The Sustainability of Pulse Crops

Pulses play an important role in sustainable agriculture

Experts predict that the global population will increase from 7.3 to 9.8 billion people by 2050, potentially increasing global food demand by as much as 59-98% (Valin 2013). At the same time, the world is facing climate change with agriculture contributing to these environmental challenges. There is a desperate need to develop short- and long-term sustainable agricultural practices to reduce natural resource usage and prevent further climate change while balancing feeding the growing population.

Research suggests that shifting to more plant-forward dietary patterns may contribute to a more sustainable food system. Dietary patterns higher in plant-based foods like fruits, vegetables, whole grains, nuts, seeds, and pulses are more health promoting and associated with lower environmental impact (E.g., greenhouse gas emissions, land usage, and water usage) compared to the typical United States diet (Nelson 2016; Harwatt 2017).

Pulse crops are one component of plant-forward diets that have the ability to play a critical role in sustainable food systems by reducing greenhouse gas emissions and natural resources usage. Simultaneously, pulses can increase crop diversity and soil quality leading to improved productivity of cropping systems at large. Given their unique environmental benefits, pulses should be strongly considered in all future solutions for developing sustainable agricultural practices in the United States and across the globe.

Incorporation of pulses into crop rotations may help reduce greenhouse gas emissions

Nitrogen is an essential nutrient for all plants. The nitrogen aids in a plant's structural development, metabolism, and in the process of photosynthesis (Sulieman 2011). It also plays an important role in regulating water and nutrient uptake via proteins in the root system as well as ensuring a plant has enough energy to optimize production yield (Muratore 2021).

The air around us is filled with nitrogen gas, but most plants cannot convert nitrogen from the air into a usable form. Instead, plants must rely on nitrogen that is present in the soil. Nitrogen in the soil comes from two main sources, 1) the conversion or "fixation" of nitrogen gas into usable forms of nitrogen by soil microbes and 2) the addition synthetic fertilizers. The overreliance on fertilizers in farming practices is a major contributor to climate change because of its extensive greenhouse gas emissions. Farm soil that is abundant in nitrogen fertilizer emits nitrous oxide, a greenhouse gas, into the atmosphere at higher levels than non-farm soil (EPA 2021). Additionally, the manufacturing, transportation, and use of synthetic fertilizer generates a significant amount of carbon dioxide. Both nitrous oxide and carbon dioxide are major greenhouse gases that are contributing to global warming (Chai 2019). Given that overuse of synthetic fertilizers can be determinantal to the environment, finding alternatives to heavy fertilizer use in cropping systems while still maximizing production yields is one potential solution to help reduce agricultural greenhouse gas emissions.

Legumes, including pulses, are unique from other crops because they have the ability to fix nitrogen in the soil. They are able to do this with a symbiotic relationship with rhizobia bacteria. The bacteria form nodules on the roots of pulse plants where they fix nitrogen gas into a more useful form of nitrogen. The plant is then able to utilize the nitrogen for growth and development. This not only reduces the pulse plant's need for fertilizer, but it also improves the soil's nitrogen content for future crop rotations and reduces the future need for synthetic fertilizers (Newton 2015). As such, pulses have lower carbon footprints than most other foods (Gustafson 2017). Including pulse crops like dry peas in a crop rotation with wheat and oilseeds could decrease nitrous oxide emissions by nearly 20-25%. In addition to reducing nitrous oxide emissions, the large-scale use of pulses to minimize fertilizer requirements is also linked to the reduction of carbon dioxide emissions that would have been generated during the production and application of synthetic fertilizer (Jeuffroy 2013). Importantly, it has been shown that the inclusion of pulses in these crop rotations can reduce greenhouse gas implications while still maintaining crop quality and growth productivity (MacWilliam 2018).

