INVESTIGATING HEAT TOLERANT TRAITS IN PEA CULTIVARS

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RATIONALE

Field pea is a major grain legume crop in western Canada. However, pea cultivars are heat sensitive and readily abort flowers and young pods in air temperatures above 30 °C, resulting in reduced and unstable yield from year to year. Our goal is to improve pea heat tolerance through a combination of phenology, pollen viability and canopy traits.

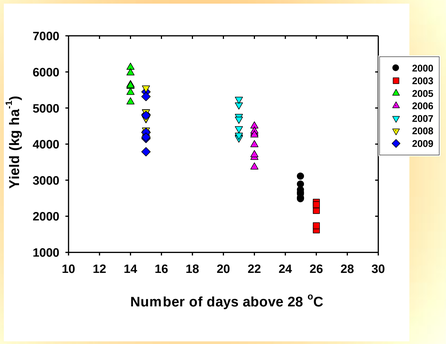
In 2010 to 2012, 12 cultivars were grown in the field in two soil zones at a normal and late seeding date to investigate yield formation. Daily maximum temperatures >29 °C caused abortion of flowers and young pods. Yield losses were greater in the later seeded plots where flowering was displaced into warmer temperatures.

In 2013 we mapped pod yield at specific nodes in controlled heat in the growth chamber. We also measured pollen viability on a subset of five cultivars from one field site (2012), noting abnormal pollen tube germination *in vitro* at temperatures > 30 °C.

Heat tolerant cultivars achieved greater pod retention through early flowering, and a longer flowering duration. An overview of our findings and future strategies to screen genotypes for other heat tolerant traits is below.

DURATION OF HEAT REDUCES YIELD

The more days , say 20 + in a season with maximum temperatures above 28°C, the less yield for dryland pea.

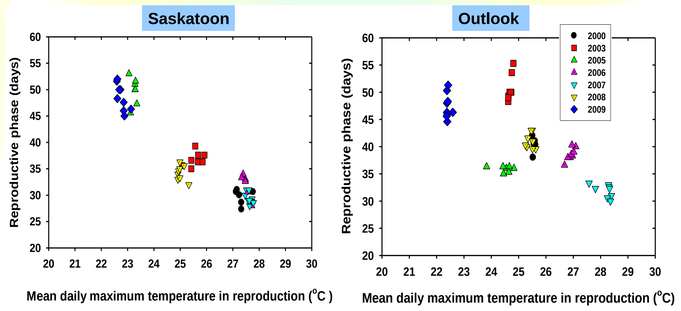


HEAT REDUCES TIME SPENT IN REPRODUCTION

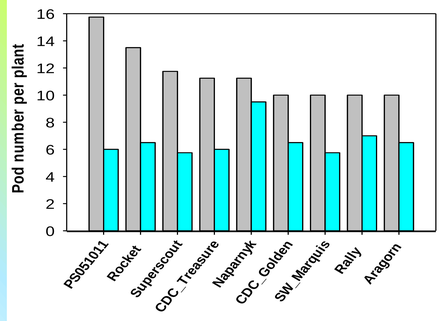
Time spent in reproductive growth is reduced by warm temperature. The higher the mean maximum temperature, the less days spent in reproductive growth, and yield is reduced.

At Saskatoon, the dryland site, 25.5°C or higher reduced reproduction to 35 days or less.

Irrigation (Outlook) ameliorates heat stress and more days are spent in reproductive growth.



