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SCREENING OF SOME PROCESSING GERMPLASMS OF POTATO AGAINST *MYZUS PERSICAE* (SULZ.) AND *BEMESIA TABACI* GENN. IN EASTERN GANGETIC PLAINS OF WEST BENGAL

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Abstract

Six processing germplasms of potato *viz.* Atlantic, Kufri Chipsona-1, Kufri Chipsona-2, Kufri Chipsona-3, Kufri Frysona and Kufri Chandramukhi were screened for resistance against *Myzus persicae* (Sulz.) and *Bemesia tabaci* (Genn.) in potato during two consecutive rabi season of 2010-11 and 2011-12 at Adisaptagram Block Seed Farm, Hooghly, West Bengal, India. Among these germplasms, Kufri Frysona was evaluated for the first time in the eastern gangetic plains of West Bengal. Kufri Chandramukhi was found to be the most susceptible germplasm harbouring highest number of major sucking pests viz., aphids (38.92 per 100 compound leaves) and whitefly (42.25 per 100 compound leaves) and at the same time produced lowest yield of potato tubers per hectare (12.22 tonnes/ha). Kufri Chipsona-3 was found to be resistant in comparison to other germplasms harbouring the least number of aphids (11.00 per 100 compound leaves) and whitefly (14.50 per 100 compound leaves) producing satisfactory tuber yield per hectare (17.80 tonnes/ha) while Kufri Frysona was found to be tolerant as it recorded the highest tuber yield per hectare (19.00 tonnes/ha) despite of higher population load of aphids (15.58 per 100 compound leaves) and whitefly (20.67 per 100 compound leaves) in comparison to Kufri Chipsona-3.

Keywords : Screening, potato, germplasms, Myzus persicae (Sulz.), Bemesia tabaci (Genn.)

Introduction

Potato popularly known as 'The king of vegetables' belongs to the family Solanaceae and is native to the Andes Mountains of South America. It is cultivated in more than 100 countries worldwide and is consumed by more than a billion people in many different ways. China is the world largest potato producer, and nearly one third of world potato production is harvested from China and India. Asia in general and India in particular are the hubs of potato production and consumption in the world. Potato is the fourth most important food crop in india after rice, wheat and maize with just 0.8 % of gross cropped area (**Scott and Suarez, 2011; Scott and Suarez, 2012**). In India, potato is a major vegetable crop and is being grown in a wide range of climatic conditions (**Pandit and Chandran, 2011**). Potato plays an important role in global food and nutritional security especially for the poor (**Thiele *et al.*, 2010**).Technological advances made by the indian scientists in the potato cultivation, have resulted in to its higher average productivity in the country and India now ranks second in World potato production (**Anonymous, 2010**). India produces 7.72% of the world's potatoes from 7.57% of the total global potato growing area, with productivity levels higher than the world's average (**Rana, 2011**). India produced 42.34 million tons from 1.86 million ha with an average yield of 22.72 t/ha of potato during 2010-11 (**Agricultural statistics at a glance, 2012**). Inspite of higher productivity, there is huge potential to increase the productivity of this crop in the country.

In India, West Bengal ranks second in potato production after Uttar Pradesh, the leader in potato production in the country. Both of them collectively contribute more than 50% of the country's production of potato. In West Bengal, Hooghly accords the highest production of potato contributing 24.82% of state's production followed by Paschim Medinipore, Burdwan, Bankura and Jalpaiguri. Only 0.5% of the total production is processed while about 17% are lost in post harvest handling, marketing and storage (Food Processing Industries Survey, West Bengal). The major varieties of potato cultivated in West bengal include Kufri Chandramukhi, Kufri Jyoti, Kufri Ashoka, Kufri Pukhraj, Kufri Chipsona-1, Kufri Chipsona-2 and Atlantic. Almost all of these are processing varieties used for chips and french fries except Kufri Ashoka and Kufri Pukhraj which are used for table consumption.

Globally potato production suffers due to plant damage by many pests at different stages of crop growth (**Shakur *et al.*, 2007; Basavaraju *et al.*, 2009**). Quality seeds and insect-pests are the major biotic constrains in the cultivation of this crop (**Thakur and Chandla, 2013**). Potato is vulnerable to damage by number of insect pests and non-insect pests viz, mites, nematodes and rhodents. The major insect pests include aphids, *Myzus persicae* (Sulz.) and *Aphis gossypii* Glov.; Epilachna beetle, *Henosepilachna vigintioctopunctata* Fab. and *Epilachna ocellata* Redt.; Cutworms, *Agrotis ipsilon* (Hufn.) and *Agrotis segetum* Schiff and potato tuber moth, *Phthorimaea operculella* (Zell.). In order to keep the pest population below the economic damage level, it becomes necessary to adopt some control measures which is economically viable, environment friendly and sustainable. The current thrust on plant protection is to promote the use of safer alternatives to pest management such as bio-control agents and resistant varieties for thier advantage of environmental safety. Therefore, the present study was undertaken to evaluate the resistant, tolerant and susceptible germplasms of potato against important sucking pests of potato in eastern gangetic plains of West Bengal.

Materials and methods

An experiment was conducted to evaluate the resistance of six processing germplasms of potato against some important sucking pests of potato viz., ***Myzus persicae* (Sulz.) and *Bemesia tabaci* Genn.** in a 3 X 3 m^2 plot with four replications using RBD during the rabi season of 2010-11 and 2011-12 at Adisaptagram Block Seed Farm, Hooghly, West Bengal. During land preparation, recommended dose of fertilizers were applied @ 200 kg nitrogen, 150 kg phosphorus and 150 kg potash per hectare. Entire amount of phosphorus and potash and half amount of nitrogen was applied as basal while the remaining half amount of nitrogen was applied at the time of first earthing up i.e., 25 days after sowing. Disease and pest free potato seed tubers were then sown following ridge and furrow method of planting at the recommended spacing of 60 cm x 20 cm (row to row and plant to plant, respectively). All the other standard agronomic practices were followed as required during the experimentation.

For the population estimation of aphid, 100-leaf index method by Simpson (Simpson, 1940) was followed where observations were taken just after germination and then at weekly interval on one upper, one middle and one lower leaf each of 34 plants selected diagonally at random. For the population estimation of whitefly, five plants per plot were randomly selected and pest population was recorded on six leaves per plant (two leaves each from top, middle and bottom of the plant respectively). At the time of harvesting, the yield and number of marketable tubers of different germplasms were taken. The data pertaining to the number of pests per leaves or plants were subjected to square root transformation and analyzed statistically applying analysis of variance (ANOVA).

Results and discussion

i) Reaction of different germplasms against aphid, *Myzus persicae* (Sulz.):

From table 1, it is clear that the population of the aphid was very low at 30 Days after Planting (DAP), but gradually increased to reach the peak at 90 DAP. The population of aphids crossed the critical level i.e. 20 aphids per 100 compound leaves in Kufri Chandramukhi at 60 DAP while in other germplasms it crossed the critical level only at 90 DAP. This finding is in line with the findings of Konar and Singh (2009) who reported that, in Kufri Chandramukhi the aphids crossed the critical level (20 aphids/100 compound leaves) earlier then other germplasms.

