monica	9.03±1.71^{ab}	21.3±4.84^{abc}	27.6±6.81^{a}	48.2±4.60^{abc}
Nyota-F1	15.0±0.64^{ab}	26.4±2.04^{bc}	31.9±4.87^{a}	44.4±4.08^{ab}
Rio Grande	6.3±1.65^{ab}	18.2±6.17^{abc}	16.9±2.77^{a}	46.7±5.34^{ab}
Roma-F1	5.3±3.49^{ab}	20.1±3.41^{ab}	38.7±7.53^{a}	65.8±3.61^{bcd}

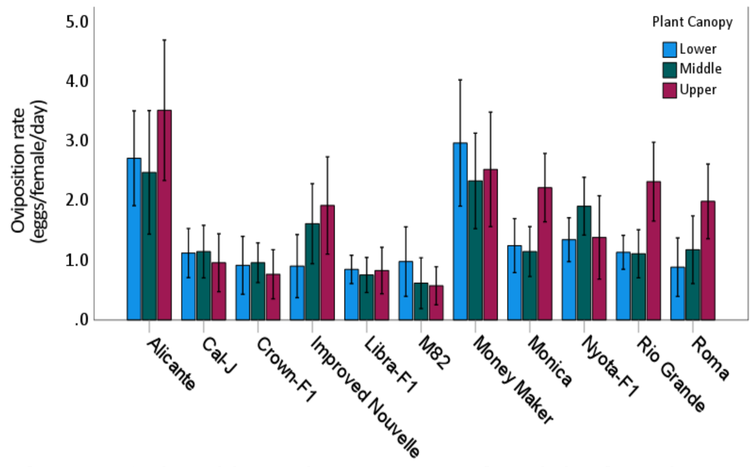


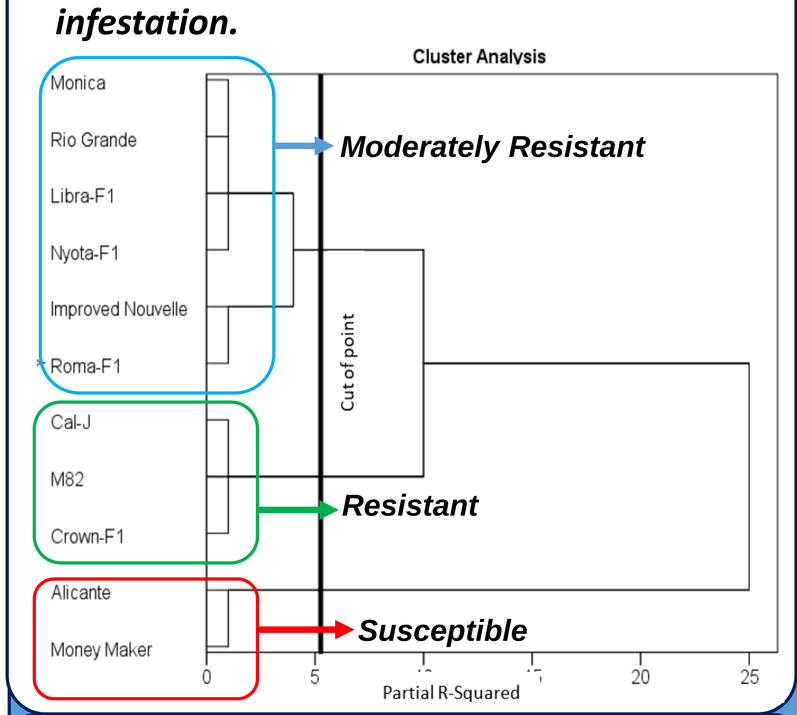
Fig 7. Oviposition deterrence of adult female *T. absoluta* across *S. lycopercium* commercial cultivars

5. Interaction between growth parameters, trichome counts and leaf damage deterrence

Table 2. stepwise regression analysis for interaction of germination growth and defense traits with overall plant damage across tomato cultivars

Variables regressed against overall plant damage	Beta coefficient	Model R-square	F-value	t-value	P-value
Number of mines on leaves	15.579	0.675	27.647	-2.586	<0.001
Seeding vigour index	-4.107	0.229	12.445	-3.528	0.001
Type VI trichomes on leaf	-10.009	0.136	7.774	-2.788	0.008

6. Cultivar ranking for susceptibility to infestation.



Conclusion

- Seed vigour and MGT influenced leaf area, shoot length and chlorophyl content across cultivars, hence number of mines as a significant indicators of fitness.
- Higher presence of Type VI glandular trichomes was a significant factor in deterring damage and oviposition.
- Significant trade-offs existed between seed dry weight, shoot biomass, and non-glandular trichome in defense response to infestation.

References

Rwomushana, et al. 2019. Tomato leafminer (*Tuta absoluta*): Impacts and coping strategies for Africa. *CABI (Center for Agriculture and Bioscience International) Working Paper, 12*.

Acknowledgements

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