Integrated Pest Management for Acacia: Prospects and Challenges

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Abstract

Species of Acacia have been extensively entrenched in the tropical, and semi-arid regions. Acacia species have been bounteous faces the pest and pathogenic pressure. Integrated Pest Management (IPM) is an immensely important aspect of producing a healthy Acacia plantation without harmful impacts on the environment. Here an attempt was made to determine the possibilities of integrated pest management for Acacia. Overall, this information will be helpful to increase awareness about the integrated pest management of the members of the genus Acacia.

Keywords: Acacia, insects, pests, management

Introduction

Forests are considered as one of the most delicate ecosystems on earth because forests are

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threatened by the non-native pests and pathogens (Wingfield et al., 2010). Trees and forests like a number of other crops are afflicted by an attack by insect pests plus diseases that result in lousy tree growth, bad timber quality, and in several instances, destruction and minimization of forest cover. With the ever-increasing human and livestock population, the amount of forest per capita is declining, particularly in the less industrialized or developing areas of the world (Wardle et al. 2004). It is estimated that the land under forest in developing countries is more than half of the forested land on earth. Considerable work is thus required in order to boost the output of the existing forests and also to afforest ideal areas. Moreover, we cannot ignore when it comes to the threats caused by forest pathogens and pests, which got amplified further by climate changes and global trade (Vitousek et al. 1989).

In this direction, a massive loss of forests, particularly by insects and invasive pests has become severe in recent years, worldwide (MacLeod et al., 2010). Under the particular circumstance, invasive pests and pathogens might be transferred to species that are native to vector. Then invasive pests can become vectors for indigenous or perhaps previously developed invasive pathogens (Wingfield et al., 2016). Several species of Acacia (particularly *A. nilotica* and *A. catechu*) are served as valuable trees of agroforestry system in India particularly the semi-arid zone of the country, because of their multipurpose uses as the critical source of timber or woody products and also of their potent therapeutic values (Chauhan et al., 2020). Sustained forestry generation of forest materials in arid and semi-arid aspects of India is of essential importance for the life support devices of the nation (Muzika RM 2017).

However, Acacias are symbiotically associated with various symbionts like ants, microbes,

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especially Arbuscular Mycorrhizal Fungi (AMF) that allow Acacias to generate a barrier against plant pathogens and pests even though some microbial strains are capable of spearing pathogenicity, either from other infected plants growing in the vicinity or due to human activities (Saini et al., 2019a; Saini et al., 2019b). Insect pests and diseases comprise the main biological determinants of forest efficiency, thus offsetting the attempt in improving wood output. In the forests as well as woody ecosystem the standard emergence, as well as the occurrence of the non-native species of insects and pathogens, start to be highly deplorable (Paine et al., 2011; Wardle et al., 2017). This newly appeared association of pests and pathogens pressurize and threaten the same trees that exist in their precisely the same indigenous environment (Mattson et al.,2007; Wingfield et al., 2010; Dudley et al., 2012).

In the past few years, the Acacia species(mainly *A. catechu* and *A. nilotica*) are planted on a large scale especially in the tropical and semi-arid environment due to their rapid growth in this environment. Now, these species become the critical components of the forestry or agroforestry industry in this environment (Chauhan et al., 2020). The forest sector related with the plantation of Acacia species severely affected due to severe impact of pests and it drastically reduced the growth and development of Acacia species and strenuously jeopardise the future of plantation forestry in the entire world. The emergence of pest and pathogens on the plantation of invasive alien species of Acacia exactly followed the similar patterns as that of invasive species of Eucalyptus (Goodland and Healey, 1996; Wylie and Speight, 2012).

The native insects and pathogens chiefly that showed wide range towards their host are the responsible agents for creating the various type of pathogenic diseases and insect pests (Trang et

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al., 2018). In South Africa, *Phytophthora sp*. found as a responsible agent for the root disease of *A. mearnsii*, and wattle bagworm (insect) was found to be the causal agent for the defoliation of the *A. mearnsii* (Van der Putten WH,2007; Kirsten et al., 2003). In South-east Asia, the native Ganoderma, *Helopeltis sp*. (insect) and larvae of Lepidopteran insect (*Plusia sp*.) are proved as the causal organism of root rot disease, shoot disease, and defoliation of *A. crassicarpa* and *A. mangium* respectively. Different species of Acacia are found to be sensitive and primarily damaged or destroyed by various groups of insect pests (such as Coleoptera, Lepidoptera, Hemiptera and Orthoptera) (Tsopelas et al., 2003).

