Pea Protein: Measurement, Management, and Drought Impact

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IMPACT STATEMENT

Based on yellow pea samples and associated management details from farms in Montana and North Dakota, water limitation may be the most important growing condition that increases pea protein in dryland pulse crop production. The use of granular rather than seed-coat inoculant correlated with higher pea protein under severe drought conditions. Other than a boost in protein with sulfur fertilization in moderate drought condition, starter phosphorus, potassium, and sulfur applications were not correlated with pea protein.

SUMMARY

The study objective was to determine standard management and environmental effects on yellow pea protein, while assessing precision of pea protein measurements. We collected 149 independent yellow pea samples and associated management details from the 2013-2016 growing seasons from 82 pea producers in Montana (71) and North Dakota (11). Observed standard practices for yellow pea included, 1) no-till seeding in cereal stubble in April, 2) use of rhizobia inoculant, and 3) use of starter phosphorus (P), potassium (K), and sulfur (S) fertilizers and pesticides. Protein concentration ranged from 18.9 to 29.6%, with a mean of 23.5%. There was large variation in pea variety, rhizobia inoculant type (granular vs. powder seed-coat), and nutrient management (application of P, K, or S fertilizers). There was higher seed protein in severe drought (24.4%) than wet (22.9%) environments; higher protein (by 1.6 units) when granular inoculant was used compared to peat-powder seed-coatings under severe drought conditions, and higher protein (0.8 units) under moderate drought conditions when S was used. There was no correlation found between application of P or K fertilizers and yellow pea protein, but the lack of response may be due to uncertainty in measuring protein content in yellow pea.

INTRODUCTION

Consumer demand for plant-based protein is rising. If Montana establishes itself as a source of yellow pea with consistently high protein, this will translate directly to greater revenues for Montana pulse growers. This project's primary objective was to identify standard management of yellow pea and identify if management variation affected yellow pea protein across Montana's water-limited growing environments.

PROCEDURES

Eighty-two producers supplied us with 149 yellow pea samples from the 2013-2016 growing seasons along with field management history. We used available climate (Abatzoglou, 2013), soils (Soil Survey Staff-NRCS, 2015), and pea growing degree day models (Miller et al., 2001) to simulate drought stress patterns over the crop cycle. Yellow pea samples were tested at MSU for protein using the combustion method, and protein estimated using NIR (near infrared reflectance). Pea protein measurements were linked to field history to look for protein correlations with growing season management (type of inoculant; P, K, or S fertilizer; pea variety, CDC Meadow vs CDC Treasure) and drought conditions.

RESULTS

Protein Content

The average protein content based on combustion method of these samples was 23.5%, but protein ranged from 18.9-29.6%. We evaluated both the variation among duplicate samples in the combustion method, and the precision and accuracy of NIR, the main protein industry method for yellow pea protein determination (Bestwick et al. 2018a). The average difference in duplicate combustion was 1.2 protein units. The average difference between NIR estimates and combustion measurements was 1.0 protein unit. Thus, accuracy of protein measurement is a key challenge.

Standard Management

The primary management variables that were ***similar*** across farms were as follows. Yellow pea is:

- seeded in April
- grown with conventional fertilizer and pesticide inputs
- grown with no-till seeding
- inoculated
- generally seeded following wheat or barley.

Management variables that were ***not similar*** across farms were as follows:

- Variety selection. CDC Meadow and CDC Treasure made up 52% of the samples, while more than 18 varieties made up the remainder.
- Inoculant. Farms were almost evenly split between using peat-granular (45%) or peat-powder seed-coat (51%) inoculant. Three farms used liquid inoculant, and two farms did not specify if they used inoculant.
- Nutrient management varied across farms. Forty percent of farms did not use fertilizer on yellow pea and 60% used various blends and rates of P, K and S fertilizer. Phosphorus was likely applied as a monoammonium phosphate blend (11-52-0) contributing the low amounts of nitrogen (N) reported (94% reported applying 2 to 11 lb N/acre). Of the 60% of farms that ***did*** apply fertilizer, the proportion that applied P, K and S, along with ranges in rates, are as follows:
    - P_2O_5: 98%, 15 to 52 lb/acre
    - K_2O: 18%, 5-10 lb/acre
    - S: 61%, 3-8 lb/acre.

Typical Growing Environments

Each line in Fig. 1A represents a simulated "drought stress pattern" for individual pea-field history samples. A detailed description of the mechanics of the simulated drought patterns can be found in Bestwick (2016). These drought stress patterns were grouped into three drought environments interpreted as favorable (green), moderate (yellow), and severe (red; Fig. 1B). In the favorable drought stress environment, pea did not undergo significant drought stress until after flowering. Favorable drought stress was due to timely precipitation, heavy soils, and moderate temperatures or any combination of environmental factors that provided the crop adequate soil water supply. Conversely, in the high drought stress environment, pea was subjected to drought stress beginning in the vegetative (V) growth stages, increasing in reproductive (R) growth stages (after flowering), and lasting to maturity. A high drought stress environment can result from low rainfall, hot temperatures, soils with low water holding capacity, or any combination of environmental factors that limit soil water supply.

