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Mechanism of major disease vectoring insects and interrelationship between disease vector acquisition by aphids with changing temperature

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Abstract
Limited study of mechanism of disease vectoring by insects in crops at local conditions of Chitwan district was observed. So, an analysis for the disease vectoring methods and their effect by fluctuating temperature was carried out in laboratory condition. Disease vectored insects and plant twigs samples were collected and studied in the laboratory of the Entomology department located at Agriculture and Forestry University, Chitwan, Nepal during December 2014 to February 2015. Molecular study of insects reared at laboratory condition was carried out to understand the mechanisms of disease transmission in different insect samples. The effect of fluctuating temperature (artificially maintained) was timely recorded to observe the change in duration of disease acquisition by aphid population. Variable types of mechanism of disease vectoring by insects was analyzed in the study location. Shorter acquisition period of disease vectoring aphids was directly correlated with the increasing temperature. After 25^0c the activities of some of the aphids in transmitting disease process gradually declined as they became lethal and inactive at that temperature. Therefore, different insects not only have specific disease transmitting mechanisms but also directly depend on the changing temperature parameters in the environment of the district.

Keywords: Aphid, disease, temperature, vectoring, virus

Introduction

Those organisms which introduce a pathogen such as a bacterium or virus into a plant to cause an infection are called vectors. Insects, mites, and nematode vectors target the movement of plant pathogens among immobile plants. Some insects are not considered as vectors as they do not contain any pathogen or disease and cannot transmit those diseases. Most of the diseases are transferred through important role the insect plays as vector. Almost all plant viruses and all wall-free, plant pathogenic bacteria known as mollicutes have recognized or suspected vectors.

Insect-borne diseases impose an immense burden on global health, and insect crop pests greatly influence economic and agricultural productivity. It is always necessary to understand why only certain kinds of insects like mite or others transmit virus or diseases and the mechanism for this process have in transmission (Gray and Banerjee, 1999) [12] Because insecticides applied to kill vectors frequently fail to control the diseases caused by the vector-borne pathogens, there sufficient ideas of the relationships between vectors and the pathogens that they transmit is important. The basic phenomena that insect transmit disease or becomes vector is that the transmission efficiency they have or mechanism of disease transmission over period of time or in some specific hosts. Generally, vector acquisition of pathogens inclines with time spent feeding on infected plant sources of the pathogen.

The time required a vector for acquisition of pathogen and its initial transmission in plant, known as latent period which rise the transmission rates over time. Some vectors could not transmit a pathogen till sometime may for a week, after they first acquire it. In some cases, we observe the transmission of pathogen with instant time period without requiring any latent period.

The nonpersistent transmission of viruses by aphids reflects the method of transmission of diseases in plants including their spread and reasons for some control strategies for these viruses that differ from those for other aphid-transmitted viruses. Through non-persistent method with relatively low vector specificity the Potato virus Y (PVY) and other potyviruses are transmitted through many varieties of aphids (family Aphididae). The PVY virus is symptomized within couple of minutes. The most convincing experimental evidence points to the tips of the vector stylets as the critical region where the virus is transferred from vector to plant during feeding. There is the bridging polypeptide molecule that connects particle of virus to the stylet tips of aphid (Froissart *et al.,* 2002) [11]. A virus can genetically code for its own relating molecule (''helper factor'') or supply a helper factor to aid the aphid transmission of another virus. The detachment process of virus from the mouth part of vector has not been clearly know till date (Pirone and Blanc, 1996) [22]. Climate change plays vital role in the incidence and severity of plant viruses are to mediated effects on plants and their insect vectors (Malmström and Field, 1997; Dáder *et al.,* 2016; Trębicki *et al.,* 2016; Trębicki *et al.,* 2017; Vassiliadis *et al.,* 2016; Trebick, 2020) [17, 8, 25, 25, 27, 26]. In contrast to elevated carbon dioxide the temperature results a direct impact on invertebrates (Bale *et al.,* 2002) [2] as they are ectothermic and sensitive to temperature change (Facey *et al.,* 2014) [10]. The generations, fecundity, and growth of insects, especially aphids are directly related with rise in temperature (Bale *et al.,* 2002; Facey *et al.,* 2014) [2, 10], as long as temperature remains within the insect thermal range for development. Soaring of temperature could affect virus incidence in some pathosystems, e.g., triggering earlier and greater barley yellow dwarf virus (BYDV) titer in wheat (*Triticum aestivum* L.), and earlier expression of virus symptoms (Nancarrow *et al.*, 2014) [21].

