Review on contributions of climate to the seasonal variation of aphids on cabbage

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Abstract –

Climate change introducing irreversible shifting in crop cultivation patterns and the consequent loss of biodiversity and ecosystem services. We are entering a period of unprecedented climate change impacts in which we will see changes in crop yields, shifts in seasonal patterns of rainfall, and extreme weather events. Climate change has been identified as the major cause of the increased incidence of pests and diseases. In recent times aphids dominating their role as the most emerging pest in agriculture. Aphids can be found in almost every part of the world, but they are most common in tropical regions. The aphids attack a wide range of crops including cereals, fruits, nuts, and vegetables. Aphids also transmit viruses that cause diseases such as bacterial wilt, *verticillium wilt*, and *fusarium wilt* which can reduce yields by up to 50%. This paper aims to take a review of research from the literature from the year *2011 to 2014* in a similar area of research to identify the extent of the climate variations' impact on aphid inducement in cabbage plants.

Keywords – *Aphids, Climate change, Ecosystem services, Fusarium wilt, Pests, Verticillium wilt*

1. Introduction

"Across the globe, populations of different species of aphids follow different trends in population abundance (Estay, Lima, Labra, & Harrington, 2012)". "A mid-season breakdown of the population follows and leads to a sharp decline in aphid abundance (Herron et al., 2014)". "Though the cabbage aphid is economically one of the most important aphids in Western Europe (Smith & Chuang, 2014)". Aphids feed on various parts of plants such as leaves, stems, or flowers causing them to wither away or die off completely (B. B. Singh, Singh, & Research, 2014). This is why these insects are considered one of the worst agricultural pests around the globe today. "Aphids are tiny, soft-bodied insects that can be found on the surface of leaves and stems (Warren & Schalau, 2014)" along with pear-shaped bodies with long legs and antennae. The aphids also have two pairs of wings but they do not fly or jump like other insects (Alford, 2012). Their bodies are covered in a waxy secretion which makes them very difficult to see through the microscope (Sarwar, 2014). In India alone, there are around 794 species of aphids with 208 genera dominating the vegetative landscape including agriculture and forest ecosystem (Ahamad, 2013).

1.1 Cabbage aphid *(Brevicoryne brassicae)*

"Cabbage aphids lay their eggs on the underside of leaves where they hatch into small greenish-white insects called crawlers (R. Singh, Dhaliwal, & Vegetables, 2011)". "These tiny insects feed by inserting their mouthparts into the leaf tissue and sucking out plant juices (Liang et al., 2013)". "They also excrete honeydew which can lead to sooty mold growth on plants in high numbers (Rice & Eubanks, 2013)". Crawlers may be

found in large groups or clumps along with adult cabbage aphids, sometimes covering entire plants with black webbing as shown in the *figure 1*. Cabbage aphids are wingless insects, which means they cannot fly (Chaplin-Kramer & Kremen, 2012). They have a pear-shaped body with two pairs of legs on each side. The adult female has a long narrow abdomen (about 1/10th inch wide) and also has wings that are too small to be seen without magnification. These wings are usually hidden under the abdomen when she is not flying or resting on the plant. The eggs of cabbage aphid can be found attached to the underside of leaves or stems by their own sticky substance called 'honeydew' (Gratwick, 2012). This honeydew may cause black sooty mold to grow on leaves if it collects in large quantities during warm humid weather conditions (Chomnunti et al., 2014).

Fig.1 Infestation by aphid *(Brevicoryne brassicae)*

1.2 Infestation by cabbage aphid *(Brevicoryne brassicae)*

The first signs of infestation are yellowing leaves as shown in *figure 2* around the base of the plant followed by stunted growth and wilting of lower leaves as well as curling up or dropping off of upper leaves. Infested plants will produce fewer flowers than healthy ones, resulting in smaller fruit sizes and reduced yield potential for all varieties grown under infestations (Sarwar, 2014).

Fig.2 Damage caused by the cabbage aphid *(Brevicoryne brassicae)* on cabbage

Aphids live in colonies called "colonies" (Pringle et al., 2014) as shown in *figure 3* where each insect acts as an individual worker bee would in a hive. Each colony has its own queen who lays eggs and then eggs hatch into nymphs within 2-3 days after being laid by the queen and then they start feeding again until they reach adulthood when they become winged females ready to mate with males (Gilbert & development, 2012). After

mating, female aphids lay up to 300 eggs which will hatch into new nymphs over time if conditions remain favorable for them (Mehrparvar, Zytynska, & Weisser, 2013). These new generations continue living off plant juices until eventually most of them will die off due to lack of food or because their environment becomes hostile to their survival.

