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The Role of Polyploidy and Soil Nutrient Levels on Aphid-Predators Interaction

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Abstract

Understanding the consequences of intra specific genetic variation within same plant communities represents a critical research direction to explore. Polyploidy plants create intra specific interactions within same species which leads to complex associations within communities of organism. We investigated the effect of polyploidy (cytotypes) and soil nutrient levels on U. nigrotuberculatum–predator interaction. We used S. altissimato investigate the interactions between U. nigrotuberculatum, ant and Hippodamia parenthesis. Plants were grown individually in 4L pots in a Metro Mix 360 soil medium combined with 50% sand. There were 32 plants in the garden; 16 diploid and 16-hexaploid plants. Eight of the plants from each cytotype received a N.P.K (18-6-12) nutrient addition (Osmocote 4g) and eight received no nutrients (control). We found that plant size play an important role in aphid choice. Plant size (biomass) is greatly influence by soil nutrient levels. Ants are in a mutual association with U. nigrotuberculatum. The presence of large population of ants prevented or reduced the activities of lady beetles.

Keywords: Predator; Aphid; Polyploidy; Plant Biomass; Soil nutrients

Introduction

Herbivores are faced with complex interactions such as interactions with host-plant, predators and the environment. Polyploidy plants create intra specific interactions within same species of plant, and thereby influence the composition and diversity of insects [1]. There are two general ways in which polyploidy occur: multiplication of one chromosome set and merger of structurally different chromosome set [2]. Polyploidy can also occur through polyploidization, and such, results in genomic change and production of new complex gene [3]. When genome reorganized polyploidy plant is formed [2]. There are two major types of polyploidy: Autopolyploid and Allopolyploid (Avraham et al., 2004). Environmental condition, herbivore, water deficit and poor nutrients enhance the rate of autoploid formation [3].

Insect herbivores have been reported to move amongst plants as a result of genetic variation [4]. Polyploidy cause an array of phenotypic changes (increase in flower size, leaf and stem) in plants and influence interactions with other species [5], and alters interactions, rapid genetic and changes in flowering plants [6]. Soil nutrients have been documented to have direct effect on plants biomass or indirectly influence plant secondary chemistry [7-9]. Nutrients such as Nitrogen, potassium and phosphorus are essential for plant growths and development [10]. Soil nutrient levels can either positively or negatively influence insect abundance.

Prior to this study, it was largely unknown the possible impact of polyploidy (cytotype) and soil nutrient levels may play on aphid-predators interactions. This study attempts to answer a critical

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ecological question: how does polyploidy and soil nutrient levels affect the complex interactions between aphid and predators? To provide answers to this question, this study had three main objectives: (1) Polyploidy effects on biomass, (2) Soil nutrients effects on biomass and (3) Insects abundance differences among cytotypes and soil treatment. Our hypotheses were: (1) Cytotypes of S. altissima with more chromosome number would have bigger biomass such that 6n>2n. (2) Soil nutrients level would be a major deciding factor in aphids choices (plants with high nutrients would have more insect abundance), and predators would be more on plants with more aphids.

Materials And Methods

Study Species

Solidago altissima L., commonly known as tall goldenrod, is a rhizomatous perennial plant species found in North America [11]. Its habitats include old field, forest openings roadsides, and other disturbed or succession areas. There are three well known cytotypes S. altissima; diploid (2n=18), tetraploid (4n=36), and hexaploid (6n=54) [1]. Diploid is mostly found in the western part of its range [11], hexaploid mostly found in the eastern part, while tetraploids are also found in the Midwest. S. altissima serves as a perfect midget to investigate the effects of cytotype (polyploidy) on aphid-predator associations due to previous investigations showing the importance of intra specific genetic variation on associated insects [12,13]. The two aphids we investigate were Uroleucon Nigrotuberculatum U. nigrotuberculatumbelong to order Hemisphere; Aphides). U. nigrotuberculatum is native to North American [14]. S.altissimaserve as primary host (most especially for U. nigrotuberculatum), and their population are regulated by different factors, such as temperature, predators and fungal disease [15,16]. The predator we observed was lady beetle. Lady beetles (Hippomania parenthesis), ladybugs, or ladybird beetles one of the most visible and best known beneficial predatory insects. Some are native to North America, and are beneficial as both adults and larvae, feeding primarily on aphids. We also documented ant-aphid interaction. Ants and aphids have a symbiotic relationship. Both species of the insects benefit from each other. The ants provide protection and prevent any predators from feeding on aphids, while the aphid, in return, provide food (honeydew) for the ants.