Table 1: Pooled data of 2010-2011 (1st season) 2011-2012 (2nd season)

Name of the germplasm	No. of aphids /100 compound leaves				No. of whitefly/ 10 leaves				Marketable Yield	
	30 DAS	60 DAS	90 DAS	Mean	30 DAS	60 DAS	90 DAS	Mean	Tubers/ plot (Kg/plot)	Tuber yield (Tons/ ha)
Kufri Chipsona-1	1.25 (1.32)*	16.00 (4.06)*	71.50 (8.48)*	29.58	1.75 (1.50)*	33.50 (5.38)*	58.75 (7.69)*	31.33	7.60	12.67
Kufri Chipsona-2	1.25 (1.32)	15.50 (4.00)	55.50 (7.48)	24.08	2.25 (1.65)	38.00 (6.20)	76.50 (8.77)	38.92	9.95	16.58
Kufri Chipsona-3	0.00 (0.70)	3.00 (1.87)	30.00 (5.52)	11.00	0.00 (0.70)	17.25 (4.21)	26.25 (5.17)	14.50	10.68	17.80
Kufri Frysona	0.00 (0.70)	7.00 (2.73)	39.75 (6.34)	15.58	0.25 (0.86)	23.25 (4.87)	38.50 (6.24)	20.67	11.40	19.00
Kufri Chandramukhi	2.50 (1.73)	23.00 (4.84)	91.25 (9.57)	38.92	3.00 (1.87)	46.25 (6.83)	77.50 (8.83)	42.25	7.33	12.22
Atlantic	1.75 (1.50)	19.00 (4.41)	75.25 (8.70)	32.00	0.50 (1.00)	27.25 (5.26)	53.00 (7.31)	26.92	8.10	13.50
S. Em.(±)	0.72	1.20	2.19	-	0.56	1.04	1.09	-	0.71	-
C.D.(0.05)	2.17	3.63	6.61	-	1.69	3.14	3.31	-	2.14	-

* values in parentheses are $\sqrt{x+0.5}$ transformed values, DAS: Days after spraying

At 30 DAP, the number of aphids in different germplasms varied from 0.00 to 2.50 per 100 compound leaves. Kufri Chipsona-3 and Kufri Frysona were free from aphid infestation while Kufri Chipsona-1 and Kufri Chipsona-2 recorded 1.25 aphids per 100 compound leaves each followed by Atlantic (1.75) which were statistically at par with each other. However, Kufri Chadramukhi recorded highest number of aphids (2.50) and was at par with Atlantic (1.75).

At 60 DAP, similar results were obtained where Kufri Chipsona-3 recorded lowest number of aphids per 100 compound leaves (3.00) followed by Kufri Frysona (7.00) while Kufri Chadramukhi recorded the highest aphid population (23.00). Kufri Chipsona-2 recorded 15.50 aphids per 100 compound leaves and was statistically at par with Kufri Chipsona-1 (16.00) and Atlantic (19.00).

At 90 DAP, Kufri Chipsona-3 recorded 30.00 aphids per 100 compound leaves which was followed by Kufri Frysona (39.75), Kufri Chipsona-2 (55.50), Kufri Chipsona-1 (71.50), Atlantic (75.25) and finally Kufri Chadramukhi (91.25).

The lower population of aphid in Kufri Chipsona-3 and Kufri Frysona as compared to Kufri Chandramukhi may be due to rough and coarse texture of their leaves which are narrower too. The taller habit of Kufri Chipsona-2 created an unfavourable microclimate, as the pest was positively correlated with relative humidity and negatively with minimum temperature during rabi season (Sontakke *et al.*, 1989). Konar and Paul (2004) also reported that Kufri Badshah, Kufri Chandramukhi and Kufri Jyoti were more susceptible to the pest as compared to Kufri Anand and Kufri Sutlej. Further, Konar and Singh (2009) also reported that Kufri Chandramukhi was susceptible to aphid and Kufri Jyoti and Kufri Jawhar were tolerant to aphids while Kufri Chipsona-1, Kufri Chipsona-2 and Atlantic need only one or two insecticide application at 15 days interval during late January to protect the crop against the aphids while other varieties will require the insecticide spraying during early January onwards to manage the crop from the infestation of aphids. The above statement correspondingly supports the findings of this experiment.

ii) Reaction of different germplasms against whitefly, *Bemesia tabaci* Genn.:
The population of whitefly was found to be high enough at 60 DAP which has been supported by the experimental findings of Chandramohan and Nanjan (1992) who mentioned that the population of whitefly was favoured by bulking stage of the crop characterised by more foliage.

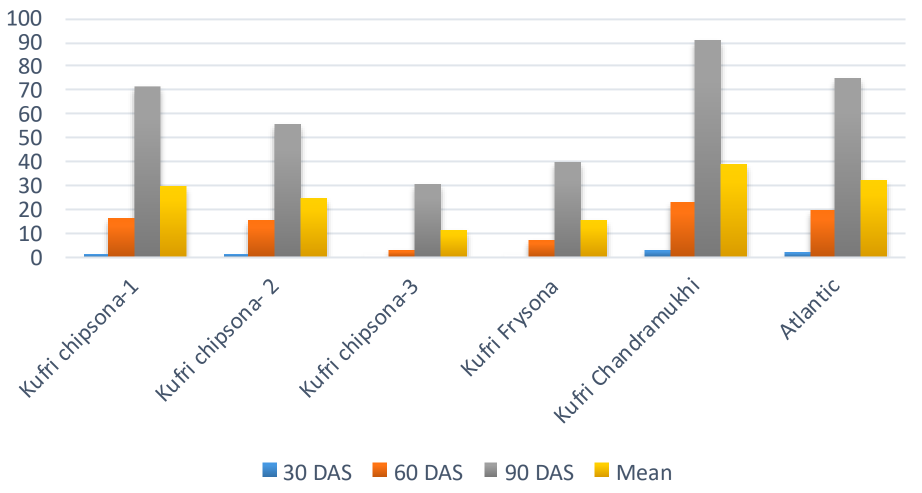
At 30 DAP, the number of whitefly per 10 leaves varied from 0.00 to 3.00 in different germplasms. Whitefly was not found to infest Kufri Chipsona-3 which was statistically at par with Kufri Frysona (0.25) and Atlantic (0.50). Highest number of whitefly was found infesting Kufri Chadramukhi (3.00) which was statistically at par with Kufri Chipsona-1(1.75) and Kufri Chipsona-2 (2.25).

