モモアカアブラムシに適用されるアントシアン忌避剤(農薬生産用農産食料製造)(農芸化学科)

Pesticide-producing Agricultural Food Processing. Anthocyan repellents applicable to *Myzus persicae* SULZER (Hemiptera: Aphididae)*

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I INTRODUCTION

The development of pesticides from agricultural food products has been explored in author's laboratory[5,6]. The major advantages in using agricultural food products for pesticidal aims are age-guaranteed safety in production and utilization and low production costs. Furthermore, the development of the food-originated pesticides may increase the economic value of the by-products of agricultural food processing.

The present investigation demonstrated that anthocyans[2], being ubiquitous in cultivated plants, could show color-vision disturbance in phytophagous insects. This possible, new usage of anthocyans as visual repellents would be added to their present major use as natural food colorlants.

Vision has a vital role in the landing process of phytophagous insects on the green plant. Indeed, as in the case of the aphid only the sense of vision, especially color vision, determines its chance of landing on objects[3]. In the present work, as an example of phytophagous insects, *Myzus persicae* SULZER was selected for the study on the effect of pigments on controlling the spectral aspects of lighting conditions in insect-plant system, achieving an insect-repellent effect via the disturbance of such a vital photophysiological phenomenon.

The present investigation provided the spectroscopic properties required for the pigments potentially being used for the fore-mentioned purpose. These aspects may be useful for the development of safe, non-toxic insecticides as proposed in previous works[4~6]

II MATERIALS AND METHODS

1 Insect

The 3rd or 4th-instar lavae of *Myzus persicae*, which had been reared on leaf mustard, *Brassica juncea* CZERN. et COSS., in a green house, were used for the present study.

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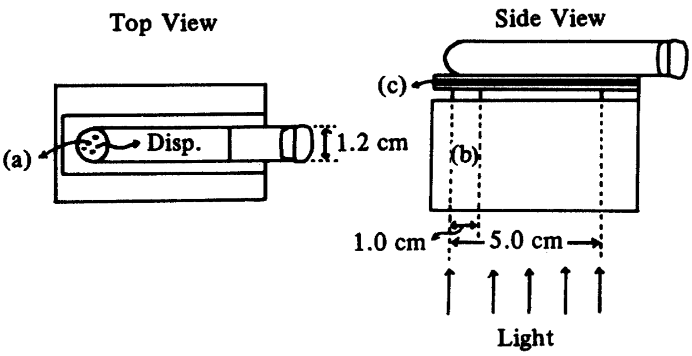
2 Pigments

Synthetic and natural pigments were used. Synthetic pigments were the dyes obtianed from Dylon International Limited, London, including Dylon Cold A3, A9, A26, A27, and A28 and Dylon Multi 21 and, furthermore, commercial food colorlants including Yellow No. 4, Yellow No. 5, Red No. 102, Red No. 104, and Blue No. 1. These pigments were dissolved into distilled water and used for the experiments. Natural pigments were extracted from plant sources; anthocyans from *Vitis Vinifera* L., *Ipomoea batatas* POIR., *Brassica oleracea* L., *Thunbergia erecta* BENTH., *Oxalis corymbosa* DC., *Solanum melongena* L., and *Hibiscus rosa-sinensis* L. and N-anthocyans from *Bougainvillea glabra* CHOISY. For the preparation of anthocyans to obtain the solutions having various absorbance peaks in a range of 500-600 nm, the pigments were extracted with 1% HC1, 1% HC1-MeOH, or 4 M NaC1[1].