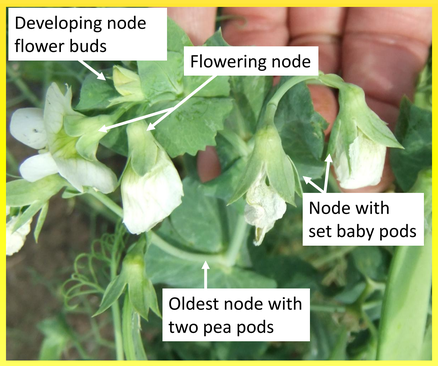
FUTURE RESEARCH – COOLING THE CANOPY

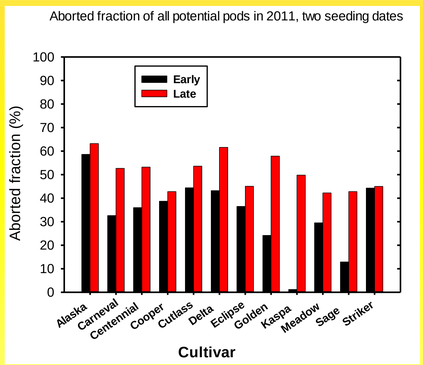


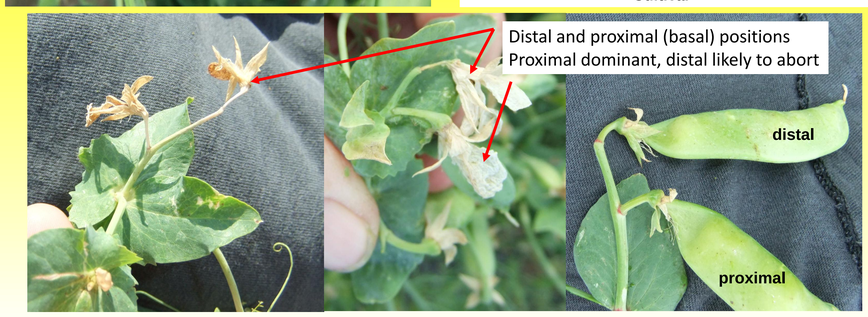
Pea under irrigation in Arizona (30 to 40°C) can still set pods and fill seed when irrigated. Out of 94 cultivars, 24 were able to set 6 or more pods from normal (grey bars) and late (cyan - hot) seeding-date trials.

Naparnyk was able to produce most pods in this hot environment, and this cultivar was indeterminate, with normal leaves. In addition to timing of flowering date and duration of flowering (phenology), various canopy traits likely reduce heat stress by maintaining cool leaves.