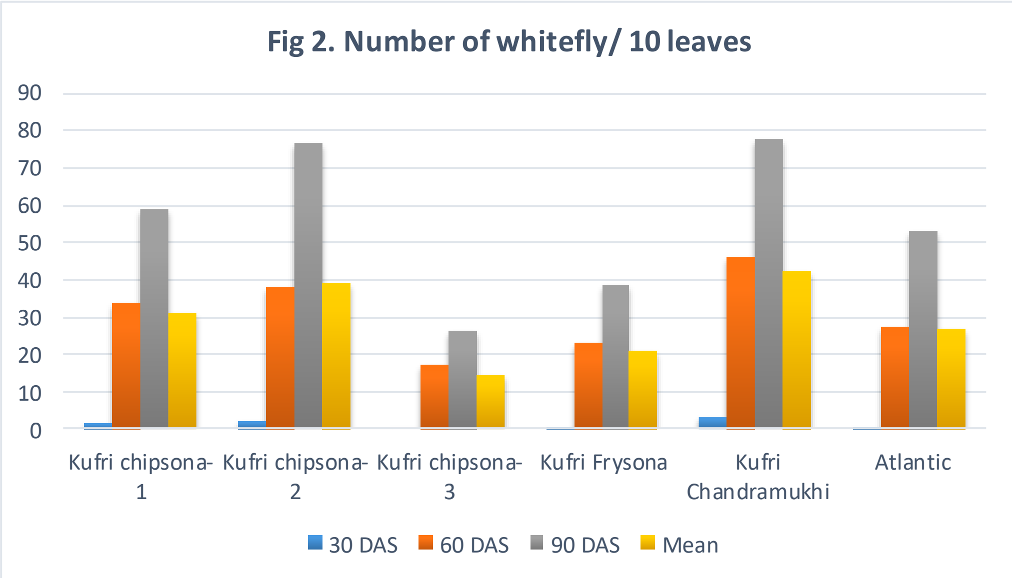
Likewise, at 60 DAP, lowest whitefly population was observed in Kufri Chipsona-3 (17.25) while highest number of whitefly was recorded in Kufri Chadramukhi (46.25).

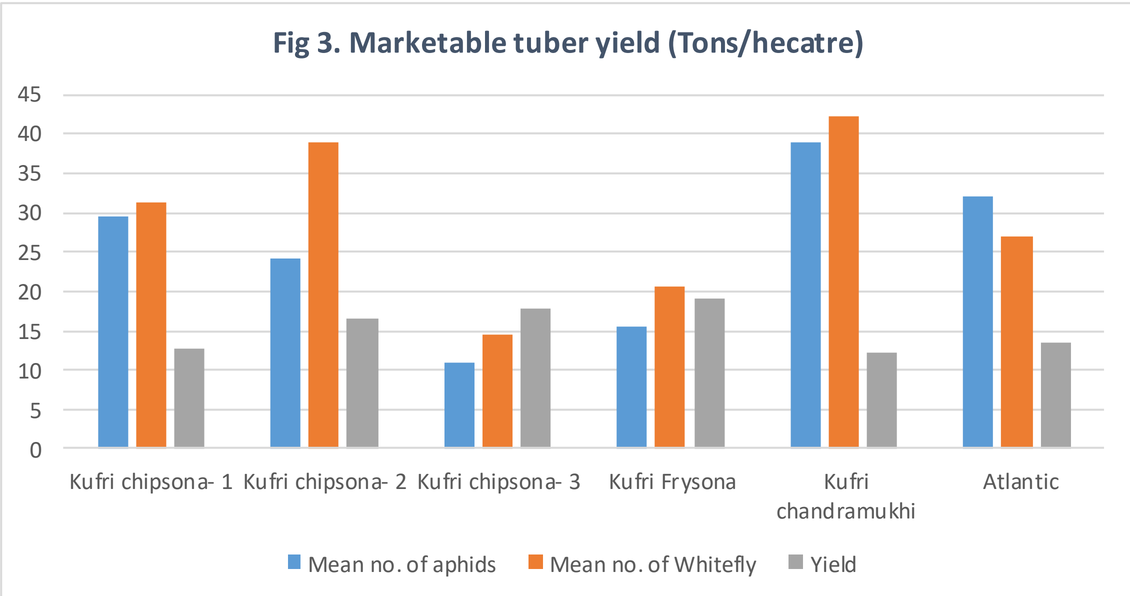
At 90 DAP, Kufri Chipsona-3 recorded 26.25 whitefly per 10 leaves which was followed by Kufri Frysona (38.50), Atlantic (53.00), Kufri Chipsona-1 (58.75), Kufri Chipsona-2 (76.50) while Kufri Chadramukhi recorded the highest number of whitefly (77.50). Sharanappa *et al.,* (2010) reported that the least whitefly population was recorded on Kufri Chipsona-2 and highest on Kufri Chandramukhi which was partially in line with the results of this experiment as Kufri Chandramukhi recorded highest mean number of whitefly (42.25) while lowest number of whitefly was reported from Kufri Chipsona-3 (14.50).

The yield of marketable tubers per plot varied from 7.33 to 11.40 kg/plot in different germplasms. Lowest marketable tuber yield per hectare was obtained from Kufri Chadramukhi (12.22 tons/ha) which was found to be statistically at par with Kufri Chipsona-1 (12.67) and Atlantic (13.50). On the other hand, highest marketable tuber yield was obtained from Kufri Frysona (19.00) which was at par with Kufri Chipsona-2 (16.58) and Kufri Chipsona-3 (17.80).

Fig 1. Number of aphids /100 compound leaves







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STUDIES ON NEWLY EMERGED INVASIVE INSECT PEST OF TOMATO, *TUTA ABSOLUTA* (LEAF MINER) IN INDIA.- A REVIEW

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Introduction

Tomato scientifically called *Solanum lycopersicum*, is the world's largest vegetable crop grown after potato and sweet potato, but it tops the list of canned vegetables (Olaniyi *et al.*, 2010). It is considered as highly growing & used food crops among the vegetables in India and is cultivated both under greenhouse and in field conditions. It is consumed as fresh table tomato and also utilize as a prominent raw material in of food processing industries. Tomato is being utilized in many food items like salad, chutney, paste, peeled tomatoes, diced product, juice, sauce and soup. It is rich in minerals, vitamins and antioxidants that are important to a well balanced diet. It is also an essential dietary component because it contains more amounts of lycopene, an antioxidant that reduces the risks associated with several cancers and neurodegenerative diseases. It provides much needed vitamins, essential amino acids and minerals to impoverished rural communities. Being a cash vegetable crop it brings good income to farmers particularly in urban areas. Despite of its socio-economic significance, its production has been fluctuating by many biotic and abiotic constraints. Majority among the biotic factors are diseases and insects pest which reduce yields and the quality of fruits in the market. Among the insects attacking tomato crop, leaf miner is an invasive species commonly known as South American leaf miner or South American pinworm or South American tomato borer or South American tomato moth. It has gained notoriety as significant and destructive insect in the fields of tomato, in the countries it has invaded so far. With different incidence levels, it is moreover recorde in India throughout the year (Sridhar *et al.*, 2014).

Key words : Tomato, *Tuta absoluta*, Damage, Management

Pest description

Tomato leaf miner is a pest with oligophagous nature (Siqueira *et al*., 2000) associated with solanaceous crops. The main attacking host is tomato, but it also been associated with other minor hosts which belongs to solanaceae family like brinjal, potato, tobacco, pepper and sweet pepper (Pereyra and Sánchez, 2006). Its aggressive nature, multivoltine character, high biotic potential and resistance to insecticides are the most important reasons for the insect to become key pest in new area (Desneux *et al.,* 2011). The severe infestation of tomato leaf miner causes 80-100% yield loss (Tropia Garzia *et al.,* 2012). Thus, it can create a severe risk to the tomato growers if unchecked. When heavily infested plants are disturbed, adults were found flying close to surface of the ground (EPPO, 2005).

