

Cassava Integrated Pest Management: Review on Cassava Mosaic Disease and Mealybug

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Abstract
Cassava mosaic disease and cassava mealybugs are some of the economically important cassava pests. Different scientists report the impacts and possible management practices. Both pests affect cassava growth, yield and quality and being threat to food security and poverty. Most findings stated as integrated pest management is very important in controlling these pests in different cassava growing areas. This might be due to the fact that integrated pest management strategies are economically sound and environmentally friend. Therefore, status and management options of cassava mosaic disease as well as whitefly and mealybugs from different scientific findings have been reviewed in this paper.
Keywords: Pest, pest management, Integration, Crop loss

1. INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a perennial root crop that belongs to family Euphorbiaceae. It is native to South America and produced for its roots as well as leaves (Chikoti *et al*., 2015; Sartiami *et al*., 2015). Cassava is a tropical food crop and one of the major root crops of Africa, the Indian sub-continent, Latin America and several Southeast Asian countries (Karthikeyan *et al*., 2016). In many Africa countries like Zambia, Mozambique, Tanzania, Malawi, Democratic Republic of Congo and Nigeria cassava produced largely by smallholder farmers (Chikoti *et al*., 2015). It serves as a famine reserve crop, industrial raw material and livestock feed (Abaca *et al*., 2014) quoted (Nkweke *et al.,* 2002). Cassava was first introduced to Ethiopia by the British and the crop has been cultivated, mainly, in the south, south west, and western parts of the country since its introduction (Mulualem and Dagne, 2014).

Besides, it was reported that Cassava (*Manihot esculenta* Crantz) is an essential part of the diet for more than half a billion people in Africa, Latin America and Asia (Ewusie *et al*., 2010) quoted (FAO, 2000). Cassava is stable or subsidiary food for world population and used as major source of dietary starch and the crops used for source of raw material for starch based industries (Jose *et al*., 2008). In addition to its importance in food security cassava is crop for income generation and employment in many Asian and African countries.

Cassava grows well wide range of environment, tolerates to drought and other important features of the crop are that the plant is not dependent on fertile soils and will produce at least some yield, even in very unfavorable conditions where it can play a key role in food security (Thresh and Cooter, 2005). Cassava produces higher yield than other crops like cereals and its propagation method done asexually by stem cuttings about 15cm long having 3-4 nodes. Cassava yield per unit of land varies depending on cultivars, growing agroecology, biotic and a biotic factors and its vegetative period (growth cycle) varies from 9 months to 18 months and in sub-Saharan Africa cassava grown by resource-poor farmers as an intercrop with many crops for food security and assured household income (Alabi *et al.* , 2011).

However, cassava production has been influenced by various a biotic and biotic factors. The most important constraints of cassava production include disease and insect pest. Many authors reported as the growth, yiled and quality affected by disease and insect pests. Commonly know diseases in different cassava producing countries include cassava mosaic disease, cassava anthracnose disease, cassava bacterial blight and cassava brown streak disease and anthracnose (*Colletotrichum gloeosporoides*) and major insect pest incudes cassava mealy bug (*Phenacoccus manihoti*), African root and tuber scale (*Stictococcus vayssierei*), cassava green mite (*Mononychellus tanajoa*) (Alabi *et al.,* 2011; Abaca *et al*., 2014; Chikoti *et al*., 2015). Low productivity of cassava in sub-Saharan Africa due to the deleterious effects of pests and diseases was indicated (Thresh and Cooter, 2005).

Cassava mosaic disease is the most economicaly importnt disease caused by whitefly and reoprted in different forms such as East African cassava mosaic virus, East African cassava mosaic Cameroon virus, East African cassava mosaic Zanzibar virus, East African cassava mosaic Malawi virus, East African cassava mosaic Kenya virus and South African cassava mosaic virus (Chikoti *et al*., 2015) cited (Bull *et al*., 2006). Whitefly transmitted virus disease causes severe economic losses in a wide range of food crops grown by many of smallholder farmers and has the widest impact on global food production, including on key crops such as cassava, tomatoes, beans and sweet potatoes. Cassava mosaic disease transmitted by infected cuttings and by whitefly transmission (Jose *et al*., 2008).

