KATIE HATLELID

Inoculation of Pulse Crops

by Colleen Buck
MSU Agricultural Extension Agent in Sheridan County

NICOLE WINKLER

Pulse crops are defined as annual grain legumes that produce large seeds and are used for human consumption or as a part of livestock rations. Montana led the nation in pulse crop production in 2016, with an estimated 1.2 million acres planted (USA Dry Pea and Lentil Council). Chickpeas, lentils, and dry peas make up the majority of pulse crops grown in Montana. As with other legume crops, pulse crops have the ability to obtain nitrogen from the air and soil surrounding their roots. In order to achieve this, the plant and soil bacteria called rhizobium form a mutually-beneficial relationship with the plant, and specifically the plant's taproot.

The symbiotic relationship between the plant and the rhizobium to fix nitrogen starts after the seed has germinated. Rhizobium bacteria enter the plant's root hairs and travel through the root wall creating an infection thread. After the rhizobia have infected the roots, they rapidly multiply, triggering the plant to respond by containing the infection to one location. The contained infection, which includes rhizobia, grows to form a specialized structure called a nodule. Evidence of nodulation on the roots may take up to three or four weeks after seed germination. Once nodules are formed the process of nitrogen fixation begins. Rhizobium bacteria (rhizobia) have the ability to "fix" nitrogen from its gaseous state (N_2) in the small air spaces in the soil by binding nitrogen to hydrogen molecules to eventually form ammonium (NH_4), which can then be used by the plants to form amino acids and proteins. The plant provides the energy, nutrients and water needed by the rhizobia in order for the process to work. Crop type, crop health, available nitrogen in the soil, and other environmental conditions are all factors in determining how much Nitrogen can be fixed when planting pulse crops.

Fifty to 80 percent of the nitrogen requirement of pulse crops can be synthesized through the nitrogen fixation process. The other 20 to 50 percent must come from the soil or fertilizer. This means before planting it is good to have soil tested to ensure that the nutrient levels in the soil are adequate for the crop to be grown. Another strategy to ensure that plants will nodulate effectively is to inoculate the seed before planting to boost the amount of rhizobium bacteria in the soil. Inoculation is especially important in fields that have yet to grow a pulse crop. There are specific rhizobia that are needed for the different pulse crops, therefore by using a species-specific inoculum, a producer can ensure that the correct rhizobia are present for the pulse crop grown. As an example, the species of rhizobia that works for pea will not necessarily inoculate another species such as lentil, they must match the desired crop being grown.

The inoculation process includes coating the seed with a liquid or peat-based powder inoculant or by treating the soil with a granular or liquid inoculant. If the same pulse crop has been grown in the field before, rhizobia may remain in the soil to inoculate the following pulse crop. The rhizobia can be affected by both the soil pH and texture, health of the crop, and won't survive between plantings, meaning each new crop must be inoculated. Rhizobia also don't move around in the soil from plant to plant, and to be effective must be in physical contact to the roots during growth. It is recommended to inoculate at each planting and carefully store seed in a cool, dark place to ensure rhizobia survival until planting.

Two to three weeks after planting, nodules should be present on the roots of the plant. The plant will reach maximum nodulation and nitrogen fixation as the plant nears the mid-flowering stage, which is when the plant has the highest nitrogen requirement. Seed-applied inoculum will result in nodules being present on the primary root near the crown of the plant. To check for nodulation, carefully dig up the entire plant and roots, wash off the dirt in a bucket of water, and look for pink-to-white colored growths on the primary root. Nodules on the secondary roots indicate that rhizobia was probably in the soil previously. The inside of a healthy nodule should be a pink to red in color. This signifies that the rhizobia is working to actively fix nitrogen and the color is an indication of the presence of leghemoglobin, which is an iron-containing pigment that needs to be present for active fixation to occur. Nodules that are inactive are generally brown, white or green when sliced open.

Ineffective nodules can lead to poor fixation of nitrogen for the plant which causes symptoms of nitrogen deficiency to occur, including reduced plant growth and decreased yield. One strategy to help ensure that there is enough nitrogen for the plant is to apply a nitrogen fertilizer at seeding, depending on the amount required by a soil test. Furthermore if nodules are ineffective or stop working because the nodule dried up, the plant can keep growing if there is an external source of nitrogen. Other factors to consider if nodulation fails include ensuring that phosphorus, potassium, and sulfur levels are adequate, since all of these elements are required for nitrogen fixation. Saline soils, soils with a pH less than 5.5 or greater than 8, high levels of soil nitrate, and water-logged or droughty soils are factors that can limit nodulation and nitrogen fixation.

Inoculation of pulse crops can be the major difference between having a successful or mediocre pulse crop, especially if the crop is being grown in a new area. As with any decision on the farm, management decisions need to be examined in great detail to determine the best option for your operation. Pulse crops continue to increase in Montana, which means that more producers are trying a new crop and need to understand the physiology behind what it takes to grow a pulse crop and understanding inoculation is a significant portion of growing pulses and legume crops.

For more information, visit landresources.montana.edu/soilfertility/index.html or contact MSU Extension soil fertility specialist Clain Jones at clainj@montana.edu. ■