Pea yield formation in warming temperatures – phenological mechanisms

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SPG Contributions	Project Status	Duration/Timeline of Project (Year to Year)	Co-funders	Total Project Cost
$92,000.00	Completed	May 2011 – December 2016	Natural Sciences and Engineering Research Council of Canada (NSERC); Western Grains Research Foundation, Saskatchewan Ministry of Agriculture – Agriculture Development Fund (ADF)	$516,000.00

Project Description

To identify from field trials why current varieties of pea are so heat sensitive; to identify heat tolerant traits via earlier flowering, a longer duration of flowering, improved pollen viability (greater pollen survival at higher daytime temperature), and a greater proportion of seed retained in each pod.

Pea crops are sensitive to heat stress. A few days of heat above 29°C in the field causes flower and young pod abortion and lowers yield. Our goal was to identify traits to improve heat resistance and yield stability in future pea varieties. The objectives were to 1) identify why current varieties of pea were so heat sensitive from field trials, 2) identify heat tolerant traits via earlier flowering, and longer duration of flowering, and 3) improve pollen viability (greater pollen survival at higher daytime temperature), and a greater proportion of seed retained in each pod.

From 2011 to spring 2016 we investigated a range of pea varieties (12) and genetic material (a collection of 94 varieties known as PAM, and a structured population of 112). Evaluation of heat took place in the field (Saskatoon, Milden, Outlook, Rosthern, Yuma Arizona) and growth chamber (University of Saskatchewan).

Outcome

We found that pea varieties were all heat sensitive, but some performed better than others. About 20% of the PAM varieties could flower and set pods in 40°C heat. The analysis from a cross of a heat sensitive and a more heat tolerant pea showed that we could further improve the flowering duration and have more pod setting, even in our better SK varieties.

Pea plants started to flower on node (leaf position) 8 to 12, and ended flowering at nodes 16 to 24, depending on genetics and the environment (drought, temperature). It took 2.5 days to make a new node. Pea flowers self pollinate when they are large flower buds, just before the flower opens. On a plant, pea has two flowers at each node/leaf position, these flowers are staggered by 12 – 24 hours in age and the youngest one usually aborted. Heat caused this abortion. In the field, 3-5 days of midday air temperature of about 29-30°C was sufficient heat stress. Three days at 32°C+ caused developing unopen flower buds in the top of the plant to fail and abort. In the growth chamber, the temperature threshold was 35°C due to lower light conditions. Heat took out the youngest open flower plus any flower buds on the top of the plant. Very young flower buds were likely to abort before pollination, and some were not formed if temperatures were intense for days.

From pollen work, varieties ranged in pollen viability in heat. Heat did not affect the look of the pollen grain surface but changed proteins and fats in the pollen coat, which may cause pollen to not stick properly to the flower stigma. Heat reduced the amount of pollen that germinated and reduced the number of seeds in a pod. Within a pod, heat caused the ovules (peas) at both ends of the pod to fail, but the fertilized ovules in the middle of the pod survived. Some varieties were better able to keep the peas at the ends of the pods. No one variety or genotype had all the positive traits, but several excelled in some traits.

Research Objective

OBJECTIVE 1

To identify from field trials why current varieties of pea are so heat sensitive.

OBJECTIVE 2

To identify heat tolerant traits via earlier flowering, a longer duration of flowering, improved pollen viability (greater pollen survival at higher daytime temperature), and a greater proportion of seed retained in each pod.