On the other hand, cassava cultivation has been problematic due to adverse effects of insect pests. In addition to whitefly, mealy bugs are among the main pests of cassava that feeds by sucking the sap of cassava plants, causing damage directly by sucking the sap and contaminating the plant with its toxic saliva and indirectly by favoring the development of sooty molds (Barilli *et al*., 2014). Finding suitable pest mannagement tactics is one of the crop protection work in order to reduce crop damage, yield loss and quality. Different cassava pests management approaches that can be used either in individual or integrated manner have been identified in different countries. Therfore, the objective of this paper is to review cassava mosaic disease and mealybug integrated management techniques for further understanding through partialfulfilment of the course integrated pest management of horticultural crop, Msc program, given at Jimma Univeristy Ethiopia during 2017.

2. CASSAVA MOSAIC DISEASE

2.1 Challenges and Impacts of Cassava Mosaic Disease

Cassava is growing from vegetative cuttings and cassava mosaic disease carried from one crop cycle to the next through the infected cuttings which are used as planting material. On the other hand, management of cassava mosaic disease needs managing whitefly which can found in every location. Another challenge in management of the disease is that smallholder farmers in different country are unwilling to rouge out infected cassava plants that otherwise increase risk of infection. Climate change that might be favorable for whitefly breeding is one of the challenges expected.

Besides, as because of change in weather pattern that harm other main stable crop of a country might open chance to promote cassava production this also contributes spread of cassava mosaic disease from one area to the other through sharing of infected cassava planting materials. Furthermore, FAO (2013) added insufficient capacities of plant protection/quarantine organizations for adequate monitoring of germplasm for pests and pathogens, and for the implementation of emergency control measures in case of accidental introductions as cassava mosaic disease management challenges.

Cassava mosaic disease is most economically important disease affecting cassava growth, yield and quality and it was reported as the disease is endemic to Sub- Saharan Africa (FAO, 2013). In many studies of cassava mosaic disease various reported as it causes loss of yield of edible roots, affects income of growers, reduces food security, cause famine and loss of planting material. East Africa has been one of the areas worst affected by whitefly, with farmers losing their cassava crops due to whitefly-borne cassava mosaic disease. Therefore, it is important to be aware of this disease, its distribution and suitable integrated management practices in order to reduce harmful effect on cassava growth and productivity.

2.2 Distribution of Cassava Mosaic Disease

It was first described in 1894 in Tanzania (Hillocks and Thresh, 2000) and the symptoms of cassava mosaic disease were first reported more than 100 years ago and further it was reported as cassava mosaic disease occurs in all the cassava-growing areas of Africa (Thresh and Cooter, 2005). For instance, studies on cassava mosaic disease in Kenya showed as it widely distributed in all major growth areas with an average incidence of 57% and use of infected cuttings accounted for 80% of the infected plants compared to the whitefly-borne infections which accounted for 19% (Mwatuni *et al*., 2015).

Moreover, cassava mosaic disease distribution studies in Guinea resulted as the symptom was found across the country in 73.6% of farms and whitefly was recorded in all surveyed farms (Bah *et al*., 2011). Similarly studies in DR-Congo showed enormous cassava yield losses due to cassava mosaic disease (Muengula-Manyi *et al*., 2012) and in India presence of cassava mosaic disease was reported (Karthikeyan *et al*., 2016).

2.3 Causal Agents of Cassava Mosaic Disease

Cassava mosaic disease is caused by begomoviruses in the family Geminiviridae and transmitted by whitefly and by using infected planting materials (Mwatuni *et al*., 2015; Thresh and Cooter, 2005). Whiteflies, Bemisia tabaci (Gennadius) are major insect pests that affect many crops such as cassava, tomato, beans, cotton, cucurbits, potato, sweet potato, and ornamental crops (Manani et al., 2017). Whitefly is polyphagous insect pest belonging to the Aleyrodidae family and considered a major pest because it causes considerable damage and loss of production to crops by sucking the sap from the host plant. Apart from the direct damage to crop whitefly transmit viral disease to many agricultural crops. Studies on whitefly efficiency in transmiting cassava mosaic disease reported as a minimum period of 6 h required for whitefly to feed and transmit the viral diseases (Njoroge et al., 2017).

