Effect of Extraction Temperature and Dilution of Solanum Panduriforme in Aphid (Brevicoryne brassicae) Control

Katsvanga C.A. T, Tafirei R, Nyakudya I. W, and Moyo M.

Abstract

The research was carried out to ascertain the optimum extraction temperature and effective dilutions for Solanum panduriforme in the control of Brevicoryne brassicae in Brassica napus cv Giant Rape. The plants were infected with Brevicoryne brassicae and left for two weeks to multiply. S. panduriforme was extracted at three temperatures, 40^0C, 50^0C and 60^0C in a water bath. Each extract solution was diluted in the following extract to water ratios, 1:1, 1:2 and 1:3 by volume and trials were replicated three times. Observations indicated that the extraction temperature of 60^0C was significantly more effective in the reduction of B. brasiccae populations as compared to 40^0C and 50^0C. The 1:1 dilution significantly (P=0.000) reduced the aphid population as compared to the 1:2 and 1:3 dilutions. However, 1:1 dilution caused leaf discoloration two days after application. The 1:2 dilution markedly reduced (P=0.007) aphid populations in comparison to the 1:3 dilution. Therefore, the aphid mortality rate of 55.8% resulting from the dilution of 1:2 extracted at 60^0C indicates high potential for S. panduriforme as a botanical pesticide if the active components are characterized and isolated. It was concluded that use of S. panduriforme as a botanical pesticide is applicable to resource-constrained farmers in the developing world and in the eco-agriculture field.

Introduction

Health risks and environmental pollution, emanating from misuse of synthetic chemicals necessitates the development of alternative strategies for sustainable pest management in vegetables (Dube et al., 1999). The importance of pest control cannot be overemphasized since an estimated one third of the world's agriculture production is destroyed by 20 000 species of field and storage pests (Stoll, 1988).

Use of botanical pesticides provides an environmentally friendly alternative to conventional pesticides. When using botanical pesticides, the user must be aware that the active substances they contain have a different effect from synthetic pesticides (Pestemer in Schwarb et al., 1995). Though there is need for the chemical characterization of botanical pesticides, farmers in developing countries are much more concerned about their efficacy. Previous studies have shown that intercropping of vegetables with aromatic plants such as garlic, chives and other bulbous plants, coriander, labiates for example mint, and basil can be applied (Schwarb et al., 1995).

Botanical pesticides are unique in that the content of the active substances vary with season, growing conditions, age at harvest, differences in extraction methods and storage conditions thus posing difficulties in dosage standardizing. Solar radiation for example accelerates decomposition (Clegg and Mackean, 1994). In addition, they have a very short shelf life so it is recommended that they be prepared and sprayed instantly (Jager et al, 1988). It is therefore imperative that the potency of a plant product be determined locally through testing different concentrations on infested plants and comparing the effects.

A number of plant species have been observed to have pesticidal properties but their effectiveness has not been fully explored (Berger 1994, Poswal et al., 1993, Poswal and Akpa 1991). In general, plants with pesticidal properties can be exploited in three ways by using whole parts of plants, in powder or as crude extracts in water or other solvents, and as purified extracts like rotenone.

Scientific research on the use of botanical pesticides and documentation on proper extraction techniques for crop protection is still meagre. Research was conducted to establish the optimum extraction temperature and effective dilutions S. panduriforme for controlling B. brassicae in B. napus cv Giant Rape.

Methods

The Aphid (Brevicoryne brassicae)

Adult aphids are small, round, plump and soft-bodied pests ranging from 1-2 mm long. They vary in colour from green, yellow, brown, grey, white and black (Blackman and Eastop, 1999). They are identified by their sucking mouth-parts, long, thin legs, long antennae, pear shaped body and a pair of tube like structures called cornices arising from the posterior of the abdomen (Dixon, 1985). The aphids are wingless but will produce wings and fly away when food resources are limited and when overcrowded. According to Smith and Kubo (2001) B. brassicae has alternating hosts and alternating asexual and sexual reproduction. A complete life cycle takes 10 to 14 days (Dixon, 1985).

