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Research Article

Studies on Banana Insect Pest complex in tropical and subtropical areas of Asia

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Abstract

The study was conducted during crop growing seasons of 2015 to 2016. Broad range surveys were conducted in all banana growing areas of India and various information collected were presented. A total of nine insect species and nematodes were found to damage banana crop from start of rhizome growth till harvesting of fruit. The major insect species discussed were rust thrips, aphids, rhizome weevils, pseudostem borer, fruit scarring beetles, hard scales, Tingid bugs and nematodes. During the survey information about banana cultivation and production constraints were collected from farmers using questionnaire, discussion, meetings, cross talks and personal calls. For more accurate update regarding banana pest complex the old aged farmers and heads of communities were contacted and information was collected. Pest Management practices followed by farmers were collected and latest information about insect pest damage and diagnosis were sheared to farmers..

Keywords:

1. Introduction

Southeast Asia is the main origin of bananas domestication. However the consumption of the banana was quoted in the earlier literatures of Greek, Latin and Arab. At global level the banana (*Musa acuminata*) comes at 4th rank as one of the most important starch crop. From nutrition point of view the content of carbohydrate in banana is very high; therefore realizing its nutrition value it is 4th widely grown food crop after rice, wheat and maize. It dominantly works as a staple food in many countries. Banana supports the farmers living in western, central, eastern and coastal areas of Asia especially India. In India, it is generally grown by small-scale farmers (Viljoen *et al*. 2016). For many purposes including domestic consumption, income generation, and preparation of organic manure and for packing various types of materials and food items. India ranks 1st as the largest banana producer in the world capturing 32% share of global banana production (AICRP-2020). According to one report from Statista inc.UK (2021) the volume of banana produced from 877 thousand hectares were 32 million metric tons during 2020. Among various banana producing certified countries the Ecuador ranks first as producer of global certified producer (FAO 2017). At present the food crisis are increasing at an alarming rate and banana is one of the crop to mitigate the crisis, since it work as one of the preferred staple food source for most of Indian people. Bananas have a good reputation because of its diverse varieties and adaptability to many types of environmental conditions. Besides, it is being easily produced due to fewer packages of practices to follow and as a ready market cash crop. In Kenya, the area under banana is comparatively larger than other fruit

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crops, cultivated year round and is adapted as an intercrop with many field, vegetable, ornamental and medicinal crops. In use the banana is multidimensional and used in many ways e.g. green, ripe and as value added product for many items.

Globally, the banana production is declining due to various factors and one of the important factor is the interference of disease, insects and vertebrates (Blomme *et al*. 2020; Blomme *et al*. 2017; Blomme and Ocimati 2018; Onyango *et al*. 2002; Tayade *et al*. 2014) that together reduce the overall production in terms of fruit quality as well as quantity. The insect pests have become a great and major trouble (Dar and Mir 2016, Dar *et al*. 2017ab) obstructing profitable yield of banana crop (Kikulwe *et al*. 2019; Kikulwe *et al*. 2020), and many cultivars have got adversely damaged by range of pests leading to great losses annually. Among insect and other agents that damage banana annually includes thrips, nematodes, and banana weevil. The main and important insect pest of banana that contributes to its major loss is Banana weevil (Kungu *et al*. 1996) causing the yield loss of about 40 to 100% (Mitchel 1980). The banana weevil *Cosmopolites sordidus* is a major problem damaging severely in highland cultivars (Gold et al.1998), and it is controlled widely by many types of traps leading to their physical destruction. Further many researchers use insecticides and some biological agents for management and results were found satisfactory (Gold and Messiaen 2000).

Here we generated the all information regarding the IPM comprised of the applications of many tactics (Dar *et al*. 2015, Dar *et al*. 2017) such as biological, cultural and chemical (synthetic and natural products) (Tlak Gajger *et al*. 2011ab; 2013ab) practices to control insect pests of banana. It seeks to use natural predators, parasites and diseases (Tlak Gajger *et al*. 2014ab, 2015) to control insect pests. Farmers and other communities use selective pesticides to manage pests as last option as backup when pests menace has crossed limits and are unable to be controlled by natural means. Aforementioned, in India the yield of banana is hindered due to many issues (Chowdhury 2014). Besides these production issues the farmers are not well aware and equipped with technical information and skills to identify and diagnose the pests and other agents, respectively. The identification and general knowledge of pest is prerequisite for the management of crop loss. The technical knowledge of the farmer to identify insect pests is essential to improve banana production in India. Empowerment of farmer community to mitigate pest problems at their banana farms at initial stage may prevent the spread of pests to other areas to prevent loss in crop. Currently many control measures are available with farmers to manage the loss and these tactics mainly includes biological, chemical, mechanical, cultural and physical. Therefore, the present study were undertaken to identify and characterize the insect pests of banana and grower's perception of core issues hindering higher yield.

