Intensifying grain legume production in dryland cropping systems

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Rotating grain legumes with wheat can help diversify grower incomes; break pest, weed, and disease cycles; and improve the use of nutrients. For this reason, grain legumes are common in crop rotations of the annual cropping zone (> 450 mm annual precipitation) of the REACCH region (Figure 1). In the grain-fallow zone (< 300 mm annual precipitation), alternative crops and rotations have not been as economically viable as traditional winter wheat-summer fallow. Nevertheless, winter and spring grain legumes may play an important role in the diversification and intensification of rotations in the annual crop-fallow transition zone (300 to 450 mm annual precipitation), as well as in the grain-fallow zone.

IMPACT

Grain legumes have the potential to improve nitrogen management in the low precipitation zones of the REACCH study area. This project will: (1) provide science-based evidence for intensifying grain legume production in dryland cropping systems, and (2) improve dinitrogen fixation and overall cropping system nitrogen use efficiency.

Recent evidence of greater interest and adoption of grain legumes is provided by the Cropland data layer, where from 2007 to 2012, the prevalence of pea, lentil, and chickpea has increased by 73% in the annual crop-fallow transition zone and by 56% in the grain-fallow zone. Cool-season grain legumes have been successfully adapted into rotations in Mediterranean-like regions of southwestern Australia that receive less than 350 mm annual precipitation. Faba bean and field pea have demonstrated tolerance to water-limited conditions via early biomass and pod production and shorter growing seasons, producing yields comparable to wheat.

Our REACCH findings suggest that grain legumes have the potential to improve nitrogen (N) management throughout the REACCH study region in the low precipitation zones. In a current 3-year study located in the annual crop-fallow transition zone of eastern Washington, the effects of spring pea included boosting subsequent winter wheat grain yield by 18% and improving the N balance by 20 lb N/acre, comparable to observations common in the annual cropping zone (data not shown). Spring pea yields from 2011 through 2013 averaged 1,618 lb/acre in the annual crop-fallow transition zone (Davenport, Washington) and 1,563 lb/acre in the annual cropping zone (Pullman, Washington). However, the standard deviation in yields was twice as high in the intermediate zone. The estimated quantity of N derived from biological fixation was less than 50% of total plant N in this zone, unlike the high rainfall zone (Figure 2). Most of this N is likely to be exported in the seed. The contribution of biological N_2 fixation to the rotation depends on selection of properly adapted legume varieties and the efficiency of rhizobia inoculum.

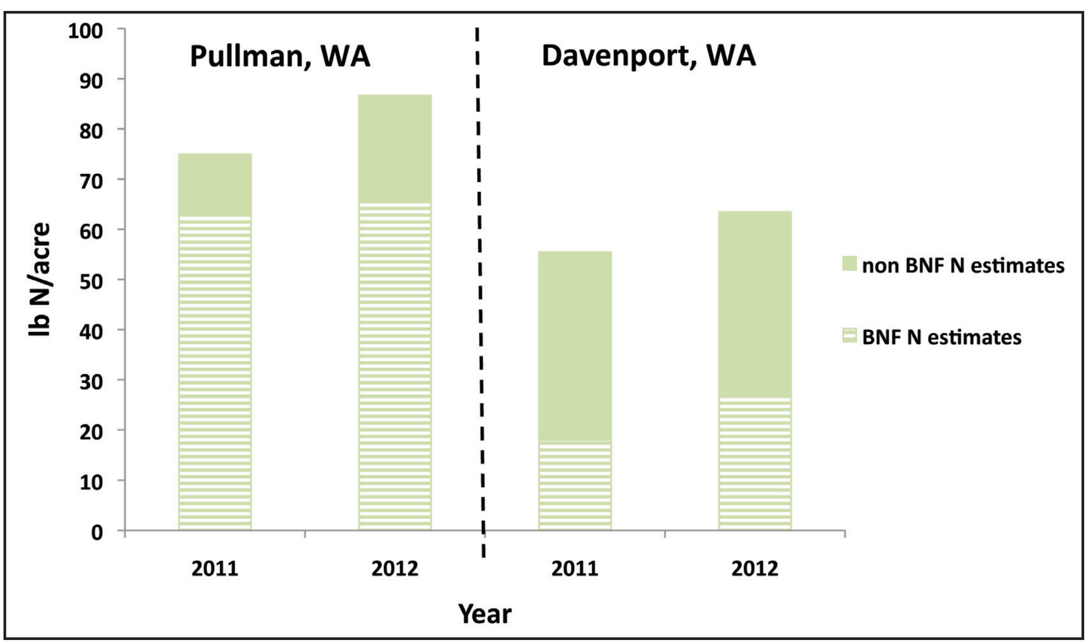

Figure 2. *Above-ground nitrogen (N) in spring pea crops at Pullman, Washington (high rainfall zone) and Davenport, Washington (intermediate rainfall zone) in 2011 and 2012. Biological N_2 fixation (BNF) estimates were calculated using a N difference approach relative to a spring wheat reference crop.*