Integrated Pest Management (IPM) works by managing the ecosystem. It mainly focuses on long-term prevention of pests or their damage by managing the ecosystem through proper strategy. Integrated pest management (IPM) strategy and tool: IPM includes the development and use of chemical, natural, biological and biotech products for pest control (Zettler et al., 1990). Complete information about pest living help to stop unwanted damage of insects species since, in several instances, a particular number of pests could be accepted (Koshiya et al., 2003). Growing plant life, which is tailored for their growing conditions, growing them in the correct spot, giving suitable interest to the water of theirs and also food requirements as the plant needs (Zettler et al., 1990). In this review article, an attempt was made to determine the possibilities of integrated pest management for Acacia.

Management approaches

Silvicultural interventions which lead to wounds should, therefore, be stayed away from during times of higher pest actions (Hayslett et al. 2008; Heath et al. 2009b). In exotic southeast Asia,

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nitidulid and ambrosia beetles are contained in Acacia plantations and also considered essential vectors of *C. manginecans*, although their activity hasn't been administered (Tarigan et al. 2011; Brawner et al. 2015). There is an expectation that insect activity will occur year-round (Wolda 1988) though. Because of the dynamics of parasitism and plant investment in anti-herbivore defences, populations may be higher during the dry than wet season (Dyer et al. 2012). Wound dressings provide a physical barrier to Ceratocystis infection as well as inhibiting fungal growth (Harrington 2008), and low toxicity treatments have been developed. Most direct and conventional methods of control are the use of fungicides, insecticides and pesticides. The Acacia seeds after their treatment are sowing in the nursery beds. Seeds are sown either by dibbling method or by broadcast sowing method. However, out of these two methods, the dibbling method is used preferably. The seedlings of *A nilotica* are infrequently nurtured in the nursery beds. Generally, polythene containers are used for their growth (Ferreira et al. 2017). In each polythene bag or container, at least two or three adequately treated seeds (about 1.5 cm deep) are sown during February-March before their transplantation into the field. Polythene Bags or containers have the soil mixture in which soil and compost are present in the ratio of 2:1. In vitro tissue should be derived from healthy plants, raised in closed facilities and grown on sterilized media (Ribeiro et al. 1988).

Physical methods

Removal of pest from the particular desired place through physical means. For example, by using barriers, traps and thorough vacuuming. The boiling water as well as acid remedies, however, most likely perform like a partial sterilization therapy for microorganisms or maybe microfauna borne

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superficially on the seed coat. The acid pretreatment is acute, having been employed effectively with *A. mangium*, but isn't suited to other species. An IPM boll weevil capture in the industry (Kim et al., 2001). Seeds are cleaned of all extraneous material and then sealed in laminated plastic bags containing carbon dioxide for two weeks, before entering the storage areas. The seed also treated with methyl bromide to avoid any type of contaminant (Dudley et al.,2012). As noted above, the hot water and acid scarification methods of breaking dormancy are extra insurance against insect pest infestation. However, these measures may not be completely effective where insect larvae are sequestered within substantial seeds treatment. For the storage of seeds basket or tins and gunny bags can be used (Zettler et al., 1990).

The cold and dry places with proper circulation of air must be selected for seed storage. For long term duration, the essential requirement is that the seeds should be wholly air-dried and should be kept in airtight containers. The seed coat of Acacia seeds is tough and impermeable. So the pretreatment becomes an essential requirement to accelerate the germination (Wardle et al. 2004). For this purpose, pods of Acacia species are used for the animal feed. Out of these four treatments, the hot water treatment of Acacia seeds proved as protected, instantaneous and efficient method and hence recommended for seed treatment. *Trichilogaster sp*. and the larvae form galls within the flower buds (and occasionally in vegetative tissue) of Acacia species resulting in reduced seed production, reduced biomass and in some cases tree mortality. Some species develop entirely in vegetative tissue of the host Acacia (Koul, 2002).

