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Review Article

Phenological Behaviour Changes in Neem Tree (*Azadirachta indica* A. Juss.) after the Cyclone 'FANI'

Kalicharan Mandal[1*], Dipanjali Singh[1], Sudam C. Sahu[2], Manas R. Mohanta[2] and Nabin K. Dhal[1]

[1]*Environment and Sustainability Department, CSIR-IMMT, Bhubaneswar-751013*

[2]*Department of Botany, North Orissa University, Baripada-757003*

Abstract

Global climate change impacts can already be tracked in many physical and biological systems; in particular, terrestrial ecosystems provide a consistent picture of observed changes. One of the preferred indicators is phenology, the science of natural recurring events, as their recorded dates provide a high-temporal resolution of ongoing changes. Occurrence of recent tropical cyclone 'Fani' has impacted on the flowering phenology of Neem plants in Odisha. Here, we have discussed on the changing pattern of phenology in Neem and the possible reason for the same after heavy cyclone.

Keywords: *Phenological Behaviour,Cyclone Fani, Azadirachta indica A. Juss.*

Introduction

Throughout their development, plants are subjected to a multiplicity of stresses, which lead to molecular, biochemical, physiological, anatomical, and morphological changes that may adversely affect their growth and productivity. Plants maximize their chances to survive adversities by reprogramming their development according to environmental conditions.

Phenology refers to ''the study of the timing of recurrent biological events, the causes of their timing with regard to biotic and abiotic forces, and the interrelationship among phases of the same or different species'' (Badeck. *et al*., 2004), and includes events such as leaf unfolding, bud-burst, full bloom, harvest and leaf fall. It provides a critical signal of climate variability and change effects on plants. Considerable work over the past five decades has quantified the extent to which plant phenophases are responding to local changes in temperature and rainfall. According to Badeck. *et al*., 2004 "the annual initiation of phenological events is driven predominantly by climatic shifts associated with the change of seasons, rather than by intrinsic controls".

Adaptive variations in the timing to flowering reflect the need for plants to set seeds under the most favourable conditions. Global changes, such as accumulating atmospheric carbon dioxide (CO_2), are directly associated with elevated global temperatures (0.2^{o}C per decade) and altered precipitation regimes .While global temperatures are rising steadily, changes in precipitation are more variable and both increases and decreases have been observed at regional scales. As the temperature and precipitation are the main drivers of tropical deciduous plant phenology, warming and altered precipitation regimes shift important stages in plant life history , such as leaf out and flowering time. .There is now ample evidence that over the last decades the phenology—the timing of seasonal activities such as timing of flowering or breeding (Walther. *et al*. 2002)—of many plant and animal species has advanced and these shifts are related to climate change (Walther. *et al*., 2002; Parmesan & Yohe, 2003; Root. *et al*., 2003).

Many studies examining the impacts of global warming on terrestrial ecosystems reveal a

***Corresponding Author:**
Kalicharan Mandal;

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consistent pattern of change, the response to warming by phonological change across the northern hemisphere seems to be especially well documented (Walther. *et al*., 2002; Parmesan & Yohe, 2003; Root. *et al*., 2003).

Neem (*Azadirachta indica* A. Juss.) is one of the most important native deciduous tree species in India, can grow without irrigation in hot and dry region of the world with annual rainfall 500 mm or less. For survival under this adverse condition neem plant maintain timing of flowering and fruiting, the time of year that is best for seed germination.

Phenology of Neem

V. S. Kishan Kumar and M. L. Arrawatia carried some basic phenological observations on Neem tree at different locations situated in six different agro-ecological zones of India. According to them neem tree is generally in heavy leafing during May-November. Generally in November leaf shedding is started and trees are back in full leafing by April. There is an appropriate drop in percentage of trees flowering immediately after May. In arid regions, the flowering peak was during April and in semi-arid regions it was in between March and May. Some restricted flowering during August and November was observed at some locations both in the semi-arid and sub-humid regions.

