Marine and fungal biostimulants (DPI4913 and AF086 Extracts) improve grain yield, plant nitrogen absorption and allocation to ear in durum wheat plants

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ABSTRACT BOOK

6. PARALLEL SESSION 2.2 – CROP NUTRITION AND IRRIGATION

PS-2.2-01

Critical Plant and Soil Phosphorus for Wheat, Maize, and Rapeseed after 44 Years of P Fertilization

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Abstract: Phosphorus (P) fertilizers are essential for crop production but they may affect water quality if managed incorrectly. The objectives of the present study were to (i) evaluate the effect of long-term (> 40 years) P fertilization on the grain yield of winter wheat (*Triticum hybernum* L.), maize (*Zea mays* L.), and rapeseed (*Brassica napus* L.), (ii) validate or establish models of critical P concentration (P_C) based on relationships of shoot P concentration with either shoot biomass or shoot nitrogen concentration, and (iii) assess both plant-based and soil-based diagnostic tools for managing P fertilization. From 2011 to 2014, several crop and soil attributes were measured from a long-term field experiment initiated in 1971 at Agroscope-Changins (Switzerland), with a 4-year rotation and five P fertilization rates (0 to 52.3 kg P ha^{-1} yr^{-1}). Shoot biomass and P concentration of winter wheat in 2011, maize in 2012, and rapeseed in 2014 were measured weekly during the growing period and grain yield was measured at harvest. Soil available P in the 0-20 cm and 20-50 cm soil layers was assessed by three chemical extractions: ammonium acetate EDTA (P-AAE), sodium bicarbonate (P-$NaHCO_3$ or P-Olsen) and CO_2-saturated water (P-CO_2). Long-term P fertilization applied over a period of 44 years affected soil available P, and the shoot growth and grain yield of winter wheat and rapeseed measured in the last four years but had not effect on maize shoot growth and grain yield. The relationships between P_C and shoot biomass or N concentration were very good ($R^2 > 0.85$) for all three crops. The P_C-shoot N concentration model for winter wheat from this study confirmed results from previous studies and can be used for calculating P nutrition index (PNI). Based on the relationship between grain yield and three indicators of soil availability, threshold values for 95% of the maximum yield for winter wheat, maize, and rapeseed were much less than those currently used in the official fertilization guidelines in Switzerland. Our results indicate that the refinement of fertilization requirements with more sensitive diagnostic tools that take into account the long-term effects of continuous fertilization could result in substantial reductions in fertilizer application rates.

Keywords: Critical P concentration, plant-available P, P nutrition index, winter wheat, maize, rapeseed.

PS-2.2-02

Using Stable Isotope Labeling to Investigate the Effect of Green Manure on the Transfer of Zinc and Cadmium from Soil to Wheat

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Abstract: Agronomic biofortification of wheat is a strategy to alleviate zinc (Zn) deficiency in human nutrition. The application of green manure (GM) to soils with low Zn availability can increase the transfer of Zn from soil to wheat, however, this practice can also influence the plant availability of the toxic metal cadmium (Cd). We tested the effect of GM addition on the transfer of Zn and Cd from soil to wheat (*Triticum aestivum* L.).

To obtain GM, sunflower (*Helianthus annus* L.) was grown and labeled with ^{67}Zn and ^{111}Cd in hydroponics. In a pot trial, different quantities of milled sunflower were amended as GM to a soil (Zn: 57 mg kg^{-1}, Cd: 0.2 mg kg^{-1}, pH: 7.7), that either was fertilized (5mg Zn (kg soil)$^{-1}$, denoted as high Zn availability) or not fertilized (low Zn availability). The soil solution was frequently analyzed during wheat growth and the wheat was harvested at flowering and full maturity. Isotope ratios ($^{67/66}$Zn and $^{111/110}$Cd) of purified soil solution and wheat samples were analyzed with a quadrupole inductively coupled plasma mass spectrometer (Q-ICP-MS).

The addition of GM to soil increased wheat root and shoot biomass as well as pH and total nitrogen (TN) in the soil solution. Furthermore, GM increased N concentrations in the wheat shoots and initially also dissolved organic carbon (DOC) in the soil solution.

The average Zn concentration in wheat grains were higher in soils with high than with low Zn availability (high Zn: 101 ± 1.9 mg kg^{-1}, low Zn 28 ± 0.9 mg kg^{-1}). However, the reverse pattern was found for Cd (high Zn: 0.15 ± 0.01 mg kg^{-1}, low Zn: 0.437 ± 0.01 mg kg^{-1}). No significant effect of GM addition on shoot and grain Zn and Cd concentration was observed due to increased biomass (dilution effect). However, the transfer of Zn and Cd into wheat shoots strongly increased with the application of