Solanum panduriforme description

Solanum panduriforme is a branched shrub, which grows to 1m. Leaves are strongly aromatic when crushed. The fruit is green at first and yellow when ripe. S. panduriforme is common at medium and low altitudes in the tropics (Smith and Kubo, 2001).

Experimental Design

Preparation of the Extracts

Ripe S. panduriforme fruits were collected in early November from Bindura (GPS coordinates X: 321774; Y: 8084694; altitude: 1093m). Extractions of the plant pesticide were carried out in a laboratory and nine treatments for each temperature and dilution were replicated three times. S. panduriforme fruits with a mass of 200 g were washed and pounded into a pulp together with 0.5 g of soap. Soap increases the tenacity of the plant extract (Jager et al, 1988). According to Grainge and Ahmed (1988), temperatures below 40^0C are not very effective in the extraction of the active substance while at 70^0C and above the active ingredients are inactivated. Therefore S. panduriforme was extracted at three temperatures, 40^0C, 50^0C and 60^0C in a water bath. Each extract solution was diluted in the following extract to water ratios 1:1, 1:2 and 1:3 by volume.

Preparation of plots and planting

Certified seeds of B. napus cv Giant Rape were sown and transplanted onto plots in a randomized block design and each plot planted with five seedlings. To cater for the differences in dilutions and temperature, distances of 2m were left between the plots. Other cultural practices were uniformly applied to all the treatments.

Introduction of aphids

After 3 weeks of transplanting when the plants had developed at least 3 fairly big leaves, ten wingless female aphids were inoculated physically onto each plant. The aphids were left to multiply for 14 days (complete life-cycle) after which extracts were sprayed onto the plants as the aphid population started to increase. Malathion 50%WP with the active ingredient Malathion 50% was used for comparison in three replicates and applied to vegetables at a rate of $0.01g/m^2$. Three untreated replicate plots were used as a control. Systematic spraying for all experimental treatments was done fortnightly. Aphid population monitoring lasted for eight weeks.

Data obtained from the experiment was analyzed at 5% significance level by ANOVA using the statistical package SPSS version 10.

Results

The findings of the effectiveness of S. panduriforme on B. brassicae control are presented in Table 1.

Table 1 - Mean percentage reduction of aphid populations

Treatment		Mean Aphid population Reduction (%)±SE
Control	**Untreated**	4.02±2.31
Synthetic Pesticide	**(Malathion 50%WP)**	98.34±1.22
Temperature ^{0}C	**Dilution**	
40	1:1	43.51±1.35
	1:2	36.06±1.69
	1:3	29.51±0.89
50	1:1	55.77±3.31
	1:2	49.91±1.01
	1:3	34.13±1.34
60	1:1	65.03±1.13
	1:2	55.77±1.67
	1:3	46.91±2.42
Significance	**Dilution**	***
	Temperature	***
	Dilution and Temperature	***

*** Significant at (p< 0.001), ** Significant at (p< 0.01),* Significant at (p< 0.05).

Comparisons of dilutions within the same extraction temperatures

There was a significant difference (P<0.05) in percentage aphid reduction for the dilutions made from the 40^{0}C extract. The 1:1 dilution significantly (P=0.000) reduced the aphid population as compared to the 1:2 and 1:3 dilutions. The same applies to the comparison of the 1:2 dilution which markedly reduced (P=0.007) the aphid population in comparison with the 1:3 dilution. The 50^{0}C extract showed no significant variation (P>0.05) in percentage aphid reduction between the 1:1 and 1:2 dilutions. However, there was significant (P=0.000) percentage aphid reduction between the 1:1 and 1:3 dilutions as well as the 1:2 and 1:3 dilutions. Application of dilutions of the 60^{0}C extract indicated that the percentage aphid reduction was significantly higher for the 1:1 dilution as compared to both the 1:2 (P=0.006) and 1:3 (P=0.000) dilutions, and the 1:2 in comparison to the 1:3 dilution (P= 0.007). For the 40^{0}C, 50^{0}C and 60^{0}C extracts at 1:1 dilution, leaf discoloration was observed after two days of application. The new shoots, which emerged after a week, were without leaf discoloration. Higher order interactions of dilution and temperature were significant (P<0.001).