2. Material and methods

The study was conducted based on the broad range surveys of all banana growing areas of India. Insect pest diversity, incidence and severity were determined. The surveys were done from March 2015- February 2016 to record insect pest complex of banana, mode of action, biological stages and extent of damage. The various insect pest samples were collected using many methods and insect nets during the survey. All insect samples collected during surveys were killed by ethyl acetate and later pinned. The killed samples were stretched using insect board and steel entomological pins, later oven dried for half an hour at 30-35 ^{0}C to avoid pathogenic contaminations. The immature and adult insect stages were collected and described based on their morphology. Under laboratory conditions various behavioral aspects especially feeding characteristics were studied. Different magnifications of stereoscopic microscope were employed for the clear identification and sample description. Plant samples were taken to laboratory and analysised for various damage symptoms.

3. Results and discussion

During the survey we found total of eight insect pests and others attacking the banana crop at various stages and cause significant losses. In India, the total loss by pests and disease rank II and contributed by 70% (Sarma *et al*. 2020) of total loss. Normally the insect pests attacking banana are sap sucking and cause quality degradation. We presented here the general description of the insect pest, damage pattern and management options taken up by farmers.

Rust Thrips

Rust Thrips *Chaetanaphohrips signipennis* are minute insect of size 1 mm long belonging to an order Thysanoptera and are generally known as slender insects.

Symptoms of damage: In banana the infestation by *C.signipennis* produce reddish brown extended oval stains. During severe infestation the peel splits and flesh discoloration occurs. Feeding damage is observed but the damage varies with host plant species and biotic and abiotic factors. Generally rust thrips prefer fresh, succulent, immature fruits, flowers and foliage. Thrips feeds on whorls of immature leaves. The leaf whorl

appears discolored and white streaks were found. The other symptoms of damage include random squiggles or curlicues at the petiole end and in unfurled leaves. The infested immature leave fall or unfurl and deform leaf whorl. Sometimes, the infested leaves have white streaks scarring on front and back of deformed spathe. The damaged areas get injured more to impact overall health of plant. Under the conditions of sever thrips infestation, the mature authurium spathes fail to open. Plant grown gets retarded and foliage deform, appear bronze like with clear streaking. The damage by rust thrips to some cultivars (kalapana and Ozaki) leads to symptoms of curlicues rather than streaks. Generally, the rust thrips damage is distinct at pseudostem, which may significantly affects marketability of produce. The damage to leaf sheaths appears as characteristic dark V-shaped marks on petiole. The leaf sheath become bronzed, and rust coloured with age. The symptoms of rust thrips attack on fruits appear soon after petals dry. The initial infection is identified by water-soaked appearance on fingers. The immature and young fruit have dark and have Smokey coloured squiggle. The fruits also show curlicue feeding streaks on surface. While as, on mature and ripe fruits the oval shaped reddish stains were observed. Under severe form of infestation, the oval shaped reddish stains were found, and more of the fruit is damaged with reddish brown discoloration. The black discoloration and superficial creaks were found on surface. Although the surface is discolored due to pest damage but the fruit is still consumable.

Management: During the survey to all banana growing area of India, the data obtained showed that commercial value of banana crop were adversely reduced due to red rust thrips from fruiting till maturity of crop. The applications of imidacloprid (0.3ml/500 ml) @ I ml/bud recorded reduced fruit damage significantly. While as applications of azadirachtin (1%) (5ml/ liter water) @ 2ml/bud were also found significant in reducing the damage. Similar, reports were also found by Bisane *et al*. (2017), Denmark and Osborne (1985), Hara *et al*. (2002) and Padmanaban and Mustaff (2010) and Patil *et al*. (2015).

Aphids *Pentalonia nigroervosa*

During survey we found that aphid species that dominantly attacks bananas is *P.nigroervosa.* It is found throughout tropical and subtropical countries and specifically in India it is found in all banana growing areas. The body coloration is dark red to black, morphologically alate and apterous; possessing siphunculi and cauda. Female is 1.28-1.73 mm long; while male is shorter and ranges from 1.10 to 1.25 mm in length.