Experimental Design

Diploid and hexaploid (2n and 6n) were used for this study. Plants were grown individually in 4L pots in a Metro Mix 360 soil medium combined with 50% sand. There were 32 plants in the garden; 16 diploid and 16-hexaploid plants. Eight of the plants from each cytotype received a N.P.K (18-6-12) nutrient addition (Osmocote™- 4g) and eight received no nutrients (control). The distance between each plant was 45cm. The initial height and diameter of each plant was measured following Williams and Megan, 2015 protocol.

Insect Abundance

Quantification of U. nigrotuberculatum, ants and lady beetles abundance started on May 13, 2020, and ended on July 28, 2020. We visually observed and monitor three times a week (Monday, Wednesday and Friday) in order to accurately estimate the time of peak abundance [17]. We estimated the peak abundance of the insects, and take the final biomass measurement [18]. We measured the above-ground biomass by measuring plant stem diameter (D) and height (H) according to this formula: Biomass (g) =D2H*0.0022) +6.3668 (R=0.70, P<0.0001).Using the non-destructive estimate of plant biomass, aphid's abundance, ant and lady beetles could be expressed as the actual number or aphids/g, ant/g, and lady beetle/g to account for treatment effects on plant biomass.

Results

Soil nutrients had a significant effect plant biomass (Figure 1) and aphid abundance (Figure 2) Plants with nutrient addition had more aphids irrespective of the cytolyses. Aphid population was much higher in both 2n and 6n plants with nutrients addition compared to those with no nutrient addition. Aphid abundance/g shows no significant difference (Figure 3). Predator abundance (ladybeetle) show no significant difference in Figure 4, though predator was absent on 6Nwn plants (Figure 4). Figure 5 Show that ant associated with all the cytotypes that had aphids. The association was more on 6nwn plants (Figure 5). (Figures 6&7) shows a significant difference in ant associations with each plant.

Discussion

This study is the first to investigate the role of Polyploidy and soil nutrient levels on Aphid-Predator interaction. Many studies within the field of community genetics have focused more on the impacts of soil nutrients on insect abundance [19], no study has investigated the impact of soil nutrients and cytolyses of S. altissimo on aphid, ants and predator association. We Quantified U. Nigrotuberculatum abundance, ants abundance and lady beetle activities during the peak abundance of U. Nigrotuberculatum, by observing and monitoring the population three times a week. U. Nigrotuberculatum populations are known to vary across a growing season [17] and we took our mean of abundance during this peak of abundance that provided the best quantification for these associations. This study found with plant biomass considered, aphid abundance was significantly affected by soil nutrients. Plants with nutrients addition had higher aphid population compared to those with no nutrient addition irrespective of the cytotypes (Figures 1&2). This study is in alignment with studies. NPK (nitrogen, phosphorus and potassium) increases plant biomass and alter herbivore composition. Our study documented that aphids prefer to feed on plants with larger biomass. Our investigation found that ant's associated wherever aphid were found. However, the ant-aphid association was more on plants with nutrient addiction (Figure 3); diploid plants and hexaploid plants with nutrient addition had more ants). The abundance of ants on 6n plants with nutrient addition (Figure 4) possibly prevented lady beetle from feeding on the aphid. This study found no significant association between polyploidy (cytotype) and insects interactions. We did not consider the genotypes of the S. altissimo used for this study. [13] Investigation found that plant genotype influence aphid abundance. Our study may be a foundational study for future directions to answering some complex interactions between plant and insects [20,21].