Origin and distribution

Tomato leaf miner was earliest described in Peru in 1917 in South American continent, where the pest is measured as one among the major destructive insects for tomato since 1960s (Barrientos et al., 1998). It is then extend to Bolivia Chile Argentina, Columbia, Brazil Ecuador, Venezuela Uruguay and Paraguay from there it is multiplied to different areas in the world, often becoming a serious risk to tomato manufacture industry wherever it invades. In Europe, *T. absoluta* presence was initially reported in Brazil between 1979 and 1980 (Muszinski *et al.,* 1982) and in the Eastern parts of Spain in late 2006 (Urbaneja *et al.,* 2007) and later in Greece, Egypt (Roditakis *et al.,* 2010), Africa, middle East and parts of Asia (Biondi *et al.,* 2018). Tomato leaf miner was foremost recorded in the continent of African countries like Tunisia, Algeria and, Morocco in the year 2007, and has since invaded about 41 African countries out of 54. In view of the high biotic potential, its ability to adapt to different climatic the invasion has impacted seriously on the trade of tomato growing farmers and also tomato related industries and agri-businesses in many places around the world. Among Asia countries, the pest spreads over Iraq, Bahrain, Iran, Israel, Jordan, Kuwait, Saudi Arabia, Lebanon, Qatar, Turkey, United Arab Emirates, Syria, Yemen (Desneux *et al.,* 2010), India (Shasank *et al.,* 2015), Nepal (Bajracharya *et al.,* 2016) and Bangladesh (Hossain *et al.,* 2016). In India, *T. absoluta* was initially discovered on October, 2014 damaging tomato crops at Dhule, Ahmednagar, Jalgaon, Satara, Nashik and Pune districts in Maharashtra (Shashank *et al.,* 2015). Subsequently *T. absoluta* was reported in Karnataka (Sridhar *et al.,* 2014; Kalleshwaraswamy *et al.,* 2015 and Ballal *et al.,* 2016), Telangana and Andhra Pradesh (Anitha *et al.,* 2015), Gujarat (Ballal *et al.,* 2016), Delhi (Shashank *et al.,* 2016), Tamil Nadu (Shanmugam *et al.,* 2016), Madhya Pradesh (Swathi *et al.,* 2017), Himachal Pradesh (Sharma and Gavkare, 2017), Punjab (Sandeep *et al.,* 2017) and Meghalaya (Sankarganesh *et al.,* 2017) causing heavy damage to tomato crops in which the pest entered in different parts of India. In 2015, *T. absoluta* was first time recorded on brinjal in Kerala (Kumar *et al.,* 2017).

Life cycle and Biology

Tomato leaf miner is a mini lepidopteran moth with heavy reproductive potentiality. The pest is multivoltine having nearly 10 to 12 generations per year and affects tomato in all growing stages. Females has high rate of fecundity and one female can able to lay a total of about 260 numbers of eggs during their lifetime on the lower or upper surface of the leaves, buds and calyxes of the green fruits. Eggs are small cylindrical about 0.35 mm long. The colour of eggs ranges from oyster-creamy colour to light yellow. Larvae come after 4-6 days of incubation period. *T. absoluta* usually have four instars. First instars were cream or whitish colored, later changes from greenish (second instar) to light pink (fourth instar) with brown head. Larva is the damaging stage which is completed within 12 to 15 days (Estay, 2000). It do not go to diapauses when food is available. The pupae were at first greenish in colour and turned to castaneous brown and then changed to dark brown before emergence as adult. Pupation takes place within the mines or on the leaf surfaces or in the soil depending up on the environmental conditions. Moths are nocturnal in habit and are usually concealed in the day time between the leaves. On an average it takes 29 to 38 days to complete its total life cycle depending on the environmental circumstances. Adult lifespan ranges between 6–7 days for males and 10–15 days for females (Desneux N *et al*., 2010). They are 5-7 mm in length with a wing span of 8-10 mm. The main significant identifying characters are the filiform antennae, silvery-grey scales and characteristic black spots present in anterior wing (Simala *et al.,* 2011) and recurved labial palps which are well developed.

Symptoms and nature of damage

The pest attacks tomato crop from seedling stage to harvesting stage. In early stage of attack freshly emerged larvae penetrates into the leaf mesophyll layer and cause damage by feeding between the upper and lower surfaces forming small transparent mines. Due to continuous larval feeding, the irregular mines combined together and eventually form galleries. The symptoms of damage of this leaf miner are differed with serpentine leaf miner (*Liriomyzatrifolii)*. The mines were filled with black fecal matter and in due time the mined areas turns to brown colour and dry up. In case of serpentine leaf miner, symptoms are observed majorly on upper surfaces of leaves, but in *T. absoluta* leaf miner, the symptoms can be seen on both sides of leaves. In fruits, the larvae tunnel inside and leave only a pinhead size hole visible from outside and make mines just at lower portion close to the stalk. More than one hole is seen near to the calyx on fruit. Damaged tomato plants are further attacked by the other pathogens which enter the wounds previously caused by the pest (Shasank *et al.,* 2015).

Management

Tomato pin worm management is difficult because its developmental cycles depend on environmental conditions (Barrientos *et al*., 1998); existence of suitable Solanaceous host plants in southern and central India makes establishment and increase of transient populations. In addition to field crops, weeds of Solanaceae could also serve as host reservoirs for the pest which do exist in India. Difficulty in management of the pest is due to non adaptation of wide area control programmes for numerous small holdings. Integration of the pest management methods like cultural, mechanical, biological and biotechnological tools is becoming necessary in managing the pest. A zoophytophagous mirid bug, *Nesidiocoris tenuis* (Hemiptera: Miridae) was recorded as predator on eggs and early larval stages under field conditions. Singh *et al.,* in 2009 demonstrated successfully use of pheromone trap @ 20/ha. Several insecticides were used to control the pest, but none of them is suitably adapted for its control as the endophytic nature of larvae, which are protected in the leaf mesophyll or inside the fruit. Additionally, insecticidal spray can be easily washed out by rain and wind (Abbes and Chermiti, 2011 and Guedes and Picanco, 2012). New molecules of insecticides such as spinosad, deltamethrin, indoxacarb, imidacloprid and Bt var *kurstaki* have effectively used in Spain (Russel, 2009), pyrethrins and chlorpyriphos were recurrently used in Italy (Garzia *et al.* 2009), abamectin, thiacloprid, imidacloprid, spinosad, indoxacarb, and *Bt var Kurstaki* were successfully used in Malta (Mallia, 2009). Now this insect developed resistance against the insecticides which includes spinosyns, organophosphates and diamides (Jallow *et al.* 2018). Indiscriminate use of insecticides in the infected crop resulted in the development of resistance to insecticide, resurgence of pest, pollution to environment, residues of pesticides in fruits, natural enemy populations' destruction and health hazards. To overcome the problems caused by indiscriminate utilization of insecticides, using of Host Plant Resistance (HPR) is an environmentally viable alternative strategy in insect pest management. Using resistant varieties now become substitute to chemical control. The research on the mechanisms and the causes for resistance to *T. absoluta* is essential for the determination of the resistance factors necessary to add into plant breeding programmes for insect resistance and to present objective parameters for the crosses. It is therefore agreed that the sustainable and most excellent option which can control the pest is by utilization of resistant varieties of tomato (Oliveira *et al.,* 2009)