3 The evaluation of color-vision disturbance

The evaluation of the extent of color-vision disturbance was carried out using the set-up shown in Figs. 1. A fluorescent lamp (20 W) was set in a wooden box with a glass window of 1.2 cm x



Figs. 1. The diagrams of the set-up used for the determination of the color vision of *Myzus persicae*
(a); Twenty aphids in the test tube closed with a cotton stopper, (b); Pigment solution in a vial, (c); Green leaf sandwiched by two slide glasses

5.0 cm for illumination at the upper side. To fit the bottom part of the test tube, a glass bottle, containing pigment solution, with a diameter of 1.0 cm and height of 3.2 cm was placed. Slide glasses sandwiching the green leaf of the leaf mustard was placed over the bottle. On the slide glasses the test tube containing 20 aphids closed with cotton stopper was placed. The aphids were light-adapted at the outset of the measurements. After collecting 20 aphids at the bottom of the test tube, the tube was quickly placed over the slide glasses located on the illumination window. The number of the aphids staying in the circular surface of the pigment solution were counted at 8, 10, and 12 min. The distribution ratios of remaining aphids, i.e. arrestivities, were evaluated at these observation times and were expressed as an average of these values for a given treatment. All procedures were carried out in a dark room.

III RESULTS AND DISCUSSION

The arrestivity of *Myzus persicae* on the green leaf of the leaf mustard was 50%, indicating that a larger fraction of the aphids stayed at the starting area. This value was significantly high in comparison to that of the arrestivity due to a random distribution, i.e. 20%.

When the light transmitted through the pigment solution located under the green leaf was incident upon the test tube containing aphids, arrestivity increased or decreased depending on the spectroscopic properties of the pigment solutions used. The arrestivity lower than 20% could be observed with many red-purple pigments while the values higher than 50% could be observed with yellow pigments, showing the enhancement in the arrestivity. The lowering effect was observed with the anthocyans and N-anthocyans of plant pigments and the dyes and food additives of synthetic pigments as shown in Tables 1 and 2, where the arrestivities were expressed as the arrestivities

Table 1. The wavelength of the absorbance peak and arrestivity of synthetic pigments

Synthetic pigment	λmax (nm)	Arrestivity (%)
Food yellow No. 4	425	163
Food yellow No. 5	478	140
Mandarin, A27	485	63
Food red No. 102	506	81
Purple vine, A19	510	60
Food red No. 104	536	47
Lilac, A3	538	52
Ultra violet, A26	546	62
Riviera blue, A28	595	18
Food blue No. 1	630	102
Elephant grey, 21	—	35
Control	—	100

Table 2. The wavelength of the absorbance peak of natural pigments and their arrestivity

Source of Natural Pigments	Solvent	λmax(nm)	Arrestivity(%)
Vitis vinifera L.; Skin	1% HC1	517	57
Ipomoea batatas Poir.; Stem	1% HC1.MeOH	525	70
Brassica oleracea L.; Leaf	1% HC1.MeOH	526	22
Thunbergia erecta Benth.; Flower	1% HC1.MeOH	533	70
Oxalis corymbosa DC.; Flower	4 M NaC1	538	35
Solanum melongena L.; Skin	1% HC1.MeOH	538	30
Bougainvillea glabra Choisy; Bract	1% HC1.MeOH	550	16
Bougainvillea glabra Choisy; Bract	4 M NaC1	550	10
Brassica oleracea L.; Leaf	4 M NaC1	550	20
Hibiscus rosa-sinensis L.; Flower	Isoamyl alc.	553	26
Vitis vinifera L; Skin	Isoamyl alc.	555	20
Hibiscus rosa-sinensis L.; Flower	Isoamyl alc*	560	7
Hibiscus rosa-sinensis L.; Flower	Isoamyl alc**	583	16
Control	—	—	100

* $AlCl_3$ added, ** $SnCl_4$ added

relative to that of non-treatment.

The data shown in Fig. 2 were the arrestivities obtained as a function of the wavelength of the major absorbance peak, whose transmittance was adjusted to 10%. It is obvious that the pigments

