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Original Article

The Push – Pull Strategy: Eco- Friendly Methods of Pest - Management

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Abstract

Push-pull strategies involve the behavioral manipulation of insect pests and their natural enemies via the integration of stimuli that act to make the protected resource unattractive or unsuitable to the pests (push) while luring them toward an attractive source (pull) from where the pests are subsequently removed. The push and pull components are generally nontoxic. Therefore, the strategies are usually integrated with methods for population reduction, preferably biological control. Push-pull strategies maximize efficacy of behaviormanipulating stimuli through the additive and synergistic effects of integrating their use. By orchestrating a predictable distribution of pests, efficiency of population-reducing components can also be increased. The strategy is a useful tool for integrated pest management programs reducing pesticide input. We describe the principles of the strategy, list the potential components, and present case studies reviewing work on the development and use of push-pull strategies in each of the major areas of pest control.

Key Words: Allelopathy, biotypes, broad spectrum pesticides, companion crops

INTRODUCTION

The term push-pull was first conceived as a strategy for insect pest management (IPM) by Pyke et al. in Australia in 1987 (115). They investigated the use of repellent and attractive stimuli, deployed in tandem, to manipulate the distribution of Helicoverpa spp. in cotton, thereby reducing reliance on insecticides, to which the moths were becoming resistant. The concept was later formalized and refined by Miller & Cowles (97), who termed the strategy stimulo-deterrent diversion while developing alternatives to insecticides for control of the onion maggot (Delia antiqua). In this review, we retain the original terminology. We describe the principles and components of the push-pull strategy, summarize developments over the past 20 years since the term was coined, and discuss how the strategy may contribute to addressing the global demand for the reduction of toxic materials in the environment as part of IPM strategies in the future. Pesticides are used in nature to increase agricultural productivity in order to ensure food security. These are associated to kill the pests and insects which mainly feed on the economic crops. However, they could also impose serious negative impacts on the environment. Injudicious application of pesticides may lead to the destruction of ecological biodiversity. These chemical molecules due to overuse could be dangerous to the birds, aquatic organisms and other vertebrates. They hamper the sustainability and normal functioning of the food chains. Pesticide hazards are common especially due to their mobility in the environment which could be by water, air and soil. They could drastically alter the natural balance of the ecosystem by decimating the non-pest or non-target beneficial organisms and indirectly favor the population increase of the pests.

Effects of Pesticide use

Overdose of pesticides have resulted in the non-native or invasive insect plagues. Introduction of the arsenic based insecticides, chlorinated hydrocarbons, organophosphates and carbamates made this worse. Nevertheless, uncontrolled use of broad spectrum high persistent pesticides or toxic molecules have negative effects on the beneficials that exert control on pests and insects. The efficiency of pesticides depends on the application practices, environmental and ecological conditions. Even a so called 'safe' molecule could turn into a 'less safe' one depending on how and when it is applied under a specific condition. The residues of many insecticides could kill beneficial foragers, predators and parasitoids which directly exert environmental resistance to the pest species. Injudicious application of toxic chemicals could show impact on the beneficial organisms by directly disrupting the reproduction and fecundity, prey searching and capturing behavior. This is because beneficial organisms are more susceptible to these chemicals than the target pest species. Excessive use of pesticides could even be deleterious to the earthworm populations that are indicators of soil health. Toxic molecules disrupt their enzymatic activities, decrease fecundity, growth and survivability, change the feeding behavior and decrease the overall community biomass. However, extensive studies had shown that even fungicides like Glyphosate and 2,4-D had affected the physiology of earthworms. It had been shown to limit the population of cocoons and juveniles in the soil. Several studies about neonicotinoid pesticides had shown their toxicity to the honey bees. Honey bees are the important agents for pollination of crops. Neonicotinoids, a type of neuro-active chemicals similar to nicotine often used as seed treatment, became systemic throughout the plant. It had been shown that even low concentration of imidacloprid, neonicotinoids and clothianidin were linked with the Colony collapse disorder of bees where the bees abandoned their hives and eventually died. One of the recent studies showed that the combination of insecticides and fungicides could have a severe impact on the immune system of bees resulting in its inability to resist infection by a deadly protozoan parasite Nosema ceranae that had been indicated in the colony collapse disorder. Indiscriminate use of pesticides lead to the development of resistance among the insects. Certain notorious insects could even develop biotypes due to prolonged use of pesticide toxins. However, secondary pest outbreak occurred due to extermination of the of the pest predators, while concealed pests like leaf miners, leaf folders and internal fruit and shoot borers remained protected from the reach of these toxicants. Pesticides however, entered into the vertebrate food chains resulting into biomagnification, as their concentration increases with each trophic level of the food chain in the ecosystem.