Conclusion

T. absoluta, which is a invasive destructive pest spreading rapidly in several countries of the world, posing heavy risk to tomato and also to other solanceous crops. In recent times, it emerges as a highly invasive key pest frightening the worldwide tomato production. An effective eco-friendly IPM of this leaf miner is badly needed as the pest is distributing quickly and causing nuisance. In many other countries, it has already developed resistance against several insecticides. For controlling this insect, combination of strategies like use of pheromone traps, botanicals, microbials, and eco-friendly molecules are essential. The commercialization and worldwide trade of fresh fruits and transplanting materials have increased the extent of this insect. The impact of this pest on worldwide tomato producing industries and on the livelihood of small tomato farming communities might be more severe in the coming years unless great efforts are made to bring to an end to its spread. Till now there is no longer cultivated variety resistant to this insect. The development and cultivation of resistant tomato cultivars against this pest is very limited in India. Therefore, it is necessary to recognize the resistant tomato variety. More studies on its biology, host range, population dynamics, biodiversity and management needs to be taken up. The socioeconomic force of the pest on subsistent agriculture also needs to be included. Explosive spread and distribution of this pest is mostly co-related with import of fruits and further spread (Potting, 2009). One of the potential ways for long distance spreading of the pest might be through packaging materials (boxes) from infested countries (EPPO, 2010). Due to this, the pest becomes a heavy risk for tomato fruit producing systems worldwide.

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INORGANIC MULCHING - A TECHNIQUE TO IMPROVE CROP PRODUCTIVITY

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Abstract

With the increasing world population, the need for feeding the world population increases. Hence, the crop production has to be increased to produce more food. Many challenges are involved in this. One among is inadequate water supply .In order to protect the available water in soil the modern mulching technology is used. Mulching protects the soil moisture and makes it available during the entire crop growth. This article explains every single aspect about inorganic mulching.

Keywords : Inorganic mulches, plastic films, soil moisture , weed control

Introduction

Agriculture is the main occupation of the most rural population and is the important sector contributing to the Indian economy .Now-a-days, Indian agriculture faces many problems and issues. The key issue is the availability of water. The farmers use excess water to the crop resulting in absence of water. In recent days, the need of water for human domestic needs has increased tremendously resulting in the depletion of major water resources. This resulted in the low presence of water for agriculture. So, various ways and method were analysed to conserve water for agriculture. Mulching is one of those water conserving technologies that primely aims at preserving the soil moisture by reducing evaporation of water . A mulch is natural or artificially spread layer of plant residues or other material on the surface of the soil. It is mainly of two types organic and inorganic mulching .The prior one works on the use of organic residues like leaf, grass, compost, etc... While the latter insists upon the use of materials like plastic films, stones .This article briefly discusses about inorganic mulching, the materials used, advantages, disadvantages.

Inorganic Mulching

Inorganic mulching involves the use of inorganic substances that does not uses organic matter in it. Inorganic mulches are stones and gravels, polyethylene films, landscape materials and rubbers. Inorganic mulches are usually used to create interruption in germination of weeds. Inorganic mulches like stones, gravels and rocks do not involve in improving soil condition but biodegradable and photo-degradable plastic mulches are readily decomposable and improve the soil condition. Heat can be absorbed and reflected by rocks which are useful in dry and hot environmental condition.

Types of Inorganic Mulches

Various types of inorganic mulches are given in the below Fig.1 types of inorganic mulches.

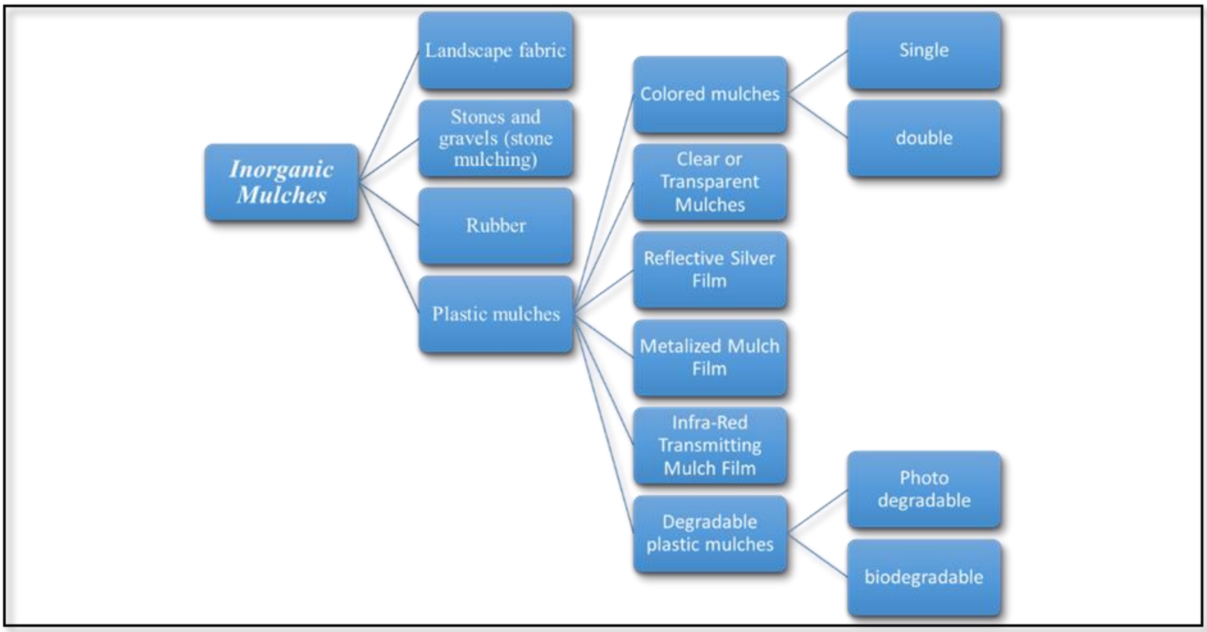

Fig.1 types of inorganic mulches.

I.) Landscape fabric

Landscape fabric is one of the better options for weed control as it allows only water and air to pass through it. Landscape fabric is created by polypropylene of high tensile strength. It controls the erosion of soil and protects the soil from wind and water erosion. It allows movement of rain water through it into the soil, which is impossible in plastic films. Landscape fabric is more popular than plastic films.

Fig.2 landscape fabric

II.) Stones and gravels

Stones and gravels are most commonly used in dryland to conserve water. They reduce the evaporation rate and improve the infiltration and percolation of water in the soil. But during hot season these stones absorbs the hot solar radiation creating high temperature. Hence, during hot season usage of these must be avoided.

Fig.3 Stone mulching

III.) Rubber

Rubber mulch is usually made from recycled rubber and tires . Due to its toxic combination it remains in the soil for long period and has high flammability. Hence , it is less prevalently used. Eventhough it has many disadvantages , it has advantages like no water and nutrient absorption , effective weed and pest control .

Fig.4 Rubber mulches

IV.) PLASTIC MULCHES

Plastic mulches are the most commonly used inorganic mulches that is involved in the conserving of water . Water and nutrients cannot pass through as it is impervious in nature . It should not kept for a long season as it deteriorates with exposture to sunlight . It is widely used in vegetable gardens . The various types of plastic mulches are discussed in the table given below.