Phenological behaviour of Neem after cyclone 'Fani'

Cyclone Fani, one of the strongest storms (category 4) to hit the Indian subcontinent in decades, made landfall near Puri, India, at 8am on Friday 3rd May, with winds gusting at more than 190kmh. The cyclone was untimely; it was one of the rarest summer cyclones, the first one in 43 years and one of 3 to hit Odisha in the last 150 years. It has left destruction in its wake, not even sparing the trees of the coastal districts in Odisha. More than 10 million trees were uprooted with an equal number of trees damaged in the extremely severe cyclone.

After the cyclone has passed away, the neem trees in the Bhubaneswar area were seen showing phonological abnormalities as they started blooming again. Several no of neem tress are observed showing reflowering and fruiting during the month of July, August and even in September.

Possible reasons behind phonological changes in Neem

Flowering event in plants take place depending upon its suitable photoperiod and vernalization. Photoperiodic induction is expressed through genetic expression with suitable hormonal proportion whereas vernalization is regulated by low temperature induction. Additions to these two mechanisms, stressful conditions were also reported to induce flowering in several plant species (Takeno, 2016). The mechanism of flowering involves synthesis of flowering hormones and proteins in leaf and transmission towards apical regions. Generally, photoperiodic induction stimulates the production of m-RNA that is further translated to Constans (CO) protein. The CO protein initiates transcription of Flowering Locus T gene (FT) produces FT protein in long day plants. Production of FT protein in the apical regions initiate flowering. However, the stress induced flowering mechanism is not well understood but there are some studies that indicated varied response of plants to the stressful conditions (Wada and Takeno, 2010; Takeno, 2016).

While considering at molecular level several literatures have reviewed that a number of stress inducible miRNAs are involved in the regulation of flowering time in plants. In *Arabidopsis thaliana*, miR156, a stress inducible miRNA, delays flowering in Arabidopsis by targeting the SQUAMOSA PROMOTER BINDING PROTEIN-LIKE (SPL) family of transcription factor for repression. Under abiotic stress condition, plants overexpressing miR156 are late flowering and more tolerant to stress, whereas plants that have a silenced copy of miR156 shows acceleratred flowering and increased sensitivity to abiotic stress whereas another miRNA(miR172) promotes flowering (Hong and Jackson, 2015). The expression of miR172 is drought stress inducible (Han. *et al*., 2013). Interestingly, high CO_2 and elevated temperatures differentially regulate the expression of miR156/157 and miR172 (May. *et al*., 2013).

Azadirachta indica is a large tree species that has flowering time during the month of March, to May and fruiting in the consecutive month. The month of May is the late flowering month and peak fruiting month for the species. The mass flowering of *A. indica* in post cyclonic days indicated towards the stress induced response of the species. On the other hand, the species must be affected with breakage of branches due to high speed wind which may result in production of new leaves in the broken branches. The leafing in branches simultaneously might have increase the hormone production suitable for flower initiation. It is more often seen that leafing and flowering event takes place quite simultaneously in the tropic. Here, we may conclude that the cyclone Fani made induction to the flowering in the plant through physical stress or may be some internal stresses induced due to external stress. Similar pattern of stress response was performed in the primary and secondary forest trees of Fiji Island after cyclone Tomas.

Fig 1: Observed neem fruit in the month of August, 2019

Fig 2: Post cyclonic flowering in neem tree and devastation caused by it

Conclusion

As the plants are hit hard with the strongest cyclone, they performed their kind of recovery response for their survival .The observed changes in phenology may be a positive sign because species are apparently adapting to changing climatic conditions, or they may be a negative sign because they show that climate change is, indeed, impacting living systems .Therefore plant phenology is an important parameter monitoring the impact of global climate change.

However this observation must be further studied for finding out the subsequent mechanism underlying the stress particularly induced by cylonic storms and the phonologies must be monitored around the coastal regions of Odisha to detect any further consequences.

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