Insect Pests of Brassica oleracea

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Definition

The propagation and regeneration of *Brassica* species has been successful using seeds and different explants like petioles, cotyledons, stems and shoot tips. Shoot regeneration and rooting of *Brassica species* are successfully obtained from cotyledons and hypocotyl explants. The biological cycle length of *Brassica species* may either differ slightly or may not differ from one species to another. For instance, the seeds of *Brassica oleracea* take five days to germinate after sowing at 20–25 °C while the seeds of *Brassica campestries* take about three to five days to germinate after sowing at 20–25 °C. The most common insect pests of economic importance to *Brassica oleracea* in African smallholder farmers include *Plutella xylostella*, *Helula undalis*, *Pieris brassicae, Brevycoryne brassicae*, *Trichoplusia ni* and *Myzus persicae*. Those insect pests infest cabbages at different stages of growth, causing huge damage and resulting into huge yield losses. The African smallholder farmers use cultural and synthetic pesticides to control those insect pests and minimize infestations. The cultural practices are environmental friendly but are ineffective to control the insect pests. Due to ineffectiveness of cultural practices, African smallholder famers use broad-spectrum synthetic pesticides to effectively control the *Brassica species* insect pests. The improper and misuse of synthetic pesticides result into insect pests resistance towards the insecticides applied, environmental pollution and human health threats. Insect pests such as *Plutella xylostella*, *Hellula undalis*, *Brevicoryne brassicae* and *Myzus persicae* have developed resistance to a wide range of pesticides used such as cypermethrin, parathion, decamethrin, quinalphos and lamda-cyhalothrin. Therefore, that calls for search of the alternative products which can effectively be used to control those insect pests in the field.

1. The Biological Cycle of Brassica Species and Their Common Insect Pests in Africa

1.1. Propagation and Biological Cycle Length of Selected Brassica Species

The propagation and regeneration of Brassica species has been successful using seeds and different explants like petioles, cotyledons, stems and shoot tips [1] (Table 1). Shoot regeneration and rooting of Brassica species are successfully obtained from cotyledons and hypocotyl explants [2]. The shoot tip explants of Brassica species are reported to be effective for initiating shoots and roots [3]. Table 1 shows the Brassica species propagation and biological cycle length.

Table 1. Propagation and biological cycle length of Brassica species.

Name of Brassica Species	Propagation	Biological CycleLength	References
Brassica oleracea L.	Conventional propagation is through seed, with seedlings being raised in beds or modules and then transplanted to field sites. However, some B. oleracea subspecies, such as tronchuda, can be propagated through vegetative from stem and side shoot cuttings whereby the stem and side shoot cuttings are obtained from 5-week old plants, which is rooted, and transplanted as normal cuttings	Seed germinates within 5 days after sowing at 20–25 °C.	[4]

Name of Brassica Species	Propagation	Biological CycleLength	References
Brassica juncea L.	Conventional propagation is through seeds also, it has been successful by using petioles, cotyledons, stems and shoot tips as explants.	Seed germinates within 5 days after sowing at 20–25 °C.	[1][5]
Brassica napus L.	Conventional propagation is through seeds. The seedlings are raised in seedling trays or in a seedbed. Also, it is propagated successful by using stems, cotyledons, nodal stems and hypocotyl as explants in vitro.	The seeds take 3–5 days to emerge at 20–25 °C	[1][6][7]
Brassica rapa L.	Conventional propagation is done using seeds but also, the propagation is successful through petioles, stems, cotyledons, stems and shoot tips as explants in vitro.	The seeds require 3–5 days to germinate at 20–25 °C	[1]
Brassica campestris L.	Conventional propagation is through seeds. Also, petiole and cotyledons can be used in the development of a plants in vitro culture. Four day seedlings are enough to give a viable Brassica campestris plants	The seeds require 3–5 days to germinate at 20–25 °C	[1][7][8]
Brassica nigra	The propagation is done using seeds. The small seeds require a level and a well-prepared seedbed.	The first leaves are usually visible within 48 h	[9]