Symptoms of damage: During survey under sever conditions of aphid attack the leaves get bunched into a rosette appearance. The leaf margin get wavy and upward curled that may overall reduce vigour and growth of plant. The infected plants do not make bunches and therefore act as a bunchy top disease. Generally this is observed that aphid form colonies on the leaf axils and pseudostem. The host range of aphid includes banana and several monocotyledonous ornamentals for example, *Dieffenbachia. P.nigroervosa* reproduces by viviparous parthenogenesis. The activity of this species ranges from autumn to winter, when it migrates subterranean to upper parts like leaves. With the rise in daily temperature, the aphids migrate back to soil till next autumn. Similar results were earlier found by Jekayinoluwa *et al*. (2021) from Kenya.

Economic importance: The aphid *P. nigroervosa* causes considerable losses in banana, form large colonies of hundreds of individuals covering all parts of plant and cause culling of fruits. The secreted honey dew cause discolorations and invite ants for more quality deterioration. The ants make nests nearby plants canopy and therefore make habitat unsuitable for natural enemies. The honeydew is colonized by disfiguring sooty-mold fungi and cause further degradation in quality and quantity of the produce (Jekayinoluwa *et al*. 2020).

Management: During survey we found that farmers practice several management practices to reduce aphid colony development. For example, polythene bags were used to cover fruits; that may also control the development of bunchy top disease. Further, the use of organophosphates were done directly against to aphids, whileas as chemical pesticides were also used by farmers to control ants which transport aphids from one site to another, and may disturb the natural enemy populations. Biologically, the commonest natural enemy of the aphid was Coccinellidae from the genus *Scymmus*. The other natural enemies which were found during survey include species of genus Syrphidae, Aphelinidae, Braconidae, Aphidiidae and *Aphidoletes aphidimyza.*

Corn Weevil *Cosmopolites sordidus*

Symptoms of damage: The *C. sordidus* is a dangerous pest of banana in many countries including India. Grub of this weevil is main causative agent of damage and it tunnel into the base of suckers, roots and rhizomes and corm. The symptoms are clear from a large number of larval tunnels in pseudostems. With the passage of time the yellowing and withering of leaves occur. The grub damage reduces plant vigour; causes root destruction and reduce the yield. The damage plants are easily blown away by winds. The *C. sordidus* is destructive pest of banana and other fruit crops in most banana growing countries, and the damage is most in variety "Highland cooking bananas" and ensete. In Highland cooking banana a heavy decline of plant population has occurred due to grub damage. The extent of damage is variable across different varieties; and in

Cavendish plantations the damage by weevil is non-significant (Gold and Messiaen 2000). The start of damage by *C. sordidus* mainly begins from base of the leaf sheath. Whileas, in case of an already injured tissue or leaf, the damage symptoms appear first from pseudostem. The young grubs make several minute tunnels. The tunnels are longitudinal and later the grub enters into adjacent inner leaf-sheath. From leaf-sheath the grub damages at pseudostem base and rhizome/corm or also penetrates into suckers and roots. The infested pseudostems fall down and the larvae tunnels are clear and run all along the entire length of stem. Plant turns dull coloured followed by yellowing of leaves and floppy foliage. The foliage dropping occurs with enhancement of infestation; whileas young suckers wither and fail to develop; and are blown down even with small speed winds. Similar damage symptoms were earlier found by Tresson *et al.* (2021).

Management: Various pesticides were used by farmers to control *C. sordidus*. The pest has substantial social and economic importance due to considerable damage to banana crops. Many classical biological control operations against *C. sordidus* were used to minimize the damage due to *C. sordidus*. Various predators, parasite and parasitoids were found efficient to control the pest. Further, ants were also used for the damage reduction. The damage sites were further followed by other infections and with the consequence the overall yield reduction were recorded. Similar results were recorded by Heck *et al*. (2021) form Brazil.

