

Grant Code: New

Title: Effect of Micronutrient Application on Winter Wheat Grain Yield, Quality and Nitrogen Use efficiency

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Justification/Rationale:

Micronutrients are essential elements that are used by plants in small quantities. For most micronutrients, crop uptake is less than one pound per acre. In spite of this low requirement, critical plant functions are limited if micronutrients are unavailable, resulting in plant abnormalities, reduced growth and lower yield. In such cases, expensive, high requirement crop inputs such as nitrogen (N) and water may be wasted because they may not be the yield-limiting factors. On the other hand, micronutrients may be yield-limiting for various reasons, such as being unavailable due to soil pH and other micro environmental problems in the soil. All micronutrients, except for molybdenum, are less available at higher soil pH. With many southern Idaho soils characterized as higher-pH soils, micronutrient deficiencies are likely to occur. Furthermore, N use efficiency is affected by the availability of other plant nutrients; and the benefits from applying N can only be maximized when adequate supply of other nutrients is assured (Aulakh and Malhi, 2007). Because of higher yield expectations, lower commodity prices and higher costs of crop inputs, growers should review all potential barriers to top grain production, including micronutrient deficiencies. In production of wheat, which is not a cash crop in most parts of southern and eastern Idaho, it is especially important to maximize the efficiency of all agricultural inputs, due to lower return on investment.

In a previous study, conducted at University of Idaho, soil- nutrient status map for each essential plant micronutrient was produced (Mahler, Robert L., A. R. Halvorson, and Ernest Hugh Gardner. "Micronutrient Mapping in Idaho, Washington and Oregon." Boise, ID: 33rd Annual NW Fertilizer Conference, 1982.). In this study, southern and eastern parts of Idaho are mapped as areas occasionally deficient in Iron (Fe), Boron (B), Zinc (Zn), and Manganese (Mn). Very little new research has been done since then., thus our proposal to re-investigate and confirm, expand or refute the findings is extremely timely. Routine soil testing at Parma R&E Center showed that many fields in Parma area may be low in several micronutrients. On the other hand, it is not uncommon to see wheat response to micronutrients even for fields not identified as micronutrient deficient. Furthermore, interactions of N and micronutrients (synergistic or antagonistic effect) is an important factor to be considered. For example, studies revealed a synergistic effect of N and micronutrients Zn in cereal crops grown on high pH soils similar to those of southern Idaho (Savithri and Ramanathan, 1990). On the other hand, application of N tends to enhance Mn uptake due to creating a more acidic soil conditions. However, N

fertilization may intensify B deficiency in some crops; in some crops, co-application of N and B may have a synergistic effect on yield (Willett et al., 1985; Patel and Golakia, 1986).

Several studies have reported that wheat grain yield and quality have significantly increased where these micronutrients were applied. However, how and why grain yield is increased due to micronutrient application is still not well understood. The interactions of micro and major nutrients, as well as application time are important. Naz et al (2007) showed that soil application of Fe and Zn at 4 mg kg⁻¹ has significant effect on plant available nutrients and nutrient concentration in wheat straw and grain. These studies have also shown that the time of application has significant effects on wheat yield and quality. Tahir et al (2009) found that foliar application of B at boot stage resulted in significantly higher wheat grain yields, compared to tillering, jointing, or flowering. It is expected for wheat varieties to respond differently based on the differences in number of tillers between varieties. There may be genetic variability as to how individual varieties utilize and respond to micro and macro nutrients. Deeper understanding of these issues would be important for producers and may form a basis for general recommendation to growers for how to manage a new variety. In this pilot project, we will initiate our investigation using two spring wheat varieties.

In 2017, we initiated a greenhouse project to study the effect of different micronutrient rates on spring wheat grain yield and quality. We applied Fe, B, Zn, and Mn at low, medium, and high rates at planting.

Results of 1-year greenhouse experiment with 6 replications showed that grain yield, heads per plant, and grains per head were significantly increased by application of micronutrients.

Especially, Mn and Zn application resulted in higher grain yields and yield components. Our survey showed that most wheat growers do not apply micronutrients to wheat in Idaho. A couple of southern Idaho producers stated that application of micronutrients appeared to improve wheat yields in their fields. Because they applied a mix of micronutrients, it is difficult to determine which specific nutrient made the positive yield contribution.

Although some micronutrients and rates had more pronounced effects on yield and yield components of wheat, in most cases micronutrient application offered significant advantage in terms of wheat grain production (Figures 1, 2, and 3). Notably, application of Zn at the lowest rate (trt 8) has significantly improved wheat yield, whereas higher application rates (trts 9 and 10) may have caused Zn toxicity in wheat. On the other hand, application of Mn at higher rate (trt 13) has significantly increased wheat yield, indicating a high demand of wheat to this micronutrient.