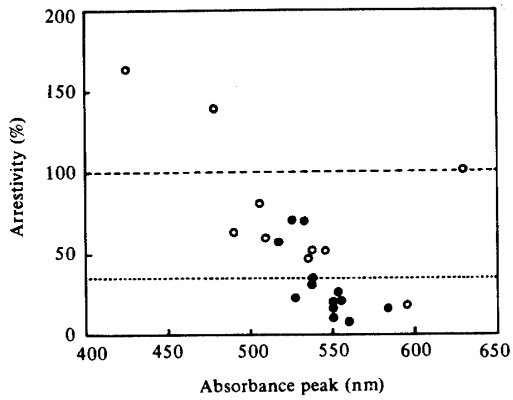


Fig. 2. The relationship between the arrestivity observed and the wavelength of the absorbance peak of the pigment used
●: Natural pigment, o: Synthetic pigment
----: Distilled water, ---------: Grey pigment

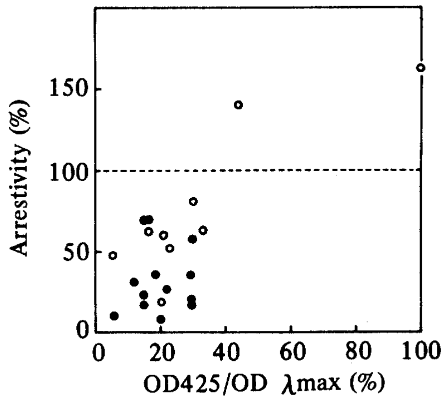


Fig. 3. The relationship between the arrestivity and the ratio of OD at 425 nm to OD at the absorption peak (%) of the pigments used
●: Natural pigment, o: Synthetic pigment

whose absorbance peaks are within a range of 500-600 nm give the arrestivities lower than non-treatment while pigments whose absorbance peaks are shorter than 500 nm give the arrestivity higher than the non-treatment.

Shown in Fig. 3 is the arrestivity as a function of the ratio of the absorbance at 425 nm to that at the absorbance peak. It was shown that lower values of the ratio tended to give a lower arrestivities and those of 25% or lower gave exceedingly low arrestivities. This may indicate that the fitness of the pigment spectrum to that of the green leaf is effectively achieved by the pigments having lower values of the ratio.

The relationship between the transmittance of the pigment solution having an absorbance peak at 555 nm (malvidin in isoamylalcohol) and arrestivity is shown in Fig. 4. The arrestivity decreased

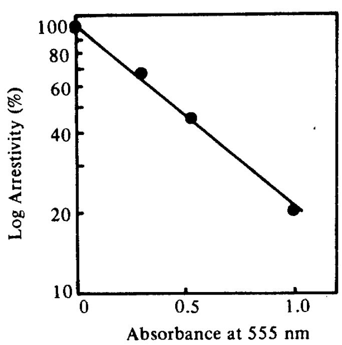


Fig. 4. The effect of absorbance at 555 nm on the logarithm percentage of the arrestivity relative to the normal green arrestivity

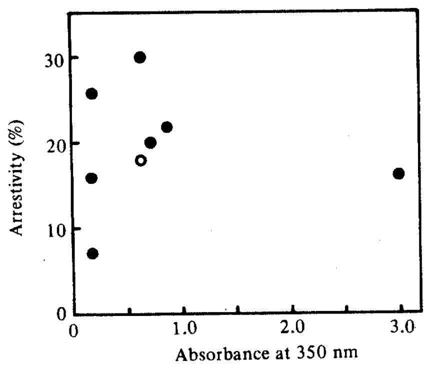


Fig. 5. The effect of absorbance at 350 nm on the arrestivity
● : Natural pigment, o : Synthetic pigment,

with increasing pigment concentration. The relationship was expressed by a linear equation:

$$\text{Log (arrestivity)} = 2 - a\,(\text{OD}), \quad (1)$$

where a was a constant, showing the presence of reasonable arrestivity even at a lower pigment concentration. Such a relationship was not observed at 350 nm as shown in Fig. 5, indicating that the near-ultraviolet sensation was irrelevant to the arrestivity modification observed in this work.

Red-purple pigments, natural or synthetic origin, were shown to have repellent effects, i.e. a decrease in arrestivity, on the phytophagous insect used in the present work. From this, the ecological significance of anthocyans in plant-insect relationships may be regarded to demonstrate the resistivity against insect attacks by repelling the insect via the disturbance of insect color-vision.