Biological methods

Biocontrol is an environmentally friendly approach and effective method of reducing or mitigating the pests and their damaging effects by the application of characteristics of the innate antagonist. Biological control is a technology by which pests such as mites, insects, weeds and diseases causal agents are efficiently destroyed with the help of microbial activities. In practice, there are few examples of successful biological control in forest trees (Wingfield et al. 2008; Garnas et al. 2016). Bacteria that live internally in plant tissue without causing any negative impact on their host are recognized as endophytic bacteria (Schulz and Gray 2013). Some have mutualistic associations with the host plants of theirs as well as an ability to live as facultative or obligate endophytes at various phases in their life cycle (Hardoim et al. 2008). The vast majority of the investigation into endophytic bacteria has been with horticultural and crops (Palumbo and Kobayashi 2000). Nonetheless, many species of endophytic bacteria have been isolated from woody species (Palumbo and Kobayashi 2000; Hinton and Bacon 2006; Izumi 2011). The more abundant biomass dynamics of trees likely offer a steady habitat for a diverse assortment of endophytes (Izumi 2011) and also increase the chance that they might perform a role as BCAs against vascular diseases like Ceratocystis (Thomma and Yadeta 2013).

Bacterial endophytes suppress plant diseases through the production of enzymes, antifungal and antibacterial compounds (allelochemicals), by competition with pathogens for nutrients or niches and stimulation of induced systemic resistance (ISR) (Compant et al. 2005; Bacon & Hinton 2006). However, there are few reports of endophytes acting as BCAs in forest trees (Chanway 1998). This delay in their development and application is in part because their performance in the field has not matched their apparent potential when tested in the assay. Thus, a selected endophyte may be replaced by or act differently in the presence of other endophytes already present in the host

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(Newcombe 2011; Hilszczanska 2016).

The efficiency of natural plant products as controlling agents of pest and pathogens

Synthetic pesticides have been applied during the past few years on a large scale for the management and control of various pest and pathogens of crops and forest trees. Applications of chemical-based pesticides act as helping hand to save the trees of the forest and also of their production (Way and Van Emden, 2000). Due to extensive and continual use of synthetic or chemical pesticides have intruded varied degree of the destructive impact on the biotic and abiotic component of the ecosystem and also create harmful effect to the nontargeting and beneficial organisms (Forage-Elaver, 1989; Rajeskaran and Baker, 1994; Gupta et al., 2015). The excessive use of synthetic pesticides or chemicals act as a toxicant, and these served as poison for the living being. The list of botanicals as controlling agents of against insect pests is provided in Table 1.

Table 1. Utilization of botanicals as controlling agents of insect pests.

Name of Plant	**Plant products**	**Biocontrol activity**	**Targeted organisms**	**References**
Acorus calamus	Acorus	Larvicidal	Aphids and caterpillar	Bhardwaj et al., 2010
Azadirachta indica	Azadirachtin	Pesticidal	All insects	Ruprrecht et al., 1990

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Allium sativum	Allicin	Insecticidal	Termites and Insects	Yang et al., 2009
Cappris decidua	Capparin	Insecticidal	Termites and insects	Upadhyay et al., 2007, 2011, 2012
Cacaliatanguitica	Rotenone	Insecticidal	Complex I inhibitor	Lu mmen, 1998
Chrysanthemum cineriaefolium	Pyrethrum	Insecticidal	Aphids	Bhardwaj et al., 2010
Croton urucurana	Resin	Larvicidal	*Dysderdercusmaurus*	Silva et al., 2012
Copaifera reticulata	Oil resin	Larvicidal	*Aedes aegypti*	Silva et al., 2007
Copaifera multijuga	Oil resin	Insecticidal	*Anopheles darling*	Trindade et al., 2013
Hot pepper	Capasciacin	Insecticidal	*Trichoplusiani*	Annontois et al., 2007
Hot pepper	Capasciacin	Insecticidal	*Tetranychusurticae*	Edelson et al., 2002
Diaprepes abbreviatus	Sabadilla	Antifeedant	*Schistocerca Americana*	Sandoval-Capinara, 2011

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Nicotiana tobaccum	Nicotine	Toxic and Antifeedant	Sucking insects	Dederer et al., 2011

