# Spring Canola and Chickpea Value in a Cereal Grain Rotation

AARON D. ESSER[1], JACK BROWN[2], AND JAMES B. DAVIS[2]
[1]WSU EXTENSION; [2]DEPT. OF PLANT SCIENCE, UI

Canola (*Brassica napus* L.) in rotation with wheat (*Triticum aestivum*) has been an option for farmers in the dryland cropping region of the Pacific Norwest for over 25 years, yet adoption has been limited because of market access, profitability and overall unfamiliarity with the crop. In 2014 a large-scale multi-year rotation study was initiated comparing spring wheat, canola and chickpea (*Cicer arietinum* L.) (1st year) in rotation with winter wheat (WW) (2nd year) and spring wheat (3rd year). The experimental design is a randomized complete block with four replications and plot size 8 x 61 meters. Each crop rotation is examined over two cycles (i.e. 6 years) and was repeated in 2015 and 2016. The study is located at the WSU Wilke Research and Extension Farm which receives an average of 350 mm of precipitation. Data collected included seed yield, costs of production, economic returns, and subsequent crop production yields and quality. Gross economic returns are calculated using local F.O.B. prices on September 15 each year, and canola and chickpea yearly contract prices. Cost of production is the input costs (seed, fertilizer, herbicides, etc.) only. Spring wheat had the greatest yield averaging 2,311 kg $ha^{-1}$, and there is no significant difference in yield between canola and chickpea at 1,035 and 1,003 kg $ha^{-1}$, respectively. Over the first three years, subsequent WW yields were greatest following chickpea at 3,978 kg $ha^{-1}$, second following canola at 3,734 kg $ha^{-1}$, and lowest following wheat at only 3,399 kg $ha^{-1}$. Over the two -year cropping sequence economic return over costs with chickpea/WW has averaged \$254 $ha^{-1}$, wheat/WW at has averaged \$208 $ha^{-1}$ and canola/WW has averaged \$164 $ha^{-1}$. Overall, canola and chickpea both show positive rotation effects on following WW yield. Grower profit will vary according to grain prices which will fluctuate over years.

# Improving Seed Size and Seedling Emergence in Transgenic *Camelina sativa* by Overexpressing the *Atsob3-6* Gene Variant

PUSHPA SHARMA KOIRALA AND MICHAEL M. NEFF
DEPT. OF CROP AND SOIL SCIENCES, WSU

Seed shape and size are important agronomic traits because they can affect yield, ease of harvesting, and seedling establishment, especially under adverse conditions (e.g. drought, weed and pest pressure). The development of crop varieties that have large seeds and long hypocotyls as seedlings, yet maintain normal growth characteristics as adults, is challenging for traditional breeding because the regulation of seed/seedling size is complex and can be linked to other agronomic traits such as heading date or flowering time.

Based on our previous findings, some of the *AHL (AT-Hook Containing, Nuclear Localized)* genes play crucial roles in determining seed size and hypocotyl length in *Arabidopsis thaliana*, a model brassica plant. When we express particular mutant form, *Atsob3-6,* of the *AHL* gene *AtAHL29/SOB3* (*Suppressor of Phytochrome B-4 #3*) the resulting transgenic *Arabidopsis thaliana* plants have normal adult growth that give rise to larger seeds and seedlings with longer hypocotyls than the wild type. *Arabidopsis thaliana* and *Camelina sativa* are from same family (Brassicas) and both have similar genomes. *Camelina sativa* is an emerging oilseed crop in dryland cropping systems.

Based on our preliminary results, we proposed: (1) to compare seed size of different mutations of *AtAHL29/SOB3* to identify the specific mutations that confer bigger seeds and longer hypocotyls than the wild type and; (2) translate the finding from *Arabidopsis thaliana* to the oil seed crop *Camelina sativa*.

In this study we have generated transgenic lines of *Arabidopsis thaliana* overexpressing *Atsob3-6*. We have then generated transgenic *Camelina sativa* plants overexpressing *Atsob3-6* as well as a similar gene variant from *Camelina sativa* (*Cssob3-6*). Seedling hypocotyl length, seed size, seed weight and seedling emergence from deep-planting assays were then measured. Our results show that transgenic plants expressing *Atsob3-6* confer bigger seeds and taller seedlings than non-transgenic lines in *Arabidopsis thaliana*. These *Atsob3-6* transgenic lines make seeds that are 50% bigger and seedlings that are twice as tall as non-transgenic plants. When we overexpress *Atsob3-6* in *Camelina sativa*, we increase seedling height (Fig. 1a), seed area (Fig. 1b) and seed weight (Fig. 1c) compared to non-transgenic plants. When we overexpress the *Camelina sativa* variant, *Cssob3-6*, in *Camelina sativa*, seeds are ~30% bigger and seedlings ~50% taller than non-transgenic plants. In order to evaluate if the larger *Atsob3-6* seeds improve *Camelina sativa* emergence from sub-surface planting, we planted two independent transgenic lines (*Atsob3-6-OX-1*, *Atsob3-6-OX-2*) and wild-type seeds 6 cm deep in moist, compacted sunshine mix #1. Approximately 25% of the *Atsob3-6-OX* transgenic seedlings emerged compared to 2% of the wild type (Fig. 2a). Hypocotyl measurements of all germinated seedlings demonstrated that *Atsob3-6-OX* increased seedling height in sub-surface planting (Fig. 2b). We also tested *Camelina sativa* emergence from sub-surface planting in dry Palouse silt loam with 30% of the *Atsob3-6-OX* transgenic seedlings and 0% of wild-type seedlings emerging (Fig. 2c). All genotypes in our emergence assays had 100% germination.