1.2. The Common Insect Pests Affecting Cabbages in Africa

Many insect pests such as diamondback moth (Plutella xylostella), cabbage webworm (Helula undalis), cabbage white butterfly (Pieris brassicae), the cabbage aphids (Brevycoryne brassicae), green peach aphids (Myzus persicae) and cabbage loopers (Trichloplusia ni) [10][11] (Table 2) hinder the proper cabbage crop production on the field in Africa. Those insect pests (Table 2) infest the cabbage crops at different stages of growth, causing significant damage to the crop [12] and resulting into huge cabbage yield losses. Krishnamoorthy [13] showed that, cabbage insect pests all together can cause 52% yield loss on cabbage. Severe infestation by Plutella xylostella usually causes huge economic crop losses and may result in 100% yield loss of the Brassica oleracea [14]. Due to heavy infestations which result into huge losses, the African smallholder farmers of cabbages spray four or more than four times in a month and two or more than two mixed insecticides into the field for strongly and effectively control of the cabbage insect pests [15][16]. The consequence of that scenario is environmental pollution especially water and soil, detrimental effects to non-target organisms and endanger the health of the human being [17]. This section reviews the major insect pests of economic importance infesting cabbage crop at different stages of growth in African countries and how the control measures are potential water and soil pollution threat.

Table 2. Common insect pests of cabbages [10][11].

Common Name	Scientific Name	Parts of Cabbages Damaged
Dimondback moth	Plutella xylostella	Cabbage heads and foliar tissues
Cabbage webworm	Helula undalis	Leaves, petioles and heads of cabbages
Cabbage white butterfly	Pieris brassicae	Head of cabbage and leaves
Cabbage aphid	Brevycoryne brassicae	Tips, flowers and leaves
Green peach aphids	Myzus persicae	Tips, flowers, developing pods and leaves
Cabbage looper	Trichloplusia ni	Leaves, stems and veins of leaves

1.2.1. Cabbage Looper (Trichoplusia ni)

The cabbage looper (Figure 1A) (Trichoplusia ni) is a moth found in the family noctuidae a family which is commonly referred to as owlet moths [18]. Its common name comes from its preferred host plants and distinctive crawling behavior. The members of noctuidae are brown or gray night-flying moths whereby the larvae infest the growth of cruciferous vegetables [19]. Cruciferous vegetables like cabbages, bok choy and broccoli are the main host plants to cabbage lopper and hence, the reference to cabbage in its common name [20]. The larvae is called a looper since it arches its back into a loop when it crawls [18]. While crucifers are preferred, however, over 160 plants can serve as hosts of cabbage looper larvae [18]. The adult cabbage looper is a migratory moth and its migratory behavior can be found in a wide range of host plants and this contribute to its wide range of distribution [19].

Figure 1. (**A**) Mature larva of the cabbage looper, Trichoplusia ni. (**B**) The cabbage plant damaged by Cabbage looper larva. Photograph by Nelson Mpumi, NM-AIST-Arusha, Tanzania.

The cabbage looper larvae is a vegetable pest for crucifers and has been reported to damage broccoli, cabbages, cauliflowers, chinese cabbages, collards, kale, mustards, radish, turnip and watercress [19]. The cabbage looper larvae interfere with plant growth and marketability by making irregular holes of variable shapes (Figure 1A,B) while feeding on the leaves of the host cabbage plants [21]. Although it is not extremely destructive, but it is becoming difficult to control and manage due to its broad distribution and resistance to many insecticides [20][21]. Therefore, African smallholder farmers rely intensively on the application of synthetic pesticides to control the cabbage insect pests. However, synthetic pesticides result into environmental pollution, insect pest resistance and contaminate the foods which consequently threaten the human health [21]. Therefore, environmental benign, the botanical pesticides from T. vogelii, S. aromaticum and C. dichogamus can be utilized to control the insect pests in the field instead of synthetic pesticides [22]. Although the potentialities are ignored, but botanical pesticides have been in use for centuries by smallholder farmers in developing countries to control insect pests of both field and stored products [23][24]. Therefore, they could be used to control cabbage insect pests in the field to minimize the infestation.