Because of their persistent nature for a long duration, these pesticides tend to accumulate in the environment, and hence these are not safe ecologically. Due to their biomagnifications, these chemicals enter into the food chain and thus causes a detrimental effect for the environmental components (Beyer and Biziuk, 2009). Therefore, the large scale use of chemicals or pesticide adversely disturb the food chains and act as a toxicant for the functioning of the beneficial and non-targeted pests. These toxic chemical pesticides function as the damaging and threatening factor for every component of the environment and so on the biodiversity. Different types of insects or pests have gained the resistance or become resistant against the synthetic chemicals or insecticides because the long term exposure of these toxic chemical induces the changes in their genetic makeup, as a consequence of which various types of strains of insects or pests developed, however, most of the insecticides or pesticides are banned (Brattsten et al., 1986; Zettler and Cuperus, 1990). List of essential oil of different plant species used as an insecticidal agent is provided in Table 2.

Table 2. The essential oil of different plant species as an insecticidal agent.

Essential oil	**Targeted insect**	**Biological activity**	**References**
Allium sativum	*Lycoriella ingénua* (Dufour)	Insecticidal	Park et al., 2006
Artemisia princeps oil	*S. oryzae* and *B. Rugimanus*	Repellent, Insecticidal	Liu et al., 2006
Cedrusdeodara	*Phthorimea*	Oviposition	Chaudhary et al.,

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	operculella	Inhibitor	2011
Capparis deciduas	*Bruchus chinensis*	Insecticidal	Upadhyay et al., 2006
Curcuma longa	*Callosobruchus maculates*	Insecticidal	Tripathi et al, 2002
Cumin	*Bruchus chinensis*	Insecticidal	Upadhyay et al., 2007
Eucalyptus oil	*Ades albopictus*	Repellent, toxic	Yang and Ma, 2005
LanatanaCamara oil	*Musca domestica*	Insecticidal & Repellent	Abdel Hady et al., 2005
*Mentha piperata*oil	*Ades albopictus*	Repellent, toxic	Yang and Ma 2005
Neem seed oil	*Tribolium castaneum*	Insecticidal & Repellent	Koul 2004
Piper nigrum	*Tribolium castaneum*	Insecticidal	Upadhyay and Jaiswal 2007
Pelargonium sp.	*Aeded aegypti*	Insecticidal	Ali et al., 2013

Due to the higher level of toxicity, environmental persistency and detrimental effects for the biotic and abiotic components, hence the demand and use of natural plant product as eco-friendly and effective insecticides or pesticides are continuously increased in controlling the disease of crops/forest trees (Ismam, 1955; Alkofahi, 1987). Various plant-based natural products or botanicals (Koshiya and Ghelani, 1993) like Acorus, azadirachtin, nicotine, pyrethroids, and rotenone (Barnby and Klocke, 1987; Ayyangar and Rao, 1989; Deota and Upadhyay, 1993).

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Currently, plant products or extracts are widely utilized as an effectual remedy against the pest and pathogens because of their strong growth and disease inhibitory potential (Koshiya and Ghelani, 1993; Ballesta 2008). Therefore, these natural plant products or biopesticides served as a potent and adequately advantageous substitute for the synthetic chemical for the management of the pest. Nowadays, the application of these environmental friendly biopesticides becoming a prime focus in the field of managed forestry or agroforestry.

Future of biological control

About 98% population of pest is controlled or regulated by the natural organisms in any environment. Currently, the use of chemical pesticides or insecticides significantly reduced because of their persistent nature and continuous accumulation in the environment they act as a toxicant for the biotic component of life and causes an environmental health hazard. Therefore, the biocontrol agents becoming an essential tool for controlling the disease incidence of pest and pathogens. In any environment, the emergence and introduction of new predators and parasitoids also act as a good source for the biological control mechanisms. The biocontrol agents are proved as advantageous that the conventional pesticides, but it is highly essential to reshape the other measures of control (like the use of pesticides). These biocontrol agents maintain the ecological balance as these are eco-friendly and does not create any harmful effect for the biotic and abiotic component of the ecosystem and hence much used as a useful measure for the management of the agricultural pest. Currently, biopesticides becoming the centre of attraction of the entire world because of their nonpercistancy and environmentally friendly nature and, hence gaining the momentum. Therefore, the collaboration between the governmental and private sector is essential to support the growth, manufacturing, and sale of these eco-friendly biopesticides.

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