Taken together, over-expression of *Atsob3-6* increases seed size, hypocotyl length and stand establishment *Camelina sativa*.

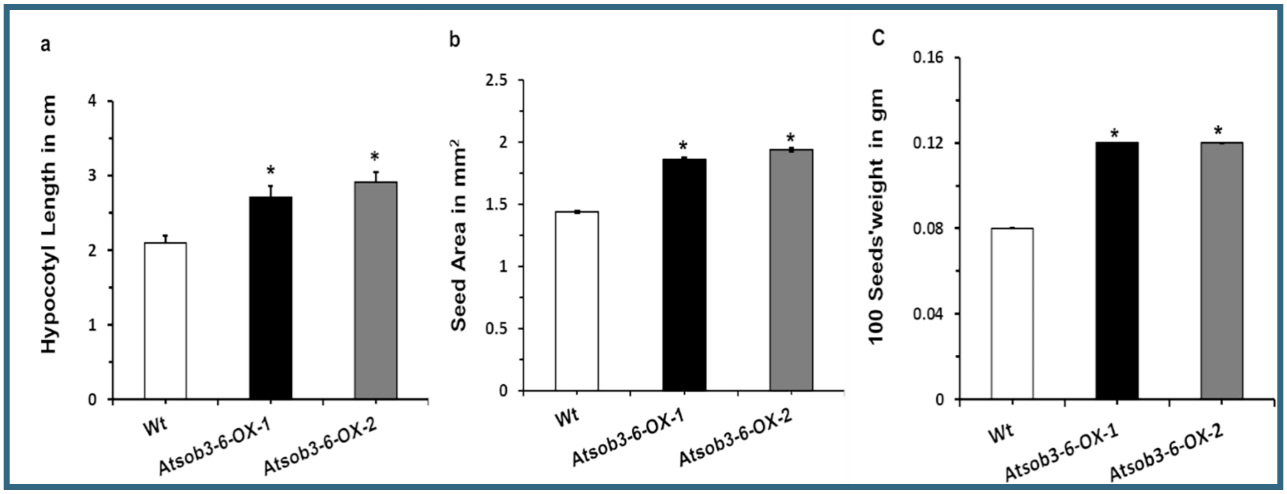


**Figure 1. <u>The *Atsob3-6* allele regulates hypocotyl length, seed size and seed weight when overexpressed in *Camelina sativa*.</u> Two independent *Atsob3-6-OX* transgenic camelina lines increased hypocotyl length (a) seed size (b) and seed weight (c) when compared to the wild type (Wt). *n* = 60 for hypocotyl length. *n* = 100 for seed area. *n* = 300 for seed weight, * p < 0.0001**

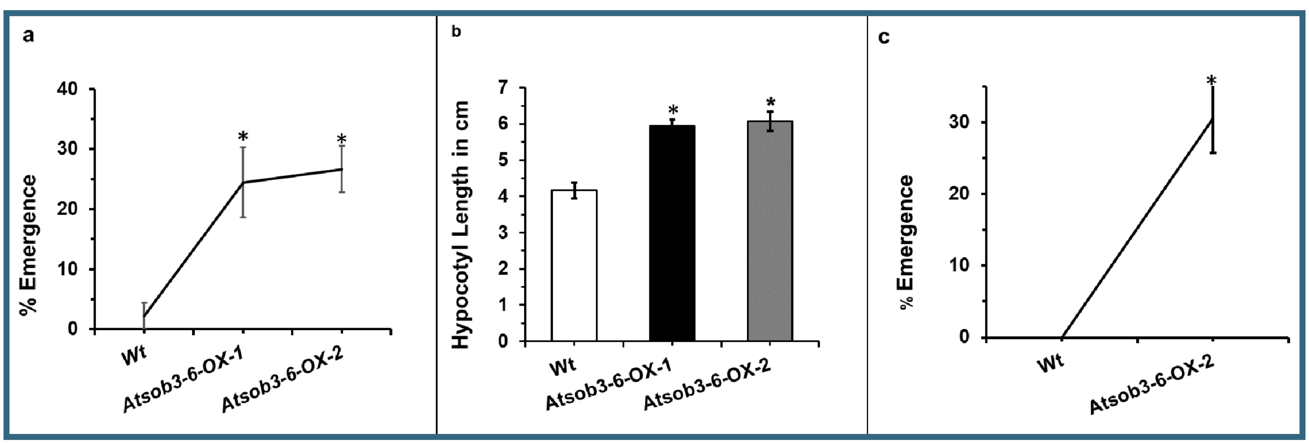


**Figure 2. <u>*Atsob3-6-OX* confers better seedlings emergence when expressed in *Camelina sativa*.</u> Seeds of two independent *Atsob3-6-OX* lines and the wild type (Wt) were germinated beneath 6 cm of lightly compacted potting mix at 25°C for seven days before measuring percent emergence (a), and total hypocotyl length within and above the soil (b), *n* = 45. Seedling emergence of *Atsob3-6-OX-2* and wild-type seedlings was also measured seven days after planting beneath 6 cm of dry Palouse silt loam (c), *n* = 36, *p< 0.0001.**