1.2.2. Cabbage Webworm (Hellula undalis)

Among the most destructive insect pests which attack cruciferous vegetables is the cabbage webworm (Figure 2A) (Hellula undalis) (Lepidoptera: Pyralidae) [25]. The cabbage webworm (Hellula undalis) is a major pest of cruciferous crops in the tropics and subtropics [26]. It is a widespread species in the world especially in Europe across Asia to the Pacific and also, in African countries [27][28]. Shine et al. [29] reported that H. undalis is distributed mostly in tropical and subtropical regions but can similarly be found in countries with moderate climates.

Figure 2. (**A**) Mature larva of the cabbage webworm, Hellula undalis. Photograph by Lyle Buss, Entomology and Nematology Department, University of Florida (March, 2016). (**B**) The cabbage plant head damaged by larva of H. undalis. Photograph by Nelson Mpumi, NM-AIST Arusha, Tanzania.

Ebenebe et al. [27] reported that, Helulla. undalis larva causes a serious and severe damage to the leaves and the heads of cabbages (Figure 2B) in the field. According to Waterhouse and Norris [30] H. undalis feeds on a variety of plants especially the Brassicaceae family members. Waterhouse and Norris [30] revealed that, H. undalis larva can cause a huge yield loses of up to 100% to crucifers crops in the field and its management is not well taken into account. The larvae feed on leaves, petioles, growing points and stems [28]. According to Sivapragasam and Aziz [25] and Waterhouse and Sands [28], the plants in which H. undalis larvae feed include broccoli, head cabbage, chinese cabbage, spoon cabbage, daikon radish, horseradish, mustard, radish and turnip. Shine et al. [29] revealed that, H. undalis is a very serious agricultural pest to crucifer crops grown by the African smallholder famers. The incidence of H. undalis did not depend on the number of insecticide applications, but depend highly to host crop abundance and the temperature of the area [31]. The larvae make mines in the leaves and bore into the stem and later, they tunnel into the heart of the plant, destroying the bud causing the leaves to become distorted and stunted [10]. A study done by Sivapragasam and Aziz [25] indicated that, a single larva of cabbage webworm, can either cause a number of deaths to the young plant or lead to the formation of unmarketable multiple heads on relatively older plant. On the field, a low population of larvae can cause very huge significant losses to the cabbage crop and in untreated cabbages, losses could go as high as 99% [27]. Although, the larva can be present throughout the cropping season, it is severe only during the period between transplanting and the heading stage of cabbage [32].

Currently, African smallholder farmers rely intensively on the application synthetic pesticides as the only effective control method to the cabbage webworm on the field [25]. The effective insecticides which are used to control cabbage webworm worldwide and Africa particularly, include permethrin, abamectin, teflubenzuron, chlorfluazuron, triflumuron, phenthoate, exthofenprox and Lamda-cyhalothrin and among those insecticides, abamectin is found to be the most effective of the other insecticides [25]. However, some are reported hazardous and therefore unwise and overuse of those insecticides can result into severe environmental pollution especially water and soil, development of insect resistance to some of insecticides and health problems to human being. Therefore, there is a need of searching and utilizing benign and environmental friendly botanicals from pesticidal plants as cabbage insect pests control strategy.