PRINCIPLES OF THE PUSH-PULL STRATEGY

Push-pull strategies use a combination of behavior-modifying stimuli to manipulate the distribution and abundance of pest and/or beneficial insects for pest management. Strategies targeted against pests try to reduce their abundance on the protected resource, for example, a crop or farm animal. The pests are repelled or deterred away from this resource (push) by using stimuli that mask host apparency or are repellent or deterrent. The pests are simultaneously attracted (pull), using highly apparent and attractive stimuli, to other areas such as traps or trap crops where they are concentrated, facilitating their elimination (Figure 1). Most work on push-pull strategies has targeted pest behavior, so this review relates mostly to pests, rather than to the manipulation of beneficial organisms. However, the latter case aims to establish a concentrated population on the protected resource to promote biological control, and although stimuli similar to those utilized in the former case are used to achieve this, they act to push the beneficials out of the surrounding area and pull them to where they are required for control. The strategies therefore comprise a two-pronged mechanism to direct the movement and affect the distribution and abundance of the insects (push-pull). Because the stimuli used to achieve this generally act by nontoxic mechanisms, integration with population-reducing methods is also usually needed when the strategies are targeted at pests. Push-pull strategies bring together various elements of different pest management tactics and provide a framework for their effective deployment.

COMPONENTS OF THE PUSH-PULL STRATEGY

The function of push components of the pushpull strategy is to make the protected resource hard to locate, unattractive, or unsuitable to the pest. This is achieved through the use of stimuli that effect natural enemy avoidance behaviors and negatively influence host location and host acceptance (feeding and reproduction). These stimuli may act over the long or short range and ultimately lead to the pest being repelled or deterred from the resource or not even approaching it. Longrange stimuli represent the first line of defense: preventing or reducing infestation in the first place. Stimuli that act over the short range, however, can be powerful tools in preventing specific pestiferous behaviors. In pull components of push-pull strategies, attractive stimuli are used to divert pests from the protected resource to a trap or trap crop. The stimuli used to achieve this act mostly over a long distance. However, short-range stimuli can be useful additions to arrest and retain the pests in a predetermined place to facilitate the concentration of their populations and to prevent them from returning to the protected resource. The stimuli can be delivered in a variety of ways.

Introduction to the Push Pull strategy of integrated pest management

Many systems for pest control techniques had been developed till date which rely on improved cultural practices, minimize fertilizer application and pesticide inputs. However, due to poor economy of subsistence farming there is always uncertainties of weather conditions with erratic rainfall patterns which made farmers reluctant to invest high cost technologies for crop production as they could even lead to crop failure without any necessary revenues. Recent advancement in integrated pest management (IPM) programmes have employed molecular techniques including better breeding programmes, genetically modified crops expressing resistant traits and use of semiochemicals. Synthetic and natural insect pheromones are in wide use around the world for pest control in horticultural crops. These pheromones act as natural signals that are associated with the change in behavior and development of many organisms. Since pesticides are expensive, could be hazardous and with time species develop resistance to a particular pesticide, thus a newer approach of pest management crept in called 'PushPull" strategy which used sparingly and selective use of pesticides along with the semiochemicals. Push-Pull strategy includes behavioral manipulation of insect pests and their natural enemies employing the integration of insect stimuli, which makes the protected resource unpalatable and unattractive to the pests (push component) while they are lured towards a more attractive source (pull component) and thus the pests are removed. Africa faces serious challenges in feeding its large population mainly due to poor crop yields, unpredictable weather conditions and poor fertility status of the soil. This Push-Pull strategy had been used in sub-Saharan Africa to control numerous stem borer and stalk borer pests of cereal crops comprised of a number of Lepidopteran members like maize stalk borer Busseola fusca (Noctuidae) and spotted stem borer Chilo partellus (Crambidae).