Malthion 50%WP showed a significantly high (P=0.000) aphid population reduction percentage in comparison to all the S. panduriforme treatments. Aphid populations in the control initially started by increasing during the first 5 weeks but there was a slight decline from the 6^{th} to the 8^{th} week. The population reduction was significantly low (P=0.000) in comparison to all the other treatments.

Discussion

The different treatments of S. panduriforme reduced aphid populations on B. napus, which shows that the plant has pesticidal properties. The order of aphid population reduction of the extraction temperature and dilution treatments were such that $60^0C>50^0C>40^0C$ and dilutions, 1:1>1:2>1:3. The results confirm that the extraction temperatures of the active ingredient and the dilution levels have an effect the efficacy of botanical pesticides. The control initially showed a continued rise in aphid population but later there was slight decline in the population. This decline could be a result of high populations on limited space. The decline is significantly lower than the S. panduriforme treatments further confirming the usefulness of botanical pesticides.

The synthetic pesticide was more effective than the S. panduriforme treatments in reducing aphid populations. For this reason farmers may continue to prefer synthetics to botanical pesticides, despite their health, safety and environmental problems (Clegg and Mackean 1994). However, an aphid mortality rate of 55.8% resulting from the dilution of 1:2 extracted at 60^0C indicates high potential for S. panduriforme as a botanical pesticide if the active components are characterized and isolated.

Conclusions

Use of S. panduriforme as a botanical pesticide is applicable to resource-constrained farmers in the developing world and in the eco-agriculture field. Further research should target chemical isolation of the active ingredient and formulation of optimum dosages to enhance efficacy of this botanical pesticide.

Acknowledgements

We acknowledge assistance from Fambidzanai Permaculture in Mt Hampden, Zimbabwe

References

Berger A. 1994: Using natural Pesticides: Current and future perspectives. Swedish University of Agriculture.

Blackman R.L., Eastop V.F. 1999. Aphids on the world's crops. John Wiley and sons, Chichester.

Clegg P, Mackean D.G. 1994. Farming for sustainable Agriculture. John Wiley and sons, New York.

Dixon A.G.F. 1985. Aphid ecology. Blackie and son Ltd, Glasgow.

Dube B., Gova M., Makaya P.R., Mutimutema E. 1999. Important vegetables pests and diseases in Zimbabwe. Identification and control. Agritex, Zimbabwe

Grainge M., Ahmed S. 1988. Handbook of plants with pest control properties. John Wiley and sons, New York.

Jager I., Schwarb A., Stoll G., Gorgen R., Altenburg R. 1988. Pestcides in tropical Agriculture: Hazards and alternatives. Magraf publishers, The Netherlands.

Poswal M.A.T., Akpa A.D. 1991. Current trends in the use of traditional and organic methods for the control of crop insect-pests and diseases in Nigeria. Tropical Pest Management, 37: 329-333.

Poswal M.A.T., Akpa A.D., Alabi O. 1993. Cultural control of pests and diseases: Prelude to integrated pest management practices for resource poor farmers in Nigerian Agriculture. Journal of Sustainable Agriculture 3:5-48

Schwarb A., Gorgen R., Dobson L. 1995. Insecticides for plants. Decker Inc, New York.

Smith K., Kubo I. 2001. Insect control agents from tropical plants. Plenum press, New York.

Stoll G. 1988. Natural plant protection in the tropics. Magraf publishers, Weikersheim.