Barley yellow dwarf virus species PAV (BYDV-PAV) reside in the genus Luteovirus (family Luteoviridae) that results delayed heading, stunting, poor growth and low yields in wheat, barley (*Hordeum vulgare* L.), and other members of the family Poaceae (Lapierre and Signoret, 2004) [16], with symptoms and severity of infection related with resistance of cultivar, plant host, infection period including climatic conditions (Miller and Rasochová 1997; Jarošová *et al.*, 2013; Nancarrow *et al.*, 2018; Chrpová, *et al.*, 2020) [19, 15, 20, 5]. Virus causes complecity in growth and development of the crop. The virus is phloem-limited and transmitted obligatorily by aphid vectors in a circulative and non-propagative method (Jarošová *et al.*, 2013; Gray *et al.*, 2014) [15, 13]. BYDV-PAV is distributed in world which is majorly transmitted by the bird cherry-oat aphid *Rhopalosiphum padi* (L.) (Hemiptera: Aphididae) (Irwin and Thresh, 1990) [14], and is among the few aphid species known to be one of the most economically vital agricultural pests worldwide which have direct relationship with changing temperature (Blackman and Eastop, 2017) [2]. Increase in temperature influences the population f aphids transferring pathogens and thus acquire disease with short period of time.

In this study the mechanisms of virus vectoring by aphid and their relationship with changing temperature have been investigated in local condition of Nepal.

Materials and Methods

Plant twigs and insects with diseases were collected from field for laboratory investigation. The study was conducted during December 2014 to February 2015 in the laboratory of Entomology in Agriculture and Forestry University, Chitwan, Nepal. Samples of insects were reared in the proper condition and their molecular study was carried at regular basis to determine the disease vectoring mechanisms and other possible details. The effect of fluctuating temperature (artificially maintained) was timely recorded to observe the change in duration of disease acquisition by aphid vectors.

The recorded data were all tabulated and systematically arranged treatment wise under three replications using MS-Excel which were subjected to Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT-0.05 level) for mean separations using Gen stat software.

Results and Discussion

Mechanisms of disease vectoring by insects and their types

Table 1: Diseases and vector-borne insects

Type of pathogen	Vectors	Type of transmission
Virus		
Lettuce mosaic potyvirus	Aphids (many species)	Nonpersistent
Barley yellow dwarf luteovirus	Aphids (few species)	Persistent days to weeks, circulative, not propagative in vector
Lettuce necrotic yellows baculovirus	Aphids (many species)	Persistent, circulative, propagative in vector
Maize rough dwarf reovirus	Planthoppers (very few spp.)	Persistent, circulative, propagative, and transovarial in vector
Maize streak geminivirus	Leafhoppers (*Cicadulina* spp.)	Persistent, circulative, non-propagative
Bacteria		
Xylella fastidiosa (numerous diseases)	Xylem sap-feeders (sucking insects in several families)	Noncirculative but persistent, propagative in vector
Aster yellows phytoplasma	Leafhoppers (several spp.)	Persistent, circulative, propagative

Many viruses and other disease agents were found transmitted by an infectious vector for many days or even weeks. For example, the beet curly top virus (BCTV) noticed only one known vector, the beet leafhopper (*Circulifer tenellus*) (Table 1). Similar result was analyzed by the study of (Carter, 1973) [3]. After latent period of only few hours the Infectious beet leafhoppers found transmitting the virus and regulating the same for some weeks. It was found that the duration of transmission was directly related with the time duration they feed on a virus-infected plant to have the Gemini virus.

The example with persistent transmission of virus that comes under Beet curly top virus is an is circulative but does not multiply within the vector (Carter, 1973) [3]. It was found that virus required huge duration of feeding period for the transmission of vector. After reaching salary glands at higher mass, it was analyzed that most lengthy latent time resulted from the requirement of the pathogens to increase their numbers within the vector to attain the numbers needed to complete the vector transmission methods. It was also investigated that some viruses and bacteria increase with in the organs and tissues in the same vector that may not require for transmission process and the result was found was that some of these plant pathogens were harmful to the vector. From some pas investigation it was found that Reoviruses (rice dwarf, for example) increases its population within both their insect vectors and plant hosts. It was observed that the multiplied and circulated pathogens in the body cavity (hemocoel) of the vector ensures that the pathogen stayed within the vector after some molts that happened as the vector develops. Non-persistently or semi-persistently transmitted viruses were no longer transmitted once the vector has molted its exoskeleton.