The first phase in this strategy is to establish plots of many grasses and other plants as possible which could be found in the particular agroecosystem so that they are relatively attractive to the pests. These plants may include members of Poeceae, Cyperaceae, Typhinae as well as some leguminous and cattle forage plants. Several host plants are employed in the system which are strongly attractive to the gravid adult females than the crop plants. These could be regarded as 'Super hosts' releasing volatile semiochemicals that would establish greater level of oviposition by the adult females. However, several plant derived semiochemicals are used which shows responses in the olfactory system of the insects and would allow definite patterns of host selection mechanism. Push-pull strategy of IPM was built on the concept of polyculture or multiple cropping where a main crop was grown with an intercrop, which repelled the insect pests and diversionary trap plants were grown around the crop perimeter which pulled the pests. As in the context of African agriculture, protection of maize, millet and sorghum was achieved by the intercropping which a forage legume Desmodium sp. which emitted volatile chemicals. that repelled the stem and stalk borers and attracted a natural enemy, a parasitic Hymenopteran wasp.

Benefits of Push-Pull strategy

Push-Pull strategy is based on growing the main crop along with an intercrop with repellent properties and an attractive trap plant planted as a border crop around the crop and intercrop perimeter. The push component which is an intercrop grown with the staple or cash crop is preferably a repellent crop which emits semiochemical particularly kairomones which repel the pests and drive them away from the main crop. Instead these pests get diverted to other crop planted along the crop perimeter which serves as a tastier meal for them. Induced emission of volatile secondary metabolites (infochemicals) includes terpenoids acting as an indirect defense to plants against herbivores that attract natural enemies of the herbivores. The effects of these compounds on the pest, their predators and other organisms in the ecosystem serve the basis to the development of the control strategy such as 'push-pull' or strategy related to 'stimulo-deterrent diversion'. Subsistence farming in Africa use the method of intercropping by growing planting beans (Phaseolus sp.) in between the rows of maize to control the Lepidopterous stem borers of maize, sorghum and other cereal crops. Cereal crops in sub-Saharan Africa (Southern and Eastern) like maize and sorghum are often infested by the stem borers and stalk borers. As previously depicted Push-pull strategy could definitely be a solution to control these pests in a non toxic way. Intercrops such as Desmodium sp. was planted as an intercrop along with the main crop and most domestic and wild grasses like Napier grass were planted in the border around the maize and sorghum fields where invading adult moths were attracted to the infochemicals emitted by these trap grasses. The push component used in this pest control was Desmodium sp. which was planted between the rows of maize or sorghum which being a low growing legume plant did not interfere with the crop growth and also enriched the soil nutrient status by enhancing organic matter accumulation and nitrogen fixation. Desmodium sp. was also known to emit kairomones which repelled the pests and diverted them away from the main crop. However, it also served as a nutritious animal fodder and effectively suppressed a problematic weed Striga. Desmodium genus produced unusual Cglycosylated flavonoids which is an effective inhibitory compounds that inhibits the seed radical development of Striga and results in its suicidal germination. Another plant showing a good repellent properties was molasses grass (Melinis minutiflora), which apart from being a nutritious animal fodder also showed tick repellent and borer parasitoid attractive properties [26]. The trap plant such as Napier grass (Poaceae) was planted as a border plant around the main crop and intercrop. These Napier grasses (Pennisetum purpureum) have unique property of secreting green leaf volatiles which were used by the gravid stem borer adult females to locate the host plants which seemed tastier than the main crop. In response to the feeding by the hatched larvae, these plants secreted a sticky exudate which trapped the larvae and exterminated them. Nevertheless, researches had shown among all varieties of Napier grass only two Bana and Ugandan hairless Napier varieties remarkably attracted gravid females for oviposition. Apart from being a trap crop, Napier grass had also been shown to be used as biofuel and decontamination of polluted soil. Push-pull strategy could also find an useful application in controlling malaria vectors like Anopheles arabiensis. According to WHO 1982, animals had been successfully used in zooprophylaxis i.e. diverting (pull) mosquitoes and flies from feeding and transmitting diseases in human to other animals in order to reduce mosquito numbers and levels of malaria infestation. Tsetse flies (vector of vertebrate sleeping sickness) could also be controlled by push-pull strategy. Several series of kairomones for Savannah tsetse flies from preferred hosts had been identified for large scale suppression of their vectors.

