Plant organ hardness as a factor of crop resistance to insect pests

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Abstract

Penetrometry studies were conducted on sorghum and mango, in order to assess plant organ hardness as a potential factor of crop resistance to insect pests. Particularly, the hardness of developing kernels and growing stems of sorghum, and that of ripening mango fruits, were evaluated. Respectively two sorghum cultivars differing by their resistance level to the panicle-feeding bug (=head-bug) *Eurystylus oldi*, two sorghum cultivars differing by their resistance level to the stem borer *Sesamia cretica*, and two mango cultivars differing by their resistance level to fruit flies (Diptera: Tephritidae), notably *Bactrocera zonata*, were evaluated. Between 10-17 days after complete anthesis, developing kernels of head-bug resistant Cirad 441 were significantly harder than those of head-bug susceptible ICSV 197. Two weeks after tillering, growing stems of stem borer susceptible Safraari were marginally significantly harder than those of stem borer resistant Majeeri. At the ripe stage, the skin of fruit fly less susceptible Tommy Atkins fruits was significantly harder than that of fruit fly susceptible Cogshall fruits. The relevance of plant organ hardness as a factor of crop resistance to pests, and of its assessment via penetrometry studies, thus depend on whether damage is inflicted via oviposition or feeding, and in the latter case whether it is via piercing-sucking or grinding mouthparts.

Objective

The objective of the presented studies was to determine whether some generic lessons could be drawn from the response of insect pests to physical barriers in plants, depending on their ethology (mainly feeding and egg-laying behavior), and why such physical resistance mechanisms are seldom used in practice (e.g. due to correlation with undesirable traits such as low yield, inappropriate plant architecture, poor product processing ability). Penetrometry studies conducted pertained to three different agricultural contexts, namely: rain-fed sorghum/panicle-feeding plant bug (*Eurystylus oldi*)(**Fig.1**), recession-cropped sorghum/stem borer (*Sesamia cretica*)(**Fig.2**), mango/fruit flies (notably *Bactrocera zonata*)(**Fig.3**).

Fig.1. Adult of *Eurystylus oldi* on a sorghum panicle

Fig.2. *Sesamia cretica larva* in a sorghum stem

Fig.3. *Bactrocera zonata* female on a ripe mango fruit

Methods

1. Hardness of immature sorghum caryopses of panicle-feeding bug resistant cultivar CIRAD 441 **[1]** and susceptible ICSV 197, were measured bi-weekly from 10-17 days after completion of anthesis with an Instron® Universal Food Testing Machine (Instron Corporation, Canton, MA, USA)**[2]**, with 0.2mm insect minutia (**Fig.4**) at 5 mm.mn^{-1} penetration speed. Endosperm hardness was defined by the charge (in N) required to penetrate the caryopse down to a depth of 1.5mm.
2. Hardness of growing stems (2 cm above the roots) of stem-borer resistant cultivar Majeeri **[3]** and susceptible Safraari, were measured bi-weekly from tillering to 3 weeks after, with the same device and penetration speed, but with Karlsbad® stainless steel #7 insect pins (**Fig.5**), and stem hardness was defined as the charge required to penetrate down to a depth of 1.5cm.
3. Hardness of ripening mangoes of fruit fly less susceptible cultivar Tommy Atkins **[4]** and highly susceptible Cogshall were measured from the green to the mature stage, with a TA.XT2® Texture Analyzer (Stable Micro Systems, London, UK), on which a 3mm diameter stainless steel cylinder probe had been adapted (**Fig.6**). Penetration speed was set at 5 mm.s^{-1}, and the variable considered was the charge at the breaking point corresponding to the force required to pierce the fruit epicarp.

Results

1. Between 2-3 weeks after complete anthesis, developing kernels of head-bug resistant Cirad 441 were significantly harder than those of head-bug susceptible ICSV 197 (**Table 1**).
2. Between 4-8 days after tillering, growing stems of stem borer susceptible Safraari were marginally significantly harder than those of stem borer resistant Majeeri (**Table 2**).
3. At the ripe stage, the skin of fruit fly less susceptible Tommy Atkins fruits was significantly harder than that of fruit fly susceptible Cogshall fruits (**Table 3**).

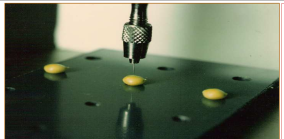

Fig.4. Insect minutia adapted to Instron® food testing machine with immature sorghum grains

Table 1. Endosperm hardening pattern of 2 sorghum cultivars (resisting penetration force in N according to time post anthesis)

no days / sorghum cv	7	10	14	17
Cirad 441	0.07 a	0.10 a	0.33 a	0.39 a
ICSV 197	0.07 a	0.07 b	0.11 b	0.28 b

Means with the same letter in a column are not significantly different (Student t test: P<0.05)

Fig.5. Stainless steel #7 insect pin adapted to Instron® food testing machine with a growing sorghum stem segment

Table 2. Stem hardening pattern of 2 sorghum cultivars (resisting penetration force in N according to time post anthesis)

no days / sorghum cv	7	10	14	17	21
Majeeri	0.49	0.49	0.66*	0.92	1.18
Safraari	0.41	0.56	0.80*	0.92	1.32

**marginally significantly different means (t test: P<0.10)*

Fig.6. Stainless steel cylinder probe adapted to TA.XT2® texture with a ripening mango fruit

Table 3. Fruit epicarp hardening pattern of 2 mango cultivars (charge at the breaking point in N according to ripening stage)

ripening stage / mango cv	green	yellow point	mature
Tommy Atkins	44.1 a	23.9 a	15.2 a
Cogshall	41.1 a	17.8 a	9.3 b

Means with the same letter in a column are not significantly different (Student t test: P<0.05)

Conclusions

The relevance of plant organ hardness as a factor of crop resistance to pests, and of its assessment via penetrometry studies, depend on whether damage is inflicted via oviposition (e.g. fruit flies & plant bugs) or feeding, and for the latter whether it is via piercing-sucking (e.g. plant bugs) or grinding mouthparts (e.g. stem borers). On the other hand, despite higher grain quality even under high bug pressure, quicker hardening in CIRAD 441 results into smaller grains.

References

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