Types of Plastic Mulches	Description
Colored mulches	i.) single colored : white cools the soil , red increases vegetable production , black helps in moisture conservation. ii.) double colored : Yellow/ Black for pests & insects , White/ Black or Silver/ Black cools off soil , Red/ Black Partially translucent to some solar rays , Blue/ Black Restricts reflections of radiation.
Clear or Transparent Mulches	solarize and increases the temperature of soil. solarize and increase the temperature of soil.
Reflective Silver Film	keeps cool the temperature of root zone.
Metalized Mulch Film	Delivers extra light to the plant and reflect a range of light which avoids the white flies and aphids
Infra-Red Transmitting Mulch Film	available in different colors from green to brown hues ; effective in controlling of weeds and increasing the temperature of soil.
Degradable plastic mulch	i.) Photo-degradable plastic mulch: Disintegrates on exposture to sunlight during the mulching period ii.) Bio-degradable plastic mulch: Mostly made from polyesters , plant sugars or starches ; gets easily decomposed.

Table .1 types of plastic mulches

Fig 5 biodegradable plastic films

Fig 6 colored plastic films

Advantages of inorganic mulching

- Reduction in the rate of evaporation
- Increase in moisture holding capacity
- Lowers leaching of nutrients
- Effective weed control
- Maintains soil structure
- Controls soil erosion

Disadvantages of inorganic mulching

- Some inorganic mulches like plastic films pollutes the soil
- Plastic films are toxic to animals
- Movement of agricultural machinery in field is difficult
- Increases soil temperature if added to large areas

Conclusion

Recent times , mulching becomes the most important and widely practiced technique to conserve the soil moisture and to increase crop productivity . The selection of mulching materials is highly based on the crop and the environment . Plastic films are one of the most popular mulching materials. Despite many advantages , it also has disadvantages like high cost of establishment , pollution to environment , difficulty in adaptability , etc…. It is concluded that despite disadvantages it helps to a considerable extent in conserving water.

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KRISHI KUMBH MOBILE APP FOR FARMERS

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Present time is an ICTs era. This time farmers also want to use new and innovative online platform. Online portals and mobile apps are innovative platforms meant for farmer's development. This paper aim is to discuss the role of Krishi Kumbh app for the development of farmers.

This app was initiated by Krishi Kumbh Kendra, Sustainable Solution for modern Agriculture. Agriculture problems are solved by this app. This is single stop solution for many problems. This app solve many problems faced by farmers.

Krishi Financing

Krishi Kumbh provides the facility of Krishi Financing. This is the endowment of many services and these services are dedicated to supporting both on- and off-farm agricultural activities. This app also provide the information on input provision, production, and distribution, wholesale, processing and marketing.

Insurance

The other facility provided by Krishi Kumbh app is Insurance facility. Unseasonal dust, thunderstorms, unseasonal rains are the main problems faced by farmers. These problems creates crop damage. This app provides the information how to protect urself by these types of farming damages.

Services for Agriprenure

This app provides fabulous scope for slight entrepreneurship to flourish in rural area by making franchise operations possible at the grassroot level. This is a type of rural bazar. This app is one-stop shop. Farmers can directly access to the procedural advisory and market linkage for farm produce. This makes farming more social, economic.

Krishi Kumbh for Institutional-Buyers

This app provide support to other buyers to buy products. This portal allows buyers for better plan and operations. This app makes the procedure easy to buy and sell the products. Artificial Intelligence engine that can correlate many of parameters that affect agriculture and provide predictive analytics and early warnings for better production and forecasting mechanism.

Services for farmers

This app provides the information on krishi financing, krishi output, health and growth, krishi output, krishi input, know your soil etc.

Farm intelligence

Krishi Kumbh provides the facility of farm intelligence. Under this facility, farmers can uses the power of real-time data and predictive modelling to help ensure the right crop protection products are applied precisely where and when they are needed to improve sustainability, optimize crop yield and enhance grower return on investment (ROI).

Krishi Output

This app also provides the information on agro inputs as well as outputs. Output can be measured in term of land and labour used in crop production.

Krishi Input

Agri-input delivery system is also one of the approach which provides support to farmers. Agri inputs are also delivered among the farmers for the affordability, availability, and incentives to adopt technological packages. This also improves the agriculture productivity.

Know Your Soil

Soil is a critical part of successful agriculture and this is the original source of the nutrients that we use to grow crops. The nutrients move from the soil into plants that we eat like tomatoes. Nutrients are also a part of the food animals eat. Healthy soil is necessary for the crops. Soil testing is usually carried out as part of a programme, consisting of four phases: [1] Soil sampling [2] Sample analysis [3] Data interpretation and [4] Soil management recommendations. Soil tests can help to determine soil fertility levels, and identify nutrient deficiencies, potential toxicities and trace minerals.

Conclusion

Mobile apps are the innovative sources used to provide the information among the farmers. Krishi Kumbh is also one of the important app for the development of farmers.

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FALL ARMYWORM (*SPODOPTERA FRUGIPERDA*): AN EMERGING DESTRUCTIVE PEST OF MAIZE

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Introduction

Maize (*Zea mays*) is known as the queen of cereals and is widely cultivated as a cereal grain that was domesticated in Central America. Maize (*Zea mays*) is one of the world's important food crops, which supplies >5% energy. Maize has become a staple food in many parts of the world, maize production is surpassing that of wheat or rice, maize is also used for animal feed, and other maize products, such as corn starch and corn syrup. The six major types of maize are dent corn, flint corn, pod corn, popcorn, flour corn, and sweet corn. Many insect pest attacks on maize crop but fall armyworm is a serious pest in current year. More than 40 species of insect pests have been recorded on maize crops. Maize fall armyworm *Spodoptera frugiperda* (Lepidoptera: Noctuidae) FAW causing hefty yield losses. Firstly empirical the FAW *Spodoptera frugiperda* in Africa results in gigantic damage. "The hungry caterpillar is threatening a global food disaster". FAW is a polyphagous lepidopteran pest. The destructive phase of fall armyworm (June - August) is when the minimum average temperature overtakes 10°C, feeding in large numbers on the leaves and stems. It is rapidly spreading throughout tropical and subtropical regions of the landmass. FAW is a migratory insect known to cause serious damage to maize crops under warm and humid conditions. The summer season provides a favorable environment for the insect to quickly multiply and spread to more areas.

This pest was first observed in Shivamogga, Karnataka on 18th May 2018. FAW was later reported in Madhya Pradesh, Andhra Pradesh, Maharashtra, Tamil Nadu, Odisha, Telangana, Bihar, West Bengal, etc.

Host range : Fall armyworm is a polyphagous pest and wide host range there is an attack on field crops, vegetable crops, etc.

❖ **Field crops**	❖ **Vegetable crops**	❖ **Other crops**
• Rice	• Cucumber	• Apple
• Maize	• Tomato	• Grape
• Sugarbeet	• Spinach	• Orange
• Sorghum	• Turnip	• Papaya
• Oat	• Sweet potato	• Orange
• Wheat	• Sweet corn	• Peach

Life cycle : The fall armyworm has four life stages: egg, larva, pupa, and adult.