1.2.3. Diamondback month (Plutella xyllostela)

The diamondback moth (Figure 3A) (Plutella xylostella), sometimes called the cabbage moth, is a moth species belonging to the family Plutellidae and genus Plutella [32][33]. Badenes-Perez et al. [34] reported that Plutella xylostella is believed to have originated in Europe, South Africa, or the Mediterranean region, but it has now spread worldwide. The diamondback moth is the dominant and most destructive insect pest of crucifer crops worldwide [23]. Justus and Mitchell [35] reported that, Plutella xylostella larva feeds on the leaves between the large veins and midribs of cruciferous crops and the plants which produce glucosinolates. Plutella xylostella larva prefers to feed on the lower leaf surface, leaving the upper epidermis intact creating a “window-paning” effect (Figure 3B) [23]. Timbilla and Nyarko [12] showed that, severe feeding damage (Figure 3B) stunts and destroys the cabbage heads and can cause heads to abort leading to huge yield depression and total crop loss. The most cabbage plant damage is caused by larval feeding resulting in a complete removal of foliar tissues and disrupt head formation in cabbages, broccoli and cauliflower [23]. The destruction of cruciferous crops by diamondback moth larva reduces the quality and the marketability of the cabbage crops and hence yield losses due to P. xylostella can go up to 100% [14][36] and vary widely depending on the season and severity of pest infestation [37].

Figure 3. (**A**) Mature larva of the Diamond back moth, Plutella xylostella. (**B**) The cabbage plant damaged by larva of P. xylostella. Photograph by Nelson Mpumi. NM-AIST, Arusha, Tanzania.

Generally, it is estimated that, diamondback moth causes an annual loss of about 16 million dollar on the basis of 2.5 per cent damage even on the protected crop [38]. Also, in the tropics, diamondback moth causes threat of great loss of 90% and above to crucifer production crop [39]. Therefore, there is a need to conduct a research to determine the cabbage losses due to infestation of diamondback moth in various parts of Africa.

The diamondback moth and its larvae control in cabbage by African smallholder farmers is still deeply dependent on chemical insecticides although their use is connected with many adverse and lethal consequences. Inappropriate and excessive application of chemical insecticides result into environmental pollution especially water and soil pollution [40][41]. Pedigo and Rice [42] indicated that, extreme use of insecticides also induces resistance development in target pests as well as killing beneficial organisms like pollinators such as bees and other natural enemies such as spiders, lacewings and ladybird beetle. Therefore, the benign, environmental friendly botanicals have to be searched to control this pest instead of relying on the synthetic pesticides which have many negative impacts and problems to the environment. The benign and environmental friendly control measures with broad spectrum of the activities are the botanicals (phytochemicals), the chemicals from pesticidal plants [22]. Those alternatives with antifeedant, repellency and insect growth regulators of their natural origin having non-neurotoxic modes of action to human being and low environmental persistence can be applied.

Botanical pesticides are not only effective against crop pests but remain safe to the environment and to natural enemies [43]. In developing countries, botanicals have been in use for centuries by smallholder farmers to control insect pests both in field and storage [23]. For instance nicotine, rotenone and pyrethrum were famous and among the botanical insecticides used in those days [24]. Those chemicals from pesticidal plants possess one or more useful properties like repellency, anti-feeding, fast knock down, flushing action, biodegradability, broad spectrum of activity and ability to reduce insect resistance [24][44]. Therefore, there is a need to use the environmental friendly products for instance, the botanicals/phytochemicals from Tephrosia vogelii, Syzygium aromaticum and Croton dichogamus to control cabbage insect pests in the field.

1.2.4. The Cabbage Aphids, (Brevicoryne brassicae)

Cabbage aphid (Figure 4A) (Brevicoryne brassicae) belongs to the family Aphididae of the order Hemiptera [45] and the genus Brevicoryne [46]. The name is derived from two Latin words “brevi” and “coryne” and which means “small pipes” [45]. In those aphids, there are two small pipes called cornicles or siphunculi at the posterior end which can be observed when using hand lens during the observation [47]. The cornicles of the cabbage aphid are comparatively shorter than the cornicles of other aphids except those of the turnip aphid, Lipaphis erysimi [47]. The short cornicles and the waxy coating present on cabbage aphids differentiate cabbage aphids from other aphids which can attack the same host plants [47][48]. The cabbage aphid is native to Europe, but now has a world wide distribution [48][49] and can be found in Africa, Asia, Canada, Australia [50], America, India, China and Netherland [46] and also in African countries.