Drought Environment and Management on Pea Protein

The highest protein content (24.4%) was associated with severe drought, and the lowest protein content (22.9%) was associated with favorable soil moisture. The impact of drought environment was the same for both CDC Meadow and CDC Treasure, and there were no protein differences between the two varieties. Tao et al. (2017) also found that environment was far more important than variety at driving protein differences, yet found a positive yield – protein relationship suggesting moisture increased protein. The timing and severity of drought influences its impact on pea protein (Tao et al., 2017; Bestwick et al., 2018a), although less predictably than in wheat. Tao et al. (2017) did find differences in how protein in each of nine cultivars responded to growing environment.

In severe drought, granular inoculant produced higher protein (24.5%) than seed-coat inoculant (22.9%). Granular inoculant has been reported to be superior to peat-powder seed-

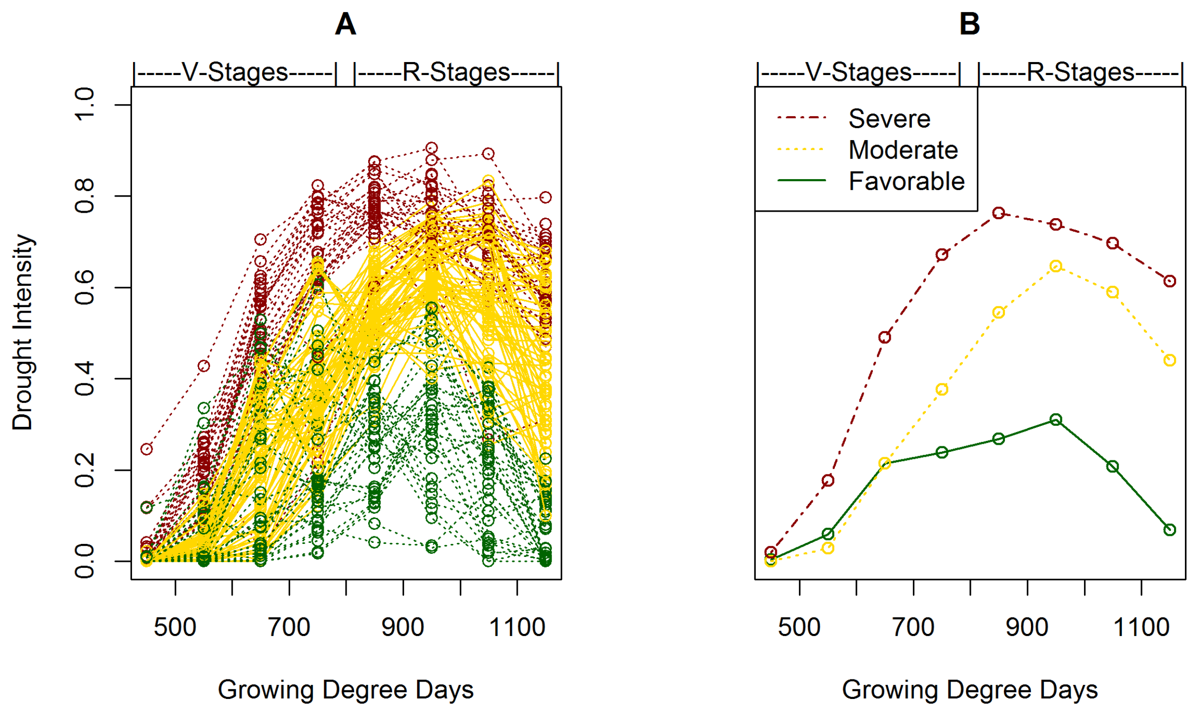

Figure 1. (A) Individual field drought simulations, and (B) typical drought patterns derived from clustering techniques. Drought intensity 0 indicates no drought stress and a value of 1 indicates extreme drought stress. V is vegetative and R is reproductive growth stages.

coatings in dry growing conditions (Clayton et al., 2004), likely because granular promotes nodule formation along the tap and lateral roots rather than clustered near the root crown, where it is often drier.

Sulfur appeared to increase protein in moderately drought stressed environments. Greenhouse studies have shown that N fixation is higher in soils with adequate S (Zhao et. al., 1999), but at the time of writing we know of no regional field trials that address the impact of S on N fixation and protein content in pea.

Phosphorus and K fertilization did not correlate with yellow pea protein. After a comprehensive review of protein formation in pea (Bestwick et al., 2018b), these results are expected. Studies throughout the Canadian prairies found that nutrient management can have significant effects on yield, but protein was often unaffected (McKenzie et al., 2001a, b). This could be in part because pea seed and protein formation occur simultaneously, that is, under adverse conditions both the rate of N transferred to the seed and seed number are lower. The uncertainty in pea protein measurements (see ***Protein Content*** above) contributes to the difficulty in finding statistical differences in management and environment impacts on pea protein.

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