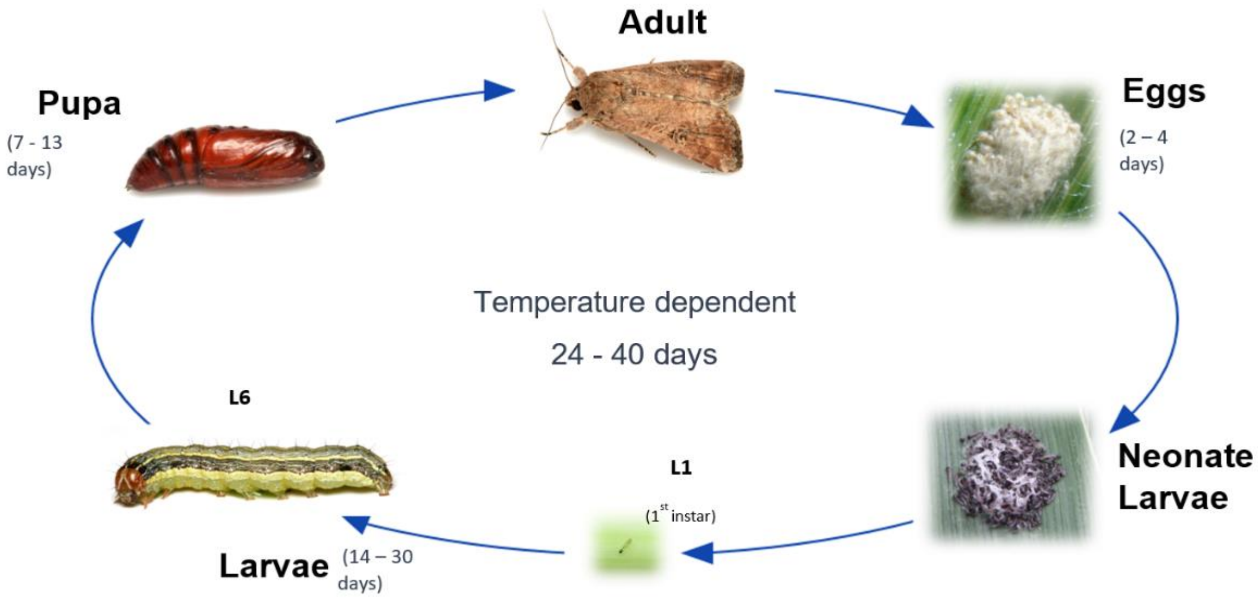

Figure:- 1

Eggs : The fecundity of the female moth is high. Female moths drop out eggs under the surface of the leaves in eggs masses. 50 -200 eggs are in egg masses. Approximately 1500 – 2000 eggs produced by her life span.

Figure:- 2

Larva : Immature stage of fall armyworm larva is brown to gray, green, or yellow-green color. Newly emerged larvae encircle itself with silken thread to the lower body after hatching. The initially emerged instar (1stto3th) larvae consumed the little leaf material, while the 4th & 5th instar larvae destroyed more than 90% of green foliage. This means during the earlier stage (1st to 3rd instar larva) damage is very minor not taken care of but after it causes serious damage (4th & 5th instar larvae)over a short time. The most active time of caterpillar is early morning to late evening and feed throughout the day.

Figure:- 3

Inverted "Y" on the head, is the most prominent characteristic of fall armyworm larva .this found between the eyes (Figure 3), and three whitish stripes on the head.

Pupa : Fall armyworm larvae carry time 2-3 weeks to reach the pupa stage. fully grown larvae passage into the ground converting the pupa. (Figure 4)

Figure:- 4

Adult : Both (male & female) adult moths are different morphological characteristics. forewing of Male moth chiefly brown-gray color with has a triangular white spot. The Fore wing of the female moth is distinctly marked with constant grayish-brown color. The hind wing is rainbow silver-white with a limited dark border in both sexes. The adult moth is a nocturnal insect and most active during warm, humid evenings they are complete many generations in one year. Most generations arise in the southern territory because the warmer climate


'Female moth' **' Male moth'**

Figure:- 5

FAW biology & Identification

Spodoptera *frugiperda* is a serious agricultural pest. The origin place is a tropical-subtropical region. It lacks diapause mechanisms and undergoes diapause in the mild climate of South Florida. The larval stage has 6 instars and feeds on many agriculture crops with a wide host range. FAW adults are nocturnal pests and do the feeding and mating activities; female insect species mate more times using a pheromone to attract the male adult species of FAW.

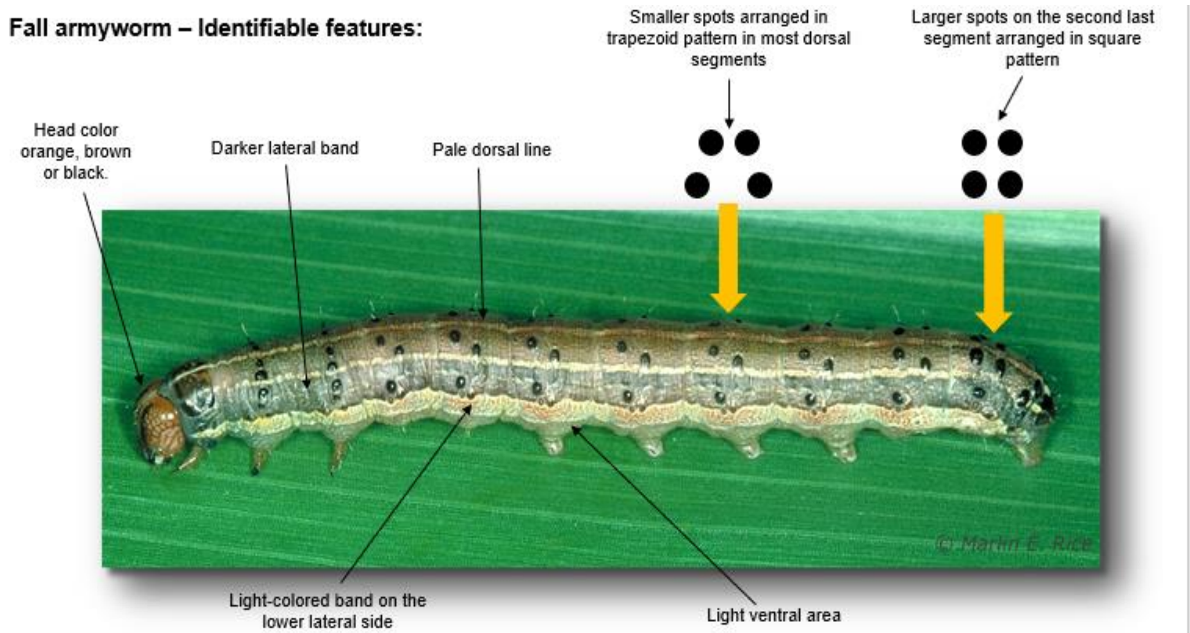

Figure:- 6

Damage symptom and management:-

Symptom-based treatment is very much effective and essential for the management of FAW because of two reasons;

- The stage of symptom indicates the stage of larval instar and its growth.
- The larval instar and its growth help to choose pesticide/control measures.

1. Elongated papery window of all sizes

- This symptom is caused by 1st and 2nd instar larvae and larvae scrapping on the leaf surface.
- Spread all over the leaves in a few adjacent plants including the crops.