Figure 4. (**A**) Cabbage aphids, Brevicoryne brassicae. (**B**) The damaged plant cabbage by cabbage Aphids. Photograph by Nelson Mpumi. NM-AIST, Arusha, Tanzania.

Jahan et al. [51] and Moharramipour et al. [52] indicated that, cabbage aphids are serious plant sap sucking pests worldwide. Those aphids are the most common damaging species causing significant yield loss to many crops of Brassicaceae, like the mustards and crucifers [52][53]. Blackman and Eastop [54] insisted that, cabbage aphids mostly attack growing parts of the host plants such as tips, flowers, developing pods, leaves and eventually cover the whole plants (Figure 4B) at high population. According to Elwakil and Mossler [55] and Lashkari et al. [56] cabbage aphids (Figure 4A) have direct and indirect damaging effects to cabbage crops. The direct damage caused by this pest is by sucking cell sap, secrete honey dew which result into sooty mold formation on leaves and shoots and indirect damaging effect is as a vector of 20 plant viral diseases in a wide range of plants. According to Valenzuela and Hoffmann [57], the damaging viruses transmitted by cabbage aphids are such as potato leafroll virus, potyviruses, beet western yellows, beet yellows, cauliflower mosaic, cucumber mosaic, lettuce mosaic, turnip mosaic and watermelon mosaic. High population and feeding of cabbage aphids result into curling, distortion and yellowing of leaves, stunting plant growth, deforming developing heads, damaging of flowers and green pods and discoloration of any growth stage and part of plants [47][50]. Feeding by cabbage aphids can stop terminal growth resulting into reduced plant size and yield [58].

Eliminating weeds in Brassicaceae field borders is one of the cultural methods which may help to reduce the population and damaging of the cabbage aphids [56][59]. However, cultural methods alone are less effective to completely control the cabbage aphids from the farmers’ field [45]. So, biological control can play a major role in the natural suppression of aphids. Among the biological controls which can be applied to control the aphids are the natural enemies such as ladybird beetles adult and larvae, lacewing larvae, syrphid fly larvae, predatory bugs and lacewing larvae [56][60]. Other biological control agents are entomopathogenic fungi, which particularly can be applied during the periods of high humidity and precipitation [55][59]. However, natural enemies alone and other biological controls are also insufficient to prevent economic damage by a rapidly increasing population of cabbage aphids [61].

Due to high pest pressure and damaging caused by those aphids on cabbages in African countries, growers resort to excessive and intensive chemical pesticides application for aphids and other insect pest management [45][60]. Chemical pesticides are intensively, excessively and doubly rated for insect pest management [45][60]. However, intensive and heavily reliance on the application of the synthetic pesticides results into extreme soil and water pollution and pose serious threats to the non-target organisms including human beings [45]. For instance, Bami [62] reported that, every year, one million people are suffering from pesticide poisoning in India. The pesticides poisoning threatens the health of human being and the natural enemies. Also, the soil pollution threatened the soil ecosystem. Decomposers are also in danger due to soil pollution through excessive and intensive application of synthetic pesticides [17].

Due to those problems associated with the application of synthetic pesticides, there is a need of assessing the potential of botanical pesticides from various plants such as T. vogelli, S. aromaticum and C. dichogamus for cabbage aphid control and management in the field. Botanicals from different pesticidal plants have many advantages over synthetic pesticides such as local availability and inexpensive pest control agents [45][63].

1.2.5. The Green Peach Aphids (Myzus persicae)

The green peach aphid, (Myzus persicae) (Figure 5A), is found throughout the world and can be present at any time throughout the year [64]. Generally, its color is pale green, and there are two forms of green peach aphids; winged and wingless forms [65]. The green peach aphid have prominent cornicles on the abdomen that are markedly swollen and club like in appearance [54]. The frontal tubercles at the base of the antennae are very prominent and are convergent [65]. Winged forms of the green peach aphid have a distinct dark patch near the tip of the abdomen; wingless forms lack this dark patch [66]. The green peach aphid is adapted to high environmental temperatures [64].