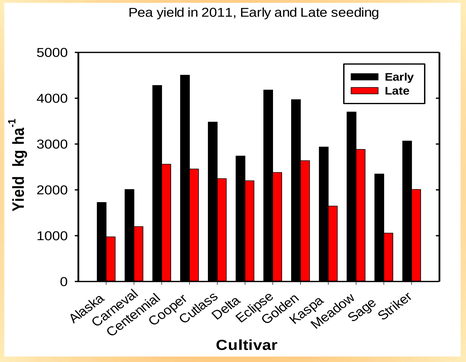
HEAT MAKES FLOWERS AND PODS FALL OFF

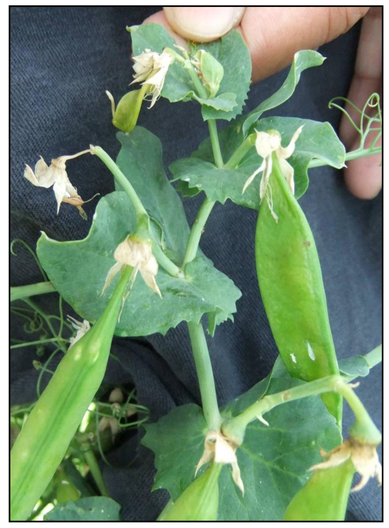






HEAT REDUCES YIELD IN LATE SEEDED PEA





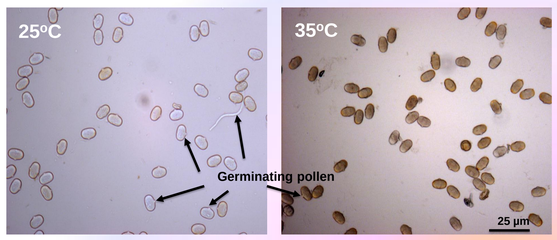
CONCLUSIONS

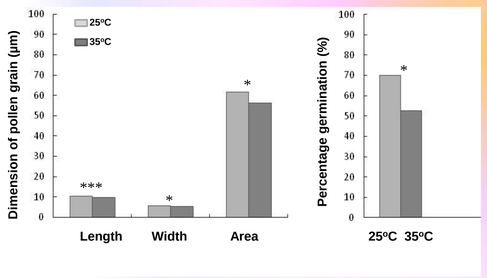
Heat stress in pea reduces time spent in reproduction. Heat causes abortion of flowers, pods and seed. Seed size is also reduced. Pollen viability in vitro is reduced by heat. Genotypic variation is apparent in heat sensitivity and tolerance.

FUTURE RESEARCH

We are in the process of characterizing heat tolerance through early flowering and flower duration via Recombinant Inbred Lines. We are also looking at pollen biology to find pea genotypes that can pollinate better under high temperature. We also plan to look at vegetative traits such as leaf type, leaf size, tendril and petiole thickness, leaf color, pigment and wax (cuticle) to help in transpirational responses and canopy cooling.

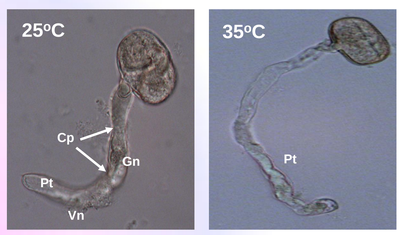
POLLEN GRAINS ARE SMALLER WITH LESS VIGOR

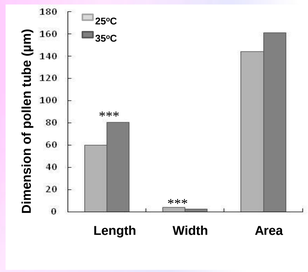




POLLEN TUBES BECOME LONGER AND THINNER

Vn- Vegetative nucleus
Gn- Generative nucleus (gives rise to 2 sperm nuclei)
Pt- Pollen tube
Cp- Callose plug





Four hours incubation of pollen *in vitro* from cv. Alaska at 25°C and 35°C. Non viable and heat treated pollen is smaller than normal viable pollen. Pollen germination is reduced by heat, and pollen tube germination in 35°C results in longer, thinner abnormal tubes.

HEAT REDUCES POD WEIGHT AND SEED WEIGHT PER POD

Pea in three days of controlled heat (ramped from 18 to 34°C for 6 hours) reduces pod weight and pea weight. Nodes were treated with heat just as the flowers of node 1 opened. Heat also reduced the distal pod weight. Measurements were made 20 days after heat treatment started. Mean of 3 reps and 10 cultivars. Note that node position and pod position within a node also have developmental responses.

Treatment	Pod weight (g)	Pea weight (g)	Pea number	Failed pollination	Aborted sites % of funiculi	Failed peas % of set peas
Temp 25 C	0.79 a	0.67 a	3.16 a	2.95 a	52.2 a	9.1 a
34 C	0.69 b	0.60 b	3.10 a	2.90 a	51.9 a	10.8 a
Node 1	1.14 a	0.99 a	4.55 a	1.80 d	34.4 d	9.6 a
2	0.88 b	0.76 b	3.77 b	2.35 c	42.7 c	11.3 a
3	0.65 c	0.55 c	2.83 c	3.00 b	54.8 b	12.2 a
4	0.29 d	0.23 d	1.36 d	4.55 a	76.4 a	6.8 a
Pod position						
proximal	0.98 a	0.84 a	4.05 a	1.98 b	38.4 b	13.8 a
distal	0.50 b	0.44 b	2.20 b	3.87 a	65.8 a	6.1 b
Node 1 25 C	1.07 a	0.88 a	4.77 a	1.71 a	32.4 a	6.9 a
34 C	0.90 b	0.10 b	4.33 a	1.88 a	36.4 a	10.4 a

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