Winter Oilseed Grower Bulletin #7: A retrospective on pennycress agronomic management.

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Pennycress (*Thlaspi arvense* L.) agronomic management has been the subject of many recent studies at the University of Minnesota. In the past, pennycress has been regarded as an agricultural weed and studies focused largely on its negative impact on cultivated crops. As the pennycress paradigm shifts from weed to crop, the research conducted must be reflective of intentional agricultural cultivation. At present, research on pennycress cultivation is in its infancy and has occurred within the past decade, but it is important to reflect on the foundational information that we have gained. To date, the overarching objectives have been to identify fundamental agronomic management practices, quantify environmental services, and establish appropriate methods to integrate pennycress into the corn-soybean [*Zea mays* L.-*Glycine max* (L.) Merr] rotation. A recent review of research by Cubins et al. (2019) established areas that require further investigation; the major topics included sowing requirements, harvest requirements, seed oil content and quality, cropping strategies, ecosystem services, and germplasm development.

Pennycress has a broad range of regional adaptation spanning temperate regions across the world. Because of this, variation in yield and development begins with planting. Within the Upper Midwest, there is strong evidence to suggest that pennycress should be planted in September due to higher soil temperatures and a longer period of time for vegetative growth before winter. Early September planting dates may also correspond to higher seed yields, higher oil content, and earlier harvest dates, which are favorable for pennycress production as a double or relay crop. There is less cohesion regarding planting rate, row spacing, and water and fertilization requirements. Planting rates have ranged between 2.7 and 15.0 lb ac^{-1} while row spacing spans 3.0 to 9.8 in. Both of these parameters can have significant implications on pennycress establishment and yield potential and require further investigation. Pennycress is adapted to regions where water availability is not an issue, but in years with low precipitation, it is highly susceptible to water stress at germination. Water stress at early growth stages is associated with smaller plants with fewer branches and can contribute to uneven germination and stand maturation. However, water stress at germination and emergence can be alleviated by supplementing soil moisture at planting.

One of the most significant challenges of pennycress management is the establishment of proper harvest practices. This has been a multi-faceted issue stemming from the weedy characteristics that our current pennycress lines retain. For example, uneven stand maturation of pennycress makes it difficult to determine stand growth stage and when to harvest, while silicle (*i.e.* pod) fragility makes pennycress susceptibility to yield loss due to shatter at advanced stages of maturity. Research trials have documented yield to average between 332 and 830 lbs ac^{-1}, which can make it difficult to predict pennycress yields in a given year. Shattering can also have direct and immediate implications on the weed seed bank and crops that follow pennycress. Each pennycress silicle can contain up to 15,000 seeds and total shatter can equal 300 times the seeding. Luckily, pennycress can easily be terminated with common herbicide chemistries to decrease the potential effects on crops that follow. To ensure

successful pennycress production in the future, our breeding team has developed lines with improved uniformity and reduced pod shatter.

Two distinct advantages of planting pennycress are its winter annual growth habit, which allows for it to be integrated into the corn-soybean rotation, and its ability to provide ecosystem services. Much of the agronomic work has focused on these facets of production. Double and relay cropping studies with pennycress have shown that it may not reduce summer annual yield or quality despite a slightly shorter growing season for the summer annual, and, in some cases, may even have a positive effect on soybean yield. Other studies, however, have cited lower summer annual yields, but an overall increase in annual seed yield, which is a promising result for this cropping system. These confounding results indicate a need for more research on pennycress cropping system integration and risk management, especially in cases where regional differences in production may occur. Outside of production, it is also important to consider other benefits that pennycress can provide. Pennycress is an excellent nutrient scavenger and can decrease the amount of nitrogen that could otherwise leach into nearby waterways and can provide pollinator forage in the early spring when other species have not begun flowering. It can lead to an increase in insect diversity, specifically for spiders and ground beetles, and may provide habitat for other insects as well. Overall, great progress has been made in advancing pennycress as a winter annual crop, but research on fundamental production aspects, such as nutrient requirements and seeding rate, and economic risks/benefits must be more robustly developed.

Reference: Cubins, J.A., M.S. Wells, K. Frels, M.A. Ott, F. Forcella, G.A. Johnson, M.K. Walia, R.L. Becker, and R.W. Gesch. 2019. Management of pennycress as a winter annual cash cover crop. A review. Agron. Sustain. Dev. 39:46. https://doi.org/10.1007/s13593-019-0592-0