Figure 5. (**A**) Green peach aphids, Myzus persicae. (**B**) The cabbage affected by green peach aphids. Photograph by Nelson Mpumi. NM-AIST, Arusha, Tanzania.

Blackman and Eastop [54] and Gu et al. [64] showed that, over 40 plant families are hosts of green peach aphids. According to them, those plants include woody and herbaceous plants including vegetable crops in the family Solanaceae, Chenopodiaceae, Compositaceae, Brassicaceae, and Cucurbitaceae. Some of the host plants which support the growth and development of green peach aphids include cabbages, spinach, asparagus, bean, beets, broccoli, Brussels sprouts, carrot, cauliflower, cantaloupe, celery, corn, cucumber, fennel, kale, turnip, eggplant, lettuce, mustard, okra, parsley, parsnip, pea, pepper, potato, radish, squash, tomato, turnip, watercress and watermelon [54]. Moreover, Gu et al. [64] added that, many flower crops and ornamental plants are also suitable for growth and development of green peach aphids. Those all crops differ in their vulnerability to green peach aphids, but the actively growing plants and plants' parts, or the youngest plant tissues often are affected by large aphid populations [66]. Broadleaf vegetables are particularly very suitable host plants for green peach aphids. Therefore, the broadleaf vegetables create pest infestation problems in nearby crops [64]. The green peach aphids can achieve very high densities on young plant tissues, causing water stress, wilting and reduced growth rate of the plant [65].

Anstead et al. [67] and Umina et al. [66] indicated that, adults and nymphs of aphids can damage the crops in three ways: - firstly, they feed directly on young tender plant tissues and causes drying out of shoots, wilting and distortions of the plants' parts (Figure 5B); secondly, they produce honeydew which falls onto foliage and becomes blackened by sooty mould fungi; and thirdly, they spread more than 100 viruses. According to Anstead et al. [67], de Little and Umina [68] and Valenzuela and Hoffmann [69], the damaging viruses transmitted by green peach aphids are such as potato leafroll, potyviruses in pepper, beet western yellows, beet yellows, cauliflower mosaic, cucumber mosaic, lettuce mosaic, papaya ringspot, turnip mosaic and watermelon mosaic. These viruses affect the proper growth and development of the crops and reduce the marketability. The damaging levels caused by green peach aphids are characterized by large numbers of aphids found on the underside of leaves sucking the plant saps [67][68]. In addition to attacking plants in the field, the green peach aphid can readily infest vegetables and ornamental plants grown in glasshouses [64]. Umina et al. [66] reported that, the aphids feed by sucking sap from leaves and flower buds, but the entire crop foliage may be covered when populations are large resulting in reduced or stunted growth of young plants. The extensive feeding of green peach aphids on crops enforces plants to turn yellow and the leaves to curl downward and inward from the edges resulting into wilting, stunted growth and finally death of the crops [68]. When young plants are infested in glasshouses and then transplanted into the field, the fields will not only be inoculated with aphids but insecticide resistance may be introduced [64]. de Little and Umina [68] insisted that, the green peach aphid is considered the most important vector of plant viruses in the world. Also, contamination of harvestable plant material with aphids, or aphid honeydew, causes the loss of the food quality and quantity [70]. Therefore, prolonged aphid infestation of crops can reduce the yield of crop products.