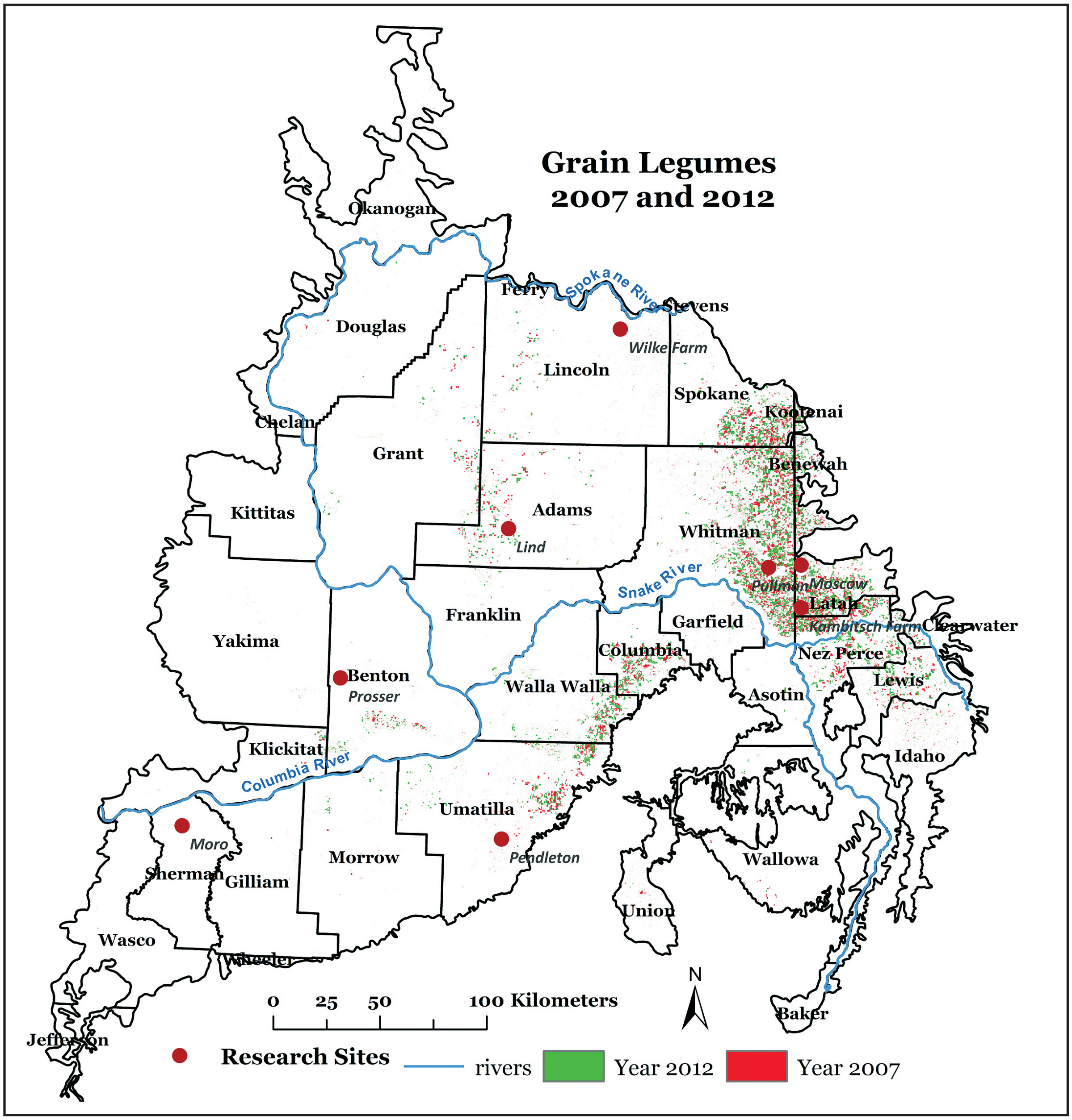

Figure 1. *Grain legume production area (2007–2012) in the REACCH region.*

In an ongoing field study near Ritzville, Washington (290 mm annual precipitation), winter pea has produced an average yield of 2,288 lb/acre when grown in a 3-year winter pea-spring wheat-summer fallow rotation (data not shown). In the second year of the study, spring wheat grain yield following winter pea was greater than that following winter wheat in a 3-year winter wheat-spring wheat-summer fallow rotation. Winter pea uses significantly less soil water than winter wheat (data not shown), and we think this will result in greater spring wheat grain yield following winter pea as the study progresses. Periodic substitution of winter pea for winter wheat will diversify rotations and give farmers an excellent opportunity to manage problematic grassy weeds such as downy brome and jointed goatgrass.

There is evidence that biological N_2 fixation may be increased in the short-term by (1) inoculating legumes more frequently, (2) inoculating with more effective, competitive rhizobial strains that produce more nodules, (3) co-inoculating with "helper organisms," (4) selecting legume varieties that support rhizobial infection, and (5) genetically engineering crops to enhance nodule size and number based on variety by strain interactions. Information found in published literature shows that significant yield increases of up to 100% as a result of inoculation of virgin soils have been observed. In addition, repeated inoculation of some crops is required when a new legume is introduced into a soil that is unlikely to contain enough rhizobia for effective root infection. Depending on soil nitrate and other conditions, a 33 to 50% yield improvement on average was achieved by inoculating all grain legumes at every planting. Our future research aims to: (1) quantify the rhizobial populations in pea currently grown in the REACCH region, (2) assess the viability of *Rhizobium leguminosarum* bv. viciae. inoculum under various crop rotation and tillage practices, and (3) further assess conditions where rhizobial inoculation is beneficial for pea.