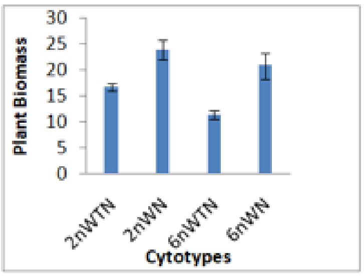

Figure 1: Mean of S.altissima biomass. 2n=diploid, 6n=hexaploid, WN=high nutrient plants and WTN=Ambient nutrient plants.

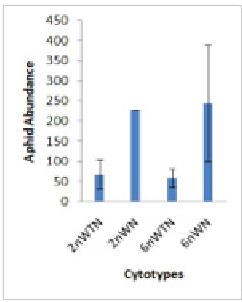

Figure 2: Mean of aphid abundance on S. altissima cytotypes.2n=diploid, 6n=hexaploid, WN=high nutrient plants and WTN=Ambient nutrient plants.

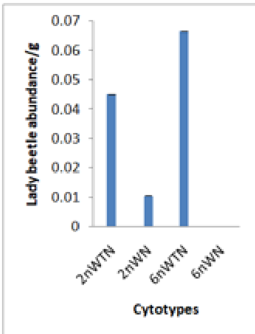

Figure 3: Mean of lady beetle abundance/g on S. altissima cytotypes.2n=diploid, 6n=hexaploid, WN=high nutrient plants and WTN=Ambient nutrient plants.

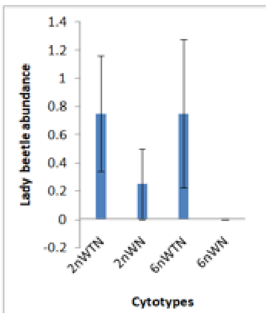

Figure 4: Mean of lady beetles abundance on S. altissima cytotypes.2n=diploid, 6n=hexaploid, WN=high nutrient plants and WTN=Ambient nutrient plants.

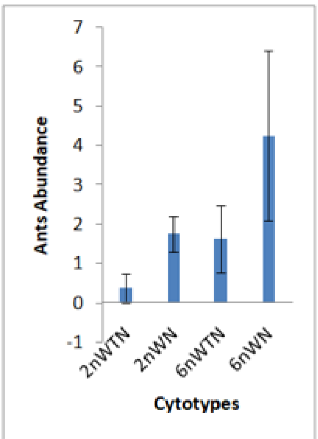

Figure 5: Mean of ants abundance on S. altissima cytotypes.2n=diploid, 6n=hexaploid, WN=high nutrient plants and WTN=Ambient nutrient plants.

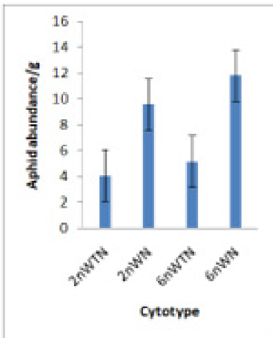

Figure 6: Mean of aphid abundance/g on S. altissima cytotypes.2n=diploid, 6n=hexaploid, WN=high nutrient plants and WTN=Ambient nutrient plants.

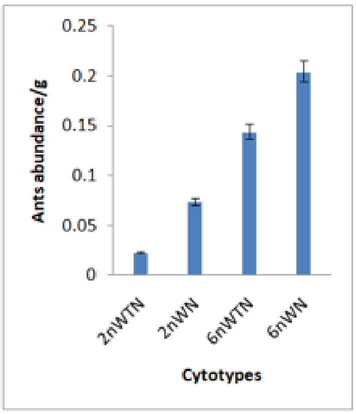

Figure 7: Mean of ants abundance/g on S. altissima cytotypes.2n=diploid, 6n=hexaploid, WN=high nutrient plants and WTN=Ambient nutrient plants.

by soil nutrient levels. Ants are in a mutual association with aphids. The presence of large population of ants prevented or reduced the activities of lady beetles.

Acknowledgement

None

Conflicts of Interest

Author declared no conflict of interests.

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