Furthermore, whiteflies are known by high reproduction, resistances to insecticides, under-leaf habitat, diversified genotype, easily adaptable to changing environment and virus transmission (Shah *et al*., 2015). These characteristics make management of whitefly difficult. Whiteflies management strategies include various approaches such as resistant variety, cultural methods, biological method and insecticides. A Whitefly resistant cassava variety reduces pesticide application and production costs for small scale farmers.

Cassava germplams evaluation works against whitefly have reported. South American genotype MEcu 72 and several Ugandan cassava landraces including Ofumba Chai, Nabwire 1 and Mercury showed good levels of resistance to *B. tabaci* (Omongo et al., 2012). Furthermore, screening method of whitefly resistance levels in cassava germplasm, as well as, accurate system to study the mechanism of this resistance to whitefly in the genus *Manihot* was developed (Bohorquez *et al*., 2013). Cultural practices of cassava whitefly management includes used of healthy and whitefly free planting material, crop rotation, adjusting planting time and avoiding whitefly breeding centers.

On the other hand, Biological control of cassava whitefly depends on natural enemies such as fungi, predators and parasitoids (Horowitz et al., 2011). However, because of the harmful effects of chemicals to humans and the ecosystem and because of resistance development, applications of alternative plant extracts have been reported. For instance, essential oils distillated from *Geranium* and *Artemisia* could be applied to control *B. tabaci* in greenhouse cucumber at V/V 12 ppm (Yarahmadi et al., 2013). Besides, insecticides recommended as last option in whitefly management while importance of insect growth regulators have been emphasized and reviewed (Horowitz et al., 2011).

2.4 Cassava Mosaic Disease Symptoms

Leaf chlorosis, mottling, mosaic, leaf discoloration, leaf malformation, stunted growth, reduced root growth and the disease symptoms are more pronounced on young plants usually under 6 months than older plants (Hillocks and Thresh, 2000; IITA, 2000; Alabi *et al.,* 2011)

2.5 Integrated Cassava Mosaic Disease Management

Integrated disease management is crop protection strategy which combines biological, cultural, physical and chemical control practices to safeguard the crop. For a proper control of the disease one has to be aware of the incidence and severity as well as the effect on crop yield and quality. Many authors reported the importance of integrated management options that have advantageous from different point of views. One important advantage of integrated disease management is that it utilized in a way that minimizes economic, health and environmental risks (El Khoury and Makkouk, 2010). According to Alabi *et al.* (2011) cassava mosaic disease management should integrate different approaches for better management in Sub-Saharan Africa. In many crop protection reports integrated disease management includes use of resistant variety, applying cultural practices, biological control as well as chemical control as major components.

2.5.1 Resistant Variety

Alabi *et al.* (2011) appritiated efforts made by IITA and CIAT in developing resisitant variety to cassava mosaic disease and the white fly vector. Resistant variety is beneficial to resource poor farmers as it does not require additional cost and environmental friendly (El Khoury and Makkouk, 2010). Virus-induced gene silencing studies in USA showed presence of resistant cassava cultivars to cassava mosaic disease and recommendations made for further application (Beyene *et al*., 2017).

Interesting studies in Sierra Leone resulted as high yielding cassava genotypes resistant to the cassava mosaic disease were identified for food, feed and industries and positive effects obtained from utilization of resistant varieties as well as neem and moringa treated cuttings in controlling cassava mosaic disease (Samura *et al.,* 2016). The authors indicated as neem and moringa based bio - pesticides use is a natural choice worth exploiting for controlling because of their antimicrobial and repellent properties.