Effect of temperature in disease vector acquisition in aphid population

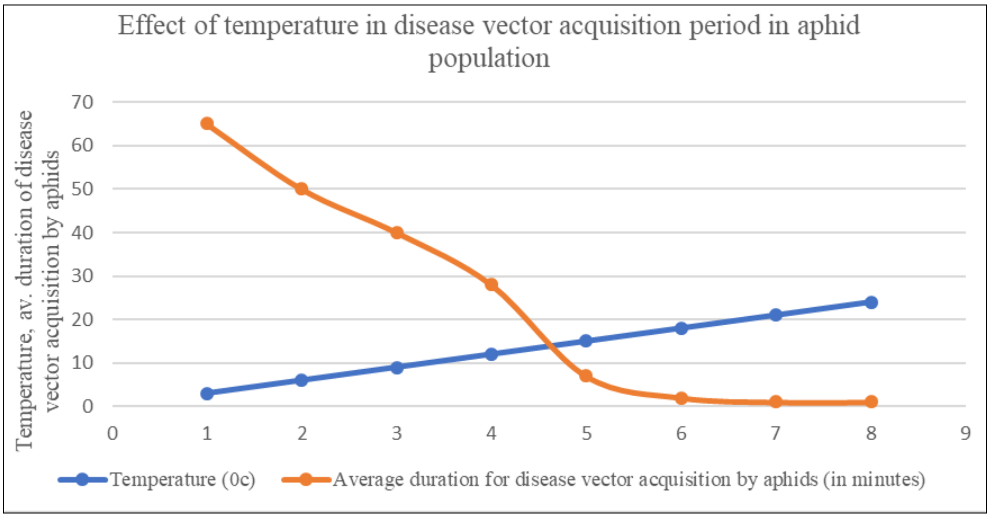

Fig 1: Relationship between temperature and disease vector acquisition period in aphid population

It was observed that at 3, 6, 9, 12, 15, 18, 21, 24 °C the period of disease vector acquisition on aphid population required the average of 65, 50, 40, 28, 7, 2, 1, and 1 minutes respectively. Above 24^{0}c the population of aphid observed lethal and complex in transmitting diseases (Figure 1).

The above study was supported by numerous investigations. In PVYO (Potato Virus) the efficiency of virus acquisition by aphids and transmission to the host plant is optimal at 20 °C. With incline in temperature to 25 °C it has been demonstrated to reflect in a significant loss in the capacity of virus acquisition (Chung *et al.*, 2016) [6]. Most of the aphids are observed to fly and transmit disease at warmer conditions, though the very high temperature may check the population of aphid and so the disease vectoring potentiality in certain aphid population (Matthews, 1991) [18].

Temperature is a key driver of vector-borne disease transmission, as replication of arboviruses and parasites within the cold-blooded vectors are dependent on the environmental temperature (Detinov, 1962; Tabachnick, 2010) [9, 23].

Similar study was carried by (Chellappan *et al.*, 2005) [4] where disease vectoring efficiency of insects in crop were greatly influenced by the temperature.

Conclusion

Disease vectored insects and plant twigs samples were collected and stored in the laboratory of the Entomology department located at Agriculture and Forestry University, Chitwan, Nepal during December 2014 to February 2015. Samples of insects were reared in the lab condition and their molecular study was carried out on a regular basis to determine the disease vectoring mechanisms and other possible details. The effect of fluctuating temperature (artificially maintained) was timely recorded to observe the change in duration of disease acquisition by aphid vectors. Different types of mechanism of disease vectoring by insects was analyzed in the study location. Shorter acquisition period of disease vectoring aphids was directly correlated with the increasing temperature, and it was also observed that after 25 °C the activities of some of the aphids in vectoring disease process gradually declined as they became lethal and inactive at that temperature.

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References

1. Bale JS, Masters GJ, Hodkinson ID, Awmack C, Bezemer TM, Brown VK, *et al*. Herbivory in global climate change research: Direct effects of rising temperature on insect herbivores. Glob Chang Biol. 2002;8:1-16.
2. Blackman RL, Eastop VF. Taxonomic Issues. In: Van Emden HF, Harrington R, editors. Aphids as Crop Pests. Oxfordshire, UK: CAB International; 2017. p. 1-36.
3. Carter W. Insects in Relation to Plant Disease. New York: J. Wiley & Sons; c1973.
4. Chellappan C, Vanitharani R, Ogbe F, Fauquet CM. Effect of temperature on Geminivirus-induced RNA silencing in plants. Plant Physiol. 2005;138:1828-1841.
5. Chrpová J, Veškrna O, Palicová J, Kundu JK. The evaluation of wheat cultivar resistance and yield loss thresholds in response to barley yellow dwarf virus-PAV infection. Agriculture. 2020;10:20.
6. Chung BN, Canto T, Tenllado F, Choi KS, Joa JH, Ahn JJ, *et al*. The effects of high temperature on infection by Potato virus Y, Potato virus A and Potato leafroll virus. Plant Pathol J. 2016;32:321-328.