Pulse can improve soil diversity and crop productivity

Including pulses in crop systems not only improves greenhouse gas emissions, but it also improves the microbial diversity and quality of the soil. With their nitrogen fixing properties, pulses improve the nitrogen and carbon content of the soil for future crops (Lupwayi 2015). When used in a crop rotation, pules can improve the soil nitrogen levels compared to wheat or barley (Gan 2015). This improved soil quality can lead to an increase in future grain production (Angus 2015; Preissel 2015). One study showed that when pulse harvests are followed by cereal crops, it can lead to a 30% increase in grain production and a 50% improvement in grain protein yield (Gan 2015). Since the global demand for grains is increasing, utilizing pulses in crop rotations with cereal crops can help improve grain yield while minimizing natural resource usage compared to cereal-only rotations.

Pulse crops can also reduce pest damage and weed growth for other crops (Robson 2002). This is because pulses are not typically suitable to the same pests or diseases as cereal crops, thus using them to create a break in between cereal-based crop rotations can give the soil a chance to recover from pests and diversify before the next cereal crop (Zander 2016; Seymour 2012). This diversity in crop rotations can improve the soil quality and reduce pest or weed damage to subsequent crops while reducing natural resource usage.

Pulses are water efficient crops

Food production is one of the top uses of water across the globe, with agriculture accounting for nearly 70% of total water use (FAO 2019). Demand for water resources is predicted to increase by approximately 20-30% by 2050 in order to feed the growing population, making the long-term sustainable use of water a growing concern (Burek 2016). As such, there is an urgent need to develop and utilize sustainable practices to improve the efficiency of agricultural water use.

Research has suggested that meat-based diets have larger water footprints than plant-based diets. From a caloric and protein standpoint, animal agriculture and livestock production require more water than crop production. The water footprint per gram of protein for milk, eggs, and chicken is nearly 1.5 times higher than for pulses. And the water footprint per gram of protein for beef is about 6 times larger than for pulses. On a per ton of product basis, the water footprint of beef is over 3.5 times larger than the water footprint of pulses (Mekonnen 2010). Shifting to more plant-forward diets may help to reduce pressure on the global water resource demand. In fact, studies have found that replacing half of all animal products with an equivalent amount of nutritious crops like pulses, vegetables, or nuts could reduce the water footprint of food production by up to 30% (Mekonnen 2010).

In addition to using water efficiently for their own growth and production, pulses can also help improve the water efficiency of other crops. Pulses have a unique rooting system that contributes to their ability to utilize water efficiently (Meena 2018); their roots allow them to use shallow soil water for their own growth while sparing the deeper soil water for use by other crops. When used in crop rotation systems, pulses have been shown to help conserve water in the soil thereby reducing irrigation requirements for future crops grown on the same fields? like cereals (E.g., wheat) or oilseeds (E.g., Canola) (Gan 2009; Gan 2015; Gan 2016; Ding 2018). Therefore, using pulses more frequently in crop rotations under certain conditions is one potential opportunity to help to reduce agricultural water usage.

The water efficiency of pulses also makes them well-suited to grow in moderately drought prone regions or low moisture settings where other crops may not be suitable (Ding 2018). Certain pulses can be used in these drier settings for harvest or as a cover crop to protect the soil in between harvest crop rotations (Curtis 2021; Fatokun 2012; Muñoz-Amatriaín 2010).

Pulses can contribute to a reduction in food waste

Pulses often require little processing and no refrigeration, which reduces their natural resource consumption near the end of the food supply chain. In addition to their reduced natural resource usage, pulses can also contribute to food security by reducing food waste. Most forms of pulses are shelf-stable and can be stored at room temperature for months or years while still maintaining their nutritional value. Because of their long shelf-life, pulses can help alleviate consumer food waste compared to fresh fruits, vegetables, and meats which are prone to spoilage. The contribution of pulses to the total global food waste footprint is relatively low, meaning they are an environmentally friendly source of important nutrients (FAO 2015).

Pulses are an environmentally beneficial and sustainable crop

The world is currently facing complex pressures to improve food security, prepare to feed a rapidly growing global population, and lower the risk for climate change and natural resources usage at the same time. In order to do this, the current natural resource usage for modern agriculture will need to be closely monitored and efforts need to be made to convert to more sustainable agricultural practices. Pulses provide a unique opportunity to grow nutritious crops to help feed the growing population while simultaneously reducing greenhouse gas emissions, synthetic fertilizer requirements, and natural resource usage.

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