✓ **Early identification of this symptom is a must for effective management of FAW**

Figure:- 7

Management

1. 5% Neem Seed Kernel emulsion (NSKE) or azadirachtin 1500ppm @ 5ml/L water.
2. *Bacillus thuringiensis* variety kurstaki formulations used (Dipel 8 l @ 2ml/L of water or Delfin 5WG @ 2g /L water).
3. Entomopathogenic fungi *Metarhizium anisopliae* (1 x 10^8 cfu/g) @ 5g/L or *Nomuraea rileyi* rice grain formulation (1 x 10^8 cfu/g) @ 3 g/L water.

2. Ragged-edged holes

- This symptom is caused by 3rd and 4th instar larvae
- Larvae feeding cause ragged-edged round holes on leaves.
- The size of holes increases with the growth of larvae.

Figure:- 8

Management

This stage need chemical control :-

1. Emamectin benzoate 5 SG @ 0.4 g/L
2. Spinosad 45 SC @ 0.3 ml/L
3. Chlorantraniliprole 18.5 SC @ 0.4 ml/L

3. Significant leaf damage

- The larva consumes voraciously until it reaches the fifth instar, shedding bigger portions of leaves.
- The 6th instar larva defoliates the leaves significantly and produces a large volume of faeces

Figure:- 9

Management

- Pesticides are not effective to control the 5th and 6th larval instar. The only effective control at this stage is poison baiting

Poison bait

- 10 kg rice bran and 2 kg jaggery should be combined in 2-3 liters of water and left to ferment for 24 hours. Add 100g Thiodicarb 75 percent WP. If the balls are too sticky, add additional sand when rolling.
- In the evening, the bait should be applied to the plant's whorl.

4. Damage to staminate and pistillate

- 6th instar larvae, affect the vulnerable part of the maize 'staminate & pistillate'.
- This stage of tassel damage is the greatest mutual which does not lead to economic damage but bore into the corn ear rapidly impacting the output. Zea mays' var. saccharata is more prone to FAW damage, which renders the pistillate unmarketable.

Figure:- 10

Management

- Chemical management is not appropriate at this time since larvae hiding inside the corn ear would not be exposed to the spray, and it is also not recommended to spray pesticides on sweet corn.
- Selecting a cultivar with a tight husk and husk covering the tip may provide some protection from FAW.

Other management Practices

1. Cultural regulator approaches/mechanical regulator approaches

- After the harvest, burn the crop remains at least 12cm deep to destroy the eggs, larvae, and pupa.
- To adopt the crop rotation Eg: cassava
- Intercropping with pigeon pea, groundnut, and beans reduces the incidence.
- If you notice the number of eggs or caterpillars are few then handpick and crush them. This is only practical for small gardens or few affected plants.
- Birds and certain predatory insects feed on FAW

Conclusion

Fall armyworm (*Spodoptera frugiperda*) is a destructive pest native to Americans, recently invaded India, and presently causing economic damage in maize. The study shows that there was a relationship between knowledge of *S. frugiperda* and the use of management practices. Increased use of pesticides to manage fall armyworm posses health and environmental risks, besides the high cost for farmers and governments.

Research into cultural and indigenous practices used by farmers will offer an opportunity for alternative and sustainable management practices.

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BIOLOGY OF INVASIVE PEST FALL ARMY WORM

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Introduction

Invasive pests are nothing but they are non-native or exotic organism that occur outside their natural adapted habitat and dispersal potential. Invasive species have been identified as second greatest threat to biodiversity after habitat loss. The increased transboundary movement of agricultural commodities, anthropogenic activities, climate change etc. led to introduction of new species. The recent invasive pest is fall army worm*, Spodoptera frugiperda* (JE Smith); Noctuidae: Lepidoptera, which have been reported in India. It was first noticed in mid-may 2018 in maize fields at College of Agriculture, Shivamogga, Karnataka(Chormule et al., 2019). After that it also noticed in parts of Andhra Pradesh, Tamil Nadu, Telangana, Maharashtra and Gujarat mainly in the maize fields. This highly destructive and invasive pest has been seen in the America several decades. But its prevalence and outbreaks in West and Central Africa were recorded for the first time in early 2016. According to the International Maize and Wheat Improvement Centre (CIMMYT) at Mexico, FAW has, damaged more than 1.5 million hectares of Africa's maize crop in two years after invasion. FAW mainly cause damage to maize crop and it is also known to attack more than 100 crops like rice, sorghum, sugarcane, cabbage, beet, tomato, onion, cotton, pasture grasses etc. Recent studies in India reported that, FAW infestation in maize crop ranged from 2 to 35%. Fall army worm is potential threat to agricultural production and Indian economy. The adult moths of FAW are highly migratory in nature, in a single season female moth is capable of travelling up 500 km to find oviposition sites and capacity to fly over 100 km per night, which is the reason for rapid spreading of this pest.

Life cycle of fall army worm

The FAW can complete their life cycle in 30 days (at mean temperature-28^{0}C) during summer months, but 60 days in spring and autumn and extend up to 80-90 days during winter. FAW is lacking the ability to diapause. In endemic areas, FAW infestation occurs throughout the year. Where in non-endemic areas, migratory FAW arrive only when environment is favourable and may complete one generation before they become locally extinct.

Egg

The female moth lays total 1500-2000 eggs in their entire life cycle in single or multiple clusters (100-200 eggs in each cluster). Female moth normally lay eggs in the underside of leaves or inside whorls or rarely on stem of the host plants. The FAW egg is dome shaped with flattened base and they are pale yellowish or creamish in colour at the time of oviposition. The egg masses are covered by greyish scales from the female abdomen. During warm periods, egg will hatch in 2-3 days.

Larva

FAW has total 6 instars with total larval period 14-30 days (depending on the temperature). First instar is greenish in colour with black head, and head will turn to orangish in second instar. The third instar is brownish in colour and lateral lines begins to form. Fourth to sixth instar have brownish body with three white dorsal line and a light lateral line. On the dorsal part of the body, dark elevated spots are seen which bear spines. White inverted 'Y' marking is seen on the head region. Caterpillar often shows high degree of cannibalism.(Firake et al., n.d.).

Pupa

FAW normally pupates in the soil at the depth of 2-8 cm in cocoons made up of soil and silk. When soil is too hard larva web together the leaf debris and other materials to form pupa in the soil surface. Pupa is shiny brown in colour. Duration of pupal mainly depends on the temperature. Pupal period is 8-9 days during summer and it may also reach up to 20-30 days in winter.

Adult

Adult moths show slight sexual dimorphism. Adult longevity is usually 7-9 days, but may extend up to 21 days. The forewing of male moth is shaded grey and brown in colour, with white triangular spots at the tip and near the centre of the wing. In case of female moth, the forewings are less distinctly marked ranging from greyish brown to fine mottling of grey and brown. The hindwings are straw colour with a narrow dark brown border in both sexes. Adults are most active during warm and humid evenings and they are nocturnal in nature. The female moth deposits most of her eggs during first 4 to 5 days, after preoviposition period of 3-4 days. Female moths are strong flier and they are migratory in nature.

Conclusion

Fall army worm is destructive invasive pest known to cause damage to economically important cultivated crops like maize, sorghum, sugarcane, cotton and also vegetable crops. All larval instars of FAW cause damage to the crop. Early detection of the pest is very much essential to avoid huge loss of the crop. And there is also urgent need to increase awareness among the farmers about the life stages of the pest and stage of the crop where pest will cause economical damage, so that one can take up right management practices for the control of the pest.

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