Furthermore, innovative combination of natural and engineered virus resistance in farmer-preferred landraces to reduce the impact of cassava viral diseases in Africa recommended (Vanderschuren *et al*., 2012). Performance of cassava varieties was evaluated in Uganda and as result resistant cultivars were identified (Abaca *et al*., 2014). Different cassava varieties tested for cassava mosaic disease resistance and presence of resistant varieties reported in Brasil (Venturini *et al*., 2016) and higher tuberous root yields were reported from cassava resistant varieties in Tanzania (Mallowa *et al*., 2011).

However, cassava genotypes variability study in Ethiopia showed very high amounts of variability for all of the quantitative characters of interest in cassava for exploitation (Mulualem and Dagne, 2014) but according to Tadesse *et al*. (2013) only 30% adoption rate for the improved cassava varieties was reported and indicated as many work left concerning development and utilization of resistant cassava variety in major producing areas of the country.

2.5.2 Cultural Practices

Cultural cassava mosaic disease amanagement includes use of healthy planting material, rouging infected plants, adjasting planting time and cropping system. The importances of sanitation such as management of plant left over after harvest, removing crop debris, cleaning farm tools, and rouging in reducing the sources of the pathogens that cause cassava diseases in farms stated (IITA, 2000). Similarly effectivenes of phytosanitation in cassava mosaic disease management in kenya was revied (Mallowa *et al.,* 2011). These are common practices done by farmers in crop production eventhough integration of such practices require capacity, skill, availability of resource and so on.

2.5.3 Biological Control

Most pests have natural enemies that suppress their harmfull effects. In case of cassava mosaic disease biological control methode direct to the control of whitefly because one means of tranmission reported is by whitefly. Thresh and Cooter (2005) reported importance of biological control of whitefly vector insect that transmit cassava mosaic disease and vector resistant variety for suitable cassava cultivation. This might be due to transmission of the disease by whitefly.

3 CASSAVA MEALYBUG

It is one of the economically important cassava insect pests feed on cassava stems, petioles and leaves, and inject a toxin that causes leaf curling, slow shoot growth and eventual leaf withering and spreading rapidly in Africa since the late 1970s (FAO, 2013). Mealy bugs (Hemiptera: Pseudococcidae) are small, soft-bodied, plant sucking insects which embrace the second largest family of scale insects (Pseudococcidae) and comprises approximately 2000 species belonging to 300 genera (Mamoon-ur-Rasheed *et al*., 2014). They are so called due to the thin to thick mealy or cottony wax secretion covering the insects. The mealybugs are generally located on the underside of the cassava canopy leaves, mainly around major leaf veins. According to Mamoon-ur-Rasheed *et al*. (2014) cassava mealybug characterized by waxy coating, high reproduction rate, protection by ants and variety of hosts.

3.1 Impact of Cassava Mealybug

Mealybugs are major insect pests of cassava, *Manihot esculenta* Crantz that suck sap and cause cassava damage as they significantly affect stem and root yields (Egho *et al*., 2013; Barilli *et al*., 2014). The mealybug feeds on the cassava stem, petiole, and leaf near the growing point of the cassava plant and during feeding the mealybug injects a toxin that causes leaf curling, slowing of shoot growth, and eventual leaf withering (Nweke, 2009; FAO, 2013). The pest spread by the wind as well as through the exchange of infested planting materials. About 60% root and 100% leaf yield reported.

3.2 Host Range of Cassava Mealybug

Cassava mealybug host range is wide as it feeds on different crops such as herbaceous plants, woody shrubby and trees. A study in Malaysia showed that the pest has been recorded feeding on hosts belonging to Cyperaceae, Euphorbiaceae, Fabaceae, Lamiaceae, Malvaceae, Nyctaginaceae, Portulacaceae, Rutaceae and Solanaceae, including crops like citrus, Solanum species and basil in addition to cassava (Sartiami *et al*., 2015). Furthermore, papaya, tomato, pineapple, yam, ground nut and okra recorded as alternative hosts of mealybug (Egho *et al*., 2013).