Fig.3 Colonies of aphid *(Brevicoryne brassicae)* on a cabbage leaf

2. Role of climate in seasonal variations of *Brevicoryne brassicae*

"As one of the main characteristics of global climate change, global warming has been widely concerned". "The Intergovernmental Panel on Climate Change (IPCC) points out that the mean global temperature has increased by 0.72 °C during the period of 1880 to 2012 with an average rise rate of 0.12 °C/10 years (Hodgson et al., 2013)". "Many aphid species have unique life characteristics, such as migration to reduce competition and avoid adverse environments and natural enemies, which are often strongly influenced by climatic factors."

Depending on the temperature and other factors, *holocyclic aphids* stimulate sexual aphids to produce fertilized eggs for overwintering (Puterka et al., 2012). Aphids are poikilothermic organisms (Sentis, Hemptinne, & Brodeur, 2012), the temperature gradient that exists between the air and soil surface, which is known as the thermal stress gradient, can be used to predict aphid population dynamics (Sutherst et al., 2011). The thermal stress gradient or "thermal strain" occurs when there is a difference in temperature between an organism's environment and its body tissue (Blazejczyk, Epstein, Jendritzky, Staiger, & Tinz, 2012). This differential temperature causes physiological changes throughout the organism; these changes are manifested by morphological adaptations such as growth rate, metabolic rate, fecundity, etc.

These physiological responses allow organisms to survive in environments with different temperatures than they would normally experience at homeostasis (i.e., constant conditions). In turn, this adaptation allows organisms to adapt to new environmental conditions without having to change their physiology drastically from what it was previously adapted for at homeostatic conditions. The thermal strain has been shown experimentally in many species of aphids including *Aphis fabae* (the cottony-cushion aphid), *Myzus persicae* (the green peach aphid), *Rhopalosiphum padi* (the pea aphid), and others (Gillespie, Nasreen, Moffat, Clarke, & Roitberg, 2012; Ismaeil et al., 2013; Ma & Ma, 2012; Vorburger, 2014).

2.1 Lifecycle of *Brevicoryne brassicae* in pursuance of climatic variations

The cabbage aphid feeds on various plants including cabbage, broccoli, cauliflower, and celery but can also feed on many other crops such as corn, tomato, or potatoes (Muniappan, 2012). Its preferred host plant is cabbage which makes up about 80% of its diet. They prefer to live in groups called colonies where they form dense populations under leaves or close to stems where they suck sap from the plant tissue causing yellowing and stunting before dying off during winter months when temperatures drop below 10°C (50°F) (Gratwick, 2012). The female lays her eggs inside these colonies which hatch out into larvae that then develop into pupae within three days after hatching; this process takes about one month depending on temperature conditions in the area where they are living. These mature adults emerge from their pupal stage between mid-may through June when temperatures rise above 15°C (59°F) for several weeks until late summer when temperatures fall again below 10°C (50°F). In warm areas like India, this period lasts only a few weeks while it extends over several months in colder regions like Europe or North America making it difficult to control infestations using conventional methods such as pesticides since there is no consistent pattern regarding the emergence dates across different locations so no single treatment will work everywhere all year round unless you use multiple treatments throughout your crop cycle.

2.2 Strategies for controlling *Brevicoryne brassicae*

Cultural Control:

“Install yellow sticky traps, yellow water pan traps @ 12/acre to monitor alates (winged adult)”.

Biological control:

“Conserve parasitoids such as Aphidius colemani (adult and nymph), Diaeretiella spp. (adult and nymph), Aphelinus spp. (adult and nymph) etc.”

“Conserve predators such wasps, green lacewings, earwigs, ground beetles, rove beetles, spiders etc.”

Chemical control:

“Foliar spray with dimethoate 30% EC @ 264 ml in 200-400 l of water/acre or fenvalerate 20% EC @ 120-150 ml in 240- 300 l of water/acre or phosalone 35% EC @ 571 ml in 200-400 l of water/acre or acetamiprid 20 % SP @ 300 ml in 200-240 l of water/acre.”

Organic insecticides are another effective way to control cabbage aphids (Gratwick, 2012). These products work by disrupting the nervous system of insects which causes them to die off after they ingest them through their mouthparts. By applying these products once a week for three weeks in order to get good results against cabbage aphids since they tend to have high reproductive rates and will quickly build up resistance if you do not treat them regularly with these types of pesticides over time. Some organic insecticides that can be used include: neem oil, pyrethrins (a natural insecticide), garlic sprays, or DE-based soaps made from diatomaceous earth (DE) (Fening et al., 2013; Stoleru, Munteanu, Stoleru, & Rotaru, 2012). These products work by

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Conclusion

As discussed in the paper, climatic variations majorly impact the lifecycle of cabbage aphids as they tend to be more sensitive to climatic variation right from their emergence as pupae to the final adult stage. Not much-identified incidences of their impact in the Indian context, they are more known for their notorious presence in Europe with over 50% of all brassicas being attacked by them at some point during their lifecycle. So proper management of these species holds promise for agricultural productivity and sustainability in long term.

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