Conclusion

The strategy push-pull is a nontoxic useful tool for integrated pest management programs reducing pesticide input. It is mainly concerned with the behavioral manipulation of the pests and natural enemies whereby several trap and companion crops are grown with the main crop with several eco-friendly approaches of pest management like use of pheromones and botanical pesticides. These eco-friendly approaches would however help in the conservation of natural enemies which would bring down the pest load below ETL and eventually lower broad spectrum pesticides use which brings pest resurgence and pest resistant problems The important demerits however lies in the methodical scientific study and dissemination of knowledge among the farmers. Constraints may involve around the farmers themselves and the need to produce clean stands of companion crops. Furthermore, very recently Napier grass, grown as trap plants was shown to suffer from Napier grass stunting disease. According to one source, the Napier stunt disease was caused by 16 SrIII group of phytoplasma whose vector could not be identified. Therefore there is an urgent need to identify the vector of Napier phytoplasma so that a regional resistance screening programme could be constructed.

References

Abate T, van Huis A, Ampofo JKO. Pest management strategies in traditional agriculture: an African perspective. Annu Rev Entomol. 2000; 45:631-659.

Agelopoulos N. Exploiting semiochemicals in insect control. Pest. Sci. 1999; 55:225-235.

Aminah A, Wong CC, Eng PK. Techniques for rapid vegetative multiplication for pasture species and commercial production. Regional Forage Development, FAO, Rome, 1997, 167-178.

Arocha Y, Teme Zerfy, Germa Abebe, Proud J, Hanson J, Wilson M et al. Identification of potential vectors and alternative plant hosts for the phytoplasma associated with napier grass stunt disease in Ethiopia. Journal of Phytopathology 2009; 157(2):126-132.

Bebawi FF, Metwali EM. Witch-weed management by sorghum–Sudan grass seed size and stage of harvest. Agron J. 1991; 83:781-785.

Birkett MA, Campbell CAM, Chamberlain K. New roles for cis-jasmone as an insect semiochemical and in plant defense. Proc Natl Acad Sci U S A 2000; 97:9329-9334.

Bouma M, Rowland M. Failure of passive zooprophylaxis: cattle ownership in Pakistan is associated with a higher prevalence of malaria. Trans. R. Soc. Trop. Med. Hyg. 1995; 89:351-353.

Brightwell R, Dransfield RD, Kyorku CA. Development of a low-cost tsetse trap and odour baits for Glossina pallidipes and G. longipennis in Kenya. Med. Vet. Entomol. 1991; 5:153-164.

Cairns JE, Hellin J, Sonder K, Araus JL, MacRobert JF, Thierfelder C et al. Adapting maize production to climate change in sub-Saharan Africa. Food Secur 2013; 5:345- 360.

Chamberlain K, Khan ZR, Pickett JA, Toshova T, Wadhams LJ. Diel periodicity in the production of green leaf volatiles by wild and cultivated host plants of stemborer moths, Chilo partellus and Busseola fusca. J Chem. Ecol. 2006; 32:565-577.

Cook SM, Khan ZR, Pickett JA. The use of 'push–pull' strategies in integrated pest management. Annu Rev Entomol. 2007; 52:375-400.

De Groote H, Vanlauwe B, Rutto E, Odhiambo GD, Kanampiu F, Khan ZR. Economic analysis of different options in integrated pest and soil fertility management in maize systems of Western Kenya. Agric Econ 2010; 41:471-482.

Hall DR, Beevor PS, Cork A, Nesbitt BF, Vale GA. 1- Octen-3-ol: a potent olfactory stimulant and attractant for tsetse isolated from cattle odours. Insect Sci. Appl. 1984; 5:153-163.

Heimbach F. Correlations between three methods for determining the toxicity of chemicals to earthworms. Pestic Sci. 1984; 15:605-611.

Khan ZR, Midega CAO, Wadhams LJ, Pickett JA, Mumuni A. Evaluation of Napier grass (Pennisetum purpureum) varieties for use as trap plants for the management of African stemborer (Busseola fusca) in a 'push–pull' strategy. Entomol Exp Appl 2007a; 124:201- 211.

Matthes M, Napier JA, Pickett JA, Woodcock CM. New chemical signals in plant protection against herbivores and weeds. In Proc. BCPC Int. Congress—Crop Science & Technology 2003, 10–12 November, SECC Glasgow,