3.3 Biology of Cassava Mealybug

Research on biology of mealybug showed as the insect reproduce sexually and adult female secretes an egg sac of white waxy substance in which egg laid (Sreerag *et al.,* 2014). Examination of cassava mealybug biological characteristics in Brasil showed that the insect completes its life cycle in approximately 45 days and more than 90% of the eggs were viable and fecundity exceeds 240 eggs per female (Barilli *et al*., 2014). According to the authors report mealybug egg stage lasted 7.7 days on average and three nymphal stages identified and their average durations indicated as 6.9, 4.9 and 5.7 days respectively. Besides, Sreerag *et al.* (2014) reported as mealybug completed its life cycle in 1-2 months and larval stage of cassava mealybugs consist three distinctive instars from which there was additional pupal stage for male while female instar molted directly in to adult female without undergoing complete metamorphosis.

3.4 Integrated Management of Cassava Mealybugs

Integrated pest management involves coordination and combination of various practices that reduces crop damage, impacts on environment and beneficial organisms, easy and applicable in crop production. Breeding for mealybugs resistant variety, cultural practices, biological methods, and as last option insecticide might be under this integrated strategy. According to FAO (2013) the recommended cassava mealybugs management practices include conservation of natural enemies, monitoring cassava plantation closely to detect the focal points of infestation, removing and burying infected plant parts, and avoiding movement of planting material from place to place.

Pretty and Bharucha (2015) indicated as ploughing and drying soil, soaking stalk cuttings in insecticide, burning of infested plants and no transport of infested plant materials in order to reduce the impacts of cassava mealybugs. Key natural enemies of mealybugs include green and brown lacewing, ladybeetles, and wasp predators and with respect to used of *Anagyrus lopezi* predators in cassava mealybug management resulted completely control in 2013 (from 200,000 to 10 hectares) in Thailand (Pretty and Bharucha, 2015).

Moreover, Africa-wide Biological Control Program of cassava pests was established at International Institute of Tropical Agriculture in Nigeria to achieve permanent, ecologically safe and economically sustainable control of the cassava mealybug and because of the release of parasitoid wasps in many African countries average cassava yields in Sub-Saharan Africa have increased steadily from 6.7 tons/ha during the 1970s to 8.5 tons/ha in the 1990s (Kristina *et al*., 2003 ; Nweke, 2009). Another finding on biological control of cassava mealybug emphasized the importance of green lacewings as one of the factors that must be taken into account to achieve the most efficient control method (Promrak and Rattanakul, 2015). However, waxy coating of mealybugs reduces the effectiveness of contact insecticides. Besides, the habit of aggregating in hidden locations makes mealybugs control by insecticides difficult.

4. SUMMARY AND CONCLUSION

Integrated pest management practices have been practiced in the management of different crop protection strategies. Cassava is one of the main root and tuber crops cultivated for food security and other various purposes. However, cassava production has been constrained by biotic factors such as cassava mosaic disease and cassava mealybugs. Both pests known in causing crop damage and yield loss. Besides, magnitude of impacts of these pests as well as management tactics was reported in different cassava producing countries in the world.

In order to reduce such impacts different findings reported as integrated pest management is best option among which use of resistant variety, biological control, phytosanitation practices and sound agronomic practices accounts its main components. Therefore, adjusting planting time, rouging infected plant materials, crop rotation, use of health planting material as well as incorporating host plant resistance into cassava germplasm become more feasible and more strategically practicable option for controlling cassava mosaic disease and cassava mealybugs.

Besides, introduction, conservation and augmentation of natural enemies will play an increasingly important role in cassava pest management systems. Application of pesticides in management of cassava mealybugs might result in unsatisfactory efficacy as the insects covered by waxy substances. Moreover, chemical pesticides have sides effects and less recommended as pest management strategy whereas different plant derivatives has to be used in pest control practices. Hence, cassava producers have to implement integrated pest management for most economically important such diseases and insect pests.

However, implementation and successfulness of this integrated cassava pest management tactics require well planned training and awareness creation to growers, agricultural development agents, extension officer, and policy makers. All direct stakeholders should have a practical understanding of the cassava mosaic disease and cassava mealybug. Besides, training using participatory approaches should be used to empower farmers with the appropriate knowledge to become better managers of their own fields.

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