One of the examples in the application of red-purple pigments as insect repellents in fields may be the pigmentation of the films or glasses for green houses or the covering materials for fruits or whole plants. An other example may be the direct application onto the plant surface as an artificial plant-pigmentation material. Finally, coapplication with traditional olfactory or gustatory repellents[4)] may give the insect repellents showing wider applicability in both insects to be repelled and the plants to be protected.

It is noteworthy that this type of pigment pesticides may be effective in preventing the infection by plant viruses, since the aphids are known as the vectors of the various plant viruses.

Since the anthocyans contained in various agricultural plants[2)] were expected to be effective in prevention against insect attacks as observed in the present work and were widely used as food colorlants after the processing of source crops, the pigments will be expected to have the qualities required for safe insecticides. When the pigment insecticides are developed up to the stage of practical utilization, the crops containing anthocyans may aquire a new economical value in their agricultural food processing.

IV SUMMARY

The color-vision dependent arrestivity of *Myzus persicae* SULZER on the green leaf of the leaf mustard was extremely decreased by the various pigments, including anthocyans, food colorlants, and dyes, whose absorbance peaks were in a range of 500-600 nm and was increased by the pigments whose absorbance peaks were at 500 nm or shorter. The lower values in the ratio of absorbance at 425 nm to that at the absorbance peak gave lower values in the arrestivity. The minimum arrestivity was observed at the ratio of 25% or lower. The arrestivity decreased with increasing absorbance at the absorption peak of 555 nm. The relationship was expressed as log (arrestivity) = 2 - a(OD), where a was a constant. It was proposed that the red-purple pigments, by lowering the arrestivity, would be used as the safe repellents for preventing insect attacks, anthocyans would function as a resistant factor of plants against attacks by phytophagous insects, and pesticidal usage of the anthocyans would be developed as one of the economical aims of agricultural food processing.

REFERENCES

1. Goto, T., Hoshino, T. and Ohba, M. 1976 Stabilization effect of neutral salts on anthocyanins: Flavylium salts, anhydrobases and genuine anthocyanins, Agr. Biol. Chem., **40**: 1593~1596
2. Harborne, J. B. 1967 Comparative biochemistry of the flavonoids, pl~36, London and New York, Academic Press, Inc.
3. Kennedy, J. S., Booth, C. O. and Kershaw, W. J. S. 1961 Host finding by aphids in the field. III. Visual attraction, Ann. Appl. Biol., **49**: 1~21
4. Kobamoto, N. 1974 Rediscovery of pesticidal significance of repellents and attractants, Sci. Bull. Agr. Univ. Ryukyus, **21**: 123~129
5. Kobamoto, N. 1976 The photochemical properties of ultraviolet light receptor complex of the Oriental fruit fly, *Dacus dorsalis* Hendel (Diptera: Trypetidae), Appl. Ent. Zool., **11**: 271~277
6. Kobamoto, N. 1977 Photochemical mechanisms of the ultraviolet light receptor complex in the bovine and insect eyes, J. Pesticide Sci., **2**: 405~411

農薬生産用農産食料製造ーモモアカアブラムシに適用されるアントシアン忌避剤

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要　約

モモアカアブラムシのカラシナ葉面上の色覚に基づく定着性は，吸収極大を500～600 nmに持つ各種色素（アントシアン類，食品着色料，及び染料を含む）の存在により著しく低下し，500 nm 以下では，逆に増加した。定着性は，また，波長 425 nm における吸光度の最大吸収波長における吸光度に対する比率が低い程低く，25％以下で最小値を示した。定着性は，さらに，555 nm の吸収極大における吸光度が高い程低く，その関係は，log（定着性）＝2－a（OD）であった（但し，a は定数）。定着性を低下させる赤紫色色素は安全な虫害予防用忌避剤として使用できること，使用した色素中のアントシアン系色素は，植物にとって，食植性昆虫に対する抵抗性を示す物質であること，さらに，これらアントシアン類の農薬としての利用は，農産製造における一目標となり得ることを示した。

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