In this project, we will assess the effect of Fe, B, Zn, and Mn application at three rates (low, medium, and high), two application methods/times (soil applied at planting, and foliar applied at tillering) on wheat yield and quality. This work will help us to provide Idaho wheat growers with more detailed information on appropriate micronutrient management.

Hypothesis & Objectives:

- 1) To assess the response of winter wheat to four micronutrients (Fe, B, Zn, and Mn) applied at three rates (low, medium, and high), and two application methods/times (soil applied at planting, and foliar applied at tillering) and quantify its' pattern throughout the growing season,

- 2) To explore the potential of using handheld spectroradiometer (ASD FieldSpec 4) to estimate wheat grain yield, quality, and macronutrient and micronutrient content of the grain.

Procedures/Plan of work:

Greenhouse experiment will be established at Parma R&E Center. The experimental design will be a randomized complete block design (RCBD) with six blocks (replicates). The main plot treatments will be four micronutrients (Fe, B, Zn, and Mn) applied at three rates (low, medium, and high, based on the University of Idaho fertilize guide). The subplot treatments will be two application methods/times (soil applied at planting, and foliar applied at tillering). Potting soil will be analyzed for macronutrient and micronutrient content prior to planting to calculate the required fertilizer rates. A no-micronutrient check will be established as a benchmark to assess wheat response to applied micronutrients. Seeds will be germinated, and seedlings will be grown in a climate-controlled greenhouse bay for three weeks (22°C, 12 h photoperiod). Selected seedlings will be then transferred into large trays with 5 rows, 10 plants per row, to a controlled environment greenhouse (25–32°C day/18°C night), with a 16 h photoperiod of irradiance.

Data collection:

The following data will be collected from each pot at Feekes 5 and Feekes 10 growth stages:

- Plant height
- Leaf reflectance using handheld spectroradiometer (ASD FieldSpec 4)

At maturity, the following data will be obtained:

- Heads per plant
- Grains per plant
- Dry weight of grain
- Grain nutrient content (grain will be analyzed for N, and micronutrient content)

Data analysis:

The response of winter wheat yield and quality to applied treatments will be assessed. Nitrogen uptake for each treatment will be calculated by multiplying wheat grain yield by wheat grain total N content. Nitrogen use efficiency will be calculated using the difference method (Varvel & Peterson, 1990).

Duration: 1 years, plus continuation

Cooperation/Collaboration:

The project will be instrumental in providing valuable data for several programs including plant cropping systems, physiology and food science.

Anticipated Benefits, Expected Outcomes and Impacts, and Transfer of Information:

We expect to produce at least 1 professional research publication focused on the response of winter wheat to micronutrients application. Other publications are probable depending on projects findings. As a long-term goal, we anticipate developing a protocol for phenotyping wheat varieties for nutrient use efficiency and/or nutrient x production practice and environment interactions. Such information would offer growers the basis for how to appropriately manage new varieties. Based on our preliminary research results, we plan to establish field experiments at different locations across Idaho in the future to evaluate the response of different wheat

varieties to micronutrients treatments under real farm conditions. The results will be shared at the professional meetings of national, regional, and local level. We plan to produce at least 1 extension publication and will post updates in the quarterly Idaho Crops & Soils Newsletter; will include the project in the on-line education including Twitter and Idaho Crops & Soils News Blog. Acquisition of our own handheld spectroradiometer data collection system will enable us to collect excellent quality data more efficiently.

FY2020

IDAHO WHEAT COMMISSION - BUDGET FORM

Principal Investigator: Sanaz Shafian

Allocated by Idaho Wheat Commission during FY 2018 \$ -

Allocated by Idaho Wheat Commission during FY 2019 \$ -

REQUESTED FY2020 SUPPORT:

Budget Categories	(10) Salaries (staff, post-docs, etc.)	(12) Temp Help	(11) Fringe	(20) Travel	(30) OE	(70) Graduate Tuition/ Fees	TOTALS
Idaho Wheat Commission	\$ 5,000	\$ -	\$ 1,655	\$ 1,000	\$ 10,000	\$ -	\$ 17,655

TOTAL BUDGET REQUEST FOR FY 2020: \$ 17,655

BREAKDOWN FOR MULTIPLE SUB-BUDGETS:

Budget Categories	Sanaz Shafian	Olga Walsh
(10) Salaries	\$ -	\$ 5,000
(12) Temp Help	\$ -	\$ -
(11) Fringe Benefits	\$ -	\$ 1,655
(20) Travel	\$ -	\$ 1,000
(30) Other Expenses	\$ 5,000	\$ 5,000
(70) Graduate Student Tuition/F	\$ -	\$ -
TOTALS	\$ 5,000	\$ 12,655

Total Sub-budgets \$ 17,655

Explanatory Comments:

Fall 2018 Version