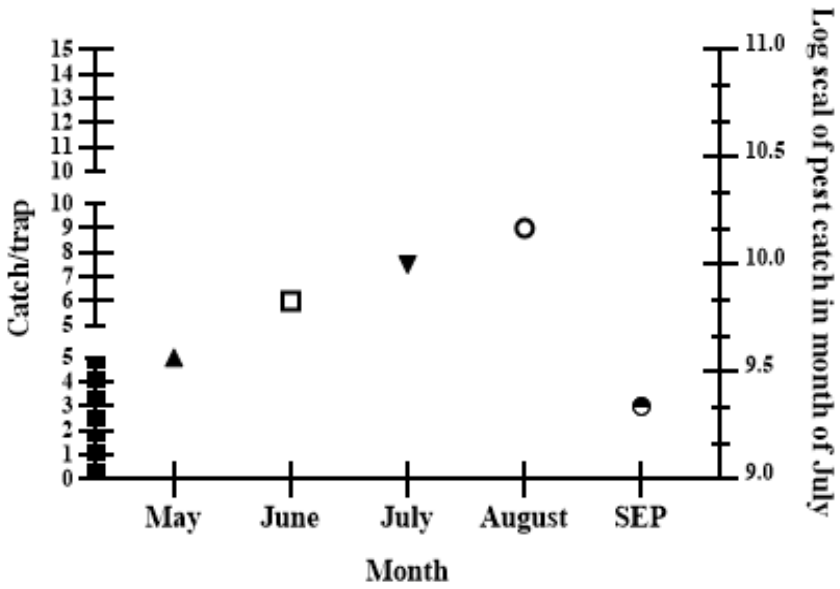

Fig 1: Monthly monitoring of banana weevil borer *C. sordidus* in plots with pheromone traps installed showed significant differences ($p < 0.05$) by pair-wise t-test comparison with different monthly catches found.

Stem weevil or Pseudostem borer Odoiporus longicollis

Symptoms of damage: The major symptom of damage by *O. longicollis* involves the appearance of small pinhead-sized holes on pseudostems. The jully like exudation on stem were found followed by secondary infection by various pathogens causing further damage of banana plants. The rotting of stem followed is by emission of foul odor. The fruits from infested pseudostems do not develop to maturity and tunneling weaken the plant that later succumb to dryness either naturally or fall down due to low speed winds.

Management: Different chemical pesticides were used for the management of stem weevil. Various biopesticides were evaluated and *Beauveria bassiana* were used to reduce the population of weevils. Further, other cultural and mechanical practices were also followed by farmer to manage the weevil damage.

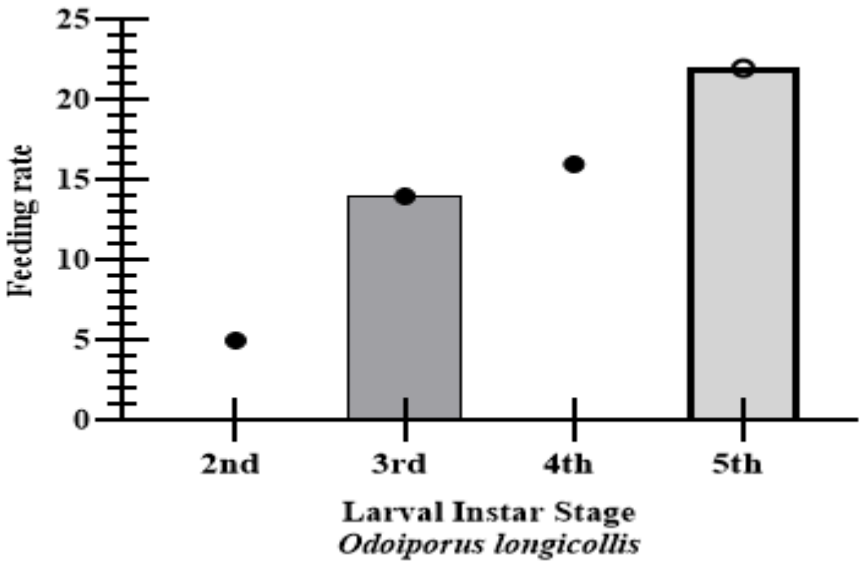

Fig 2: Feeding rate of different grub stages of *Odoiporus longicollis*

Banana fruit scarring beetle Basilepta subcostata (Chrysomelidae : Coleoptera)

During the survey of two years, we found that *B. subcostata* is an important insect pest of banana. The pest damages leaves and fingers; and higher levels of damage degrades the cosmetic value of fruits. During the survey we found that pest has spread to many states like Assam, Bihar, Chhattisgarh and in the North-Eastern Hill regions which is in confirmation with the findings of Mishra *et al*. (2015) and Bhagabati and Deka (2016) from India. At present the pest is controlled by foliar sprays of many insecticides. Further, various attempts are being made by farmers to control this pest using many entomopathogenic formulation obtained from *O. longicollis*, *C. sordidus*, *B. subcostata* and *Galleria melonella*. The pest is distributed in many regions of Africa and India. Research suggested that this pest is comprised of almost 200 species (Simmonds, 1966) and is considered as one of the most economically important pests in North-Eastern India (Mishra et al., 2015 and Bhagabati and Deka, 2016). The genatilia of either sex helps in correct identification of pest as *B. subcostata* (Prathapan *et al*. 2019) and many strains of Entomopathogenic were observed and found suitable for commercialization to control the pest damage. The majority of Entomopathogenic formulations used for the management of *B. subcostata* were cultured from *Ascomycota*, *Beauveria* spp. and *Metarhizium* spp.