The green peach aphid is attacked by a number of common predators such as lacewings, lady beetles, syrphid flies and parasites, including the parasitic wasps (Lysiphlebus testaceipes, Aphidius matricariae, Aphelinus semiflavus, and Diaeretiella rapae), and is susceptible to the fungus disease, Entomophthora spp. All those natural enemies together with field sanitation helps to control the incidence and spread of viruses transmitted by green peach aphid, but it does little to control the aphid itself. So, the smallholder farmers rely on the application of chemical insecticides to control the green peach aphids in the field. The use of chemical pesticides to control M. persicae on the food crops is increasing globally [71]. For instance in African countries like Tanzania, M. persicae are now extensively controlled with insecticides in oilseeds, pulses, and vegetable crops [65]. However, heavy reliance on insecticides to manage aphid populations result into strong insect pest resistance and M. persicae has probably developed resistance to more insecticides than any other insect species [71][72]. Therefore, broad spectrum insect pest control strategies are needed to ensure the aphids are controlled.

The severe damaged caused by insect pests in various parts of B. oleracea (Table 3 and Figure 5) compel the African smallholder farmers to increases the doses of the synthetic pesticides during the application.

Table 4. The parts of Brassica oleracea damaged by insect pests, signs and their effects [10][36][44][73].

Insect Pests	Parts of Cabbages Damaged	Signs of the Damaged Crop	Effects
Plutella xylostella	Cabbage heads and remove foliar tissues	Stunts and destroys the cabbage heads	Reduces quality and marketability of cabbage crops
Helula undalis	Leaves, petioles and heads of cabbages	Distorted of plant organ and stunted growth	Deaths to young plants and formation of unmarketable multiple heads
Pieris brassicae	Head of cabbage and leaves	Deforming developing heads of cabbage and leaves	Interfere with plant growth and marketability of the cabbages
Brevycoryne brassicae	Tips, flowers and leaves	Curling, distortion and yellowing of leaves, stunting growth, deforming developing heads	Stop terminal growth leading to reduced plant size and yield
Myzus persicae	Tips, flowers, developing pods and leaves	Yellowing of leaves, stunting growth, deforming developing heads and curling of leaves	Wilting, stunted growth and finally death of the crops

Insect Pests	Parts of Cabbages Damaged	Signs of the Damaged Crop	Effects
Trichloplusia ni	Leaves, stems and veins of leaves	Large irregular holes of variable shapes on the leaves	Interfere with crop growth and marketability of the cabbages

1.2.6. Brassica oleracea Insect Pests with Insecticides' Resistance

Some of the important pests of Brassica oleracea such as the Diamond Back Moth (Plutella xylostella), cabbage webworms (Hellula undalis), whiteflies (Bemicia tabaci) and aphids (Brevicoryne brassicae and Myzus persicae) have developed resistance to a wide range of commonly used pesticides [74]. For instance, Plutella xylostella is documented to have developed resistance to a number of insecticides [75]. The tests done in four regions in New Zeland between 1999 and 2000 reported that, P. xylostella developed resistance to synthetic pyrethroids [76]. The resistance of P. xylostella to pyrethroids is based on the oxidative detoxification of monooxygenase enzymes [77]. The level of resistance of P. xylostella to cypermethrin can be 1096 fold [78]. However, the resistance of P. xylostella to pyrethroids insecticides can be even 2880 fold [75]. Varma and Sandhu [79] reported the resistance of P. xylostella to DDT and parathion organochlorine insecticides in India. Also, P. xylostella is reported to developed resistance to fenitrothion and malathion [80], cypermethrin, decamethrin and quinalphos [81], cartap hydrochloride, diafenthiuron and flufenexuron [75][80]. The major reasons for P. xylostella to develop resistance to insecticides includes: the increase in number of sprays, misuse of pesticides, inappropriate dosages used by farmers and frequency of applications [82]. Apart from the insecticides resistance developed by P. xylostella, also cabbage webworms (Hellula undalis), whiteflies (Bemicia tabaci), aphids (Brevicoryne brassicae and Myzus persicae) have developed resistance to cypermethrin, decamethrin, chlorpyrfors, malathion and lamda-cyhalothrine [76]. Therefore, Brassica oleracea insect pest resistance to synthetic pesticides calls for search of the alternatives products which can effectively control those insect pests in the field.

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Keywords

Plutella xylostella;Helula undalis;biological cycle length, and regeneration