7. Chung BN, Koh SW, Choi KS, Joa JH, Kim CH, Selvakumar G. Temperature and CO2 level influence Potato leafroll virus infection in Solanum tuberosum. Plant Pathol J. 2017;33:522-527.
8. Dáder B, Fereres A, Moreno A, Trębicki P. Elevated CO_2 impacts bell pepper growth with consequences to *Myzus persicae* life history, feeding behavior and virus transmission ability. Sci Rep. 2016;6:19-120.
9. Detinova TS. Age-grouping methods in *Diptera* of medical importance with special reference to some vectors of malaria. Monogr Ser World Health Organ. 1962;47:13-191.
10. Facey SL, Ellsworth DS, Staley JT, Wright DJ, Johnson SN. Upsetting the order: How climate and atmospheric change affects herbivore-enemy interactions. Curr Opin Insect Sci. 2014;5:66-74.
11. Froissart R, Michalakis Y, Blanc S. Helper component trans complementation in the vector transmission of plant viruses. Phytopathology. 2002;92(6):576-579.
12. Gray S, Banerjee N. Mechanisms of arthropod transmission of plant and animal viruses. Microbiol Mol Biol Rev. 1999;63:128-148.
13. Gray S, Cilia M, Ghanim M. Circulative, “Non-propagative” virus transmission: An orchestra of virus-, insect-, and plant-derived instruments. In: Advances in Virus Research. Amsterdam: Elsevier Inc.; 2014. p. 141-199.
14. Irwin ME, Thresh JM. Epidemiology of Barley Yellow Dwarf: A Study in Ecological Complexity. Annu Rev Phytopathol. 1990;28:393-424.
15. Jarošová J, Chrpová J, Šíp V, Kundu JK. A comparative study of the Barley yellow dwarf virus species PAV and PAS: Distribution, accumulation, and host resistance. Plant Pathol. 2013;62:436-443.
16. Lapierre H, Signoret PA. Viruses and Virus Diseases of Poaceae (Gramineae). Paris: INRA Editions; c2004. ISBN 2738010881.
17. Malmström CM, Field CB. Virus-induced differences in the response of oat plants to elevated carbon dioxide. Plant Cell Environ. 1997;20:178-188.
18. Matthews REF. Plant Virology. 3rd ed. Amsterdam: Elsevier BV; 1991. p. 864.
19. Miller WA, Rasochová L. Barley Yellow Dwarf Viruses. Annu Rev Phytopathol. 1997;35:167-190.
20. Nancarrow N, Aftab M, Freeman A, Rodoni B, Hollaway G, Trębicki P. Prevalence and Incidence of Yellow Dwarf Viruses Across a Climatic Gradient: A Four-Year Field Study in Southeastern Australia. Plant Dis. 2018;102:2465-2472.
21. Nancarrow N, Constable F, Finlay KJ, Freeman A, Rodoni B, Trębicki P, Vassiliadis S, Yen A, Luck J. The effect of elevated temperature on Barley yellow dwarf virus-PAV in wheat. Virus Res. 2014;186:97-103.
22. Pirone TP, Blanc S. Helper-dependent vector transmission of plant viruses. Annu Rev Phytopathol. 1996;34:227-247.
23. Tabachnick WJ. Challenges in predicting climate and environmental effects on vector-borne disease episystems in a changing world. J Exp Biol. 2010;213:946-954.
24. Trębicki P, Nancarrow N, Bosque-Pérez NA, Rodoni B, Aftab M, Freeman A, *et al*. Virus incidence in wheat increases under elevated CO2: A 4-year study of yellow dwarf viruses from a free air carbon dioxide facility. Virus Res. 2017;241:137-144.
25. Trębicki P, Vandegeer RK, Bosque-Pérez NA, Powell KS, Dader B, Freeman AJ, i. Virus infection mediates the effects of elevated CO2 on plants and vectors. Sci Rep. 2016;6:22785.
26. Trebicki P. Climate change and plant virus epidemiology. Virus Res. 2020;286:198059.
27. Vassiliadis S, Plummer KM, Powell KS, Trębicki P, Luck JE, Rochfort SJ. The effect of elevated CO2 and virus infection on the primary metabolism of wheat. Funct Plant Biol. 2016;43:892-902.