Hard scale Aspidiotus destructor (Diaspididae: Hemiptera)

Symptoms of damage: The weakening and death in plants occur due to feeding of grub on internal tissues. The bored rhizomes cause excessive weakening in plant. The brown to dark black coloured tunnels are produced that ultimately lead to withering of outer leaves and finally death of plant. The *A. destructor* also attacks other fruit plants like coconut, savocado, breadfruit, ginger, guava, mango, mock orange, mountain apple, oil palm, sugarcane, and tea (Almarinez *et al*. 2020). Many control tactics have been practiced by many researchers and significant achievements have been recorded (Palen *et al*. 2019).

Some Biological aspects of A. destructor

Eggs: Usually laid beneath the scale, females shrink in size and lay eggs in concentric circles around it. Oviposition in 3 to 4 batches are laid at once and a total of 70-105 eggs were seen to be laid by single female.

Nymph: The crawlers are equipped with well developed legs, antennae, pairs of bristles on abdomen, with maximum free living time of about two days. First moulting starts just after the larval attachment to leaf surface that leads to its rapid growth in size for 9 to 12 days. There are five larval stages differing in their length (**Fig-1**). There were differences among sexes in larval periods and usually lasts from 5-7 and 9-11 days in males and females, respectively.

Tingid or Lace wing bug (Stephanitis typicus):

In order Hemiptera the Tingidae are a family of very minute insects varying in size from 2.00-10.00 mm in length. Members from family Tingid are distributed worldwide and comprised of 2000 species.

Symptoms of damage: This pest is prevalent in Asian and African countries, infesting coconut and bananas and causing considerable losses in overall yield. The populations of this tingid bug build up under suitable environmental conditions and usually the population is brought down by predators, parasites and diseases. During the survey we found that the bug infestation cause white spots on upper surface of leaves and sucks sap from foliage. The bug also acts as a vector for the transmission of phytoplasma from wilted roots to healthy plants.

Management: The natural enemies especially predatory insect species *Stethoconus praefectus* reduce the infestation when farmers use them in an integrated approach with other tactics. Neem oil emulsion and garlic oil @ 2% as spray were used to control this pest. Poorani *et al*. (2019) found that *S. typica* is parasitized by an obligate predator and egg parasitoids especially *Erythmelus panis* and *Anagrus* spp.

Burrowing Nematode Radopholus similis

Symptoms of damage: This nematode is a very widespread problem in banana crop. The nematodes look reddish-brown to black in colour. The main site of damage is roots. The elongated area seen parallel to the root axis which eventually blacken and die. The plant showed lack of vigour and later poor fruit yield is achieved. Plants showed weakness and topple over its weight and roots get exposed; therefore causes toppling disease in banana. The burrowing by nematodes destroys the root system. The plants are left with little to no support and fail to take up water and translocate the nutrient.

Management: During the two years of survey we found that keeping cultivated land follow for the period of one year reduces the burrowing nematodes. Further the addition of nematicidal treatments to the soil also reduces nematodes during banana cultivation. The nematode control is normally based on few applications of nematicides per year; however the repeated applications create many problems like toxicity to end consumers of crops and the environment. Most researchers have observed that a simple fallow period of one is not insufficient to reduce nematode populations significantly. For complete elimination of the nematodes, many things need to be done properly like efficiency of destruction of old banana debris, sanitations and maintaince of proper soil physical and chemical conditions. In one of the study done regarding *R. similis* two treatment effects were compared, comprised of injection of glyphosate in pseudostems and normal mechanical elimination of pseudostems through spading-machine. The two techniques employed have enhanced the benefits of fallow cycle and has reduced infested plant population to 12.2% in contrast to 76% infested plants under mechanical control. The overall yield gains during the experiment were 14% and 29% of output in tonnes. The genetically modified banana developed at UK and Uganda have offered some level of resistance to parasitic nematodes. In Africa, the expected loss due to nematode damage is almost 25 million dollars. Haung et al. (2021) observed that R. *similis* is an important migratory endoparasitic nematode damaged banana and citrus at large scale. The nematode attacks and feeds in cells of the cortex of the roots; producing cavities which coalesce and form red-brown lesions. With the advance of infection, the root tissues turn into black to brownish mass and with consequence plants becomes weak, yellow and ultimately wither away. The disease produced by this nematode is called as toppling disease which causes heavy losses to global banana yield; therefore this pest is categorized as one of the top ten plant parasitic nematode worldwide (Jones 2013).

4. Conclusion

Banana is damaged by several insect pests and yield losses are high in all areas. Therefore conducting this survey based study, it is stressed and strongly felt that latest technological intervention and shearing of IPM knowledge among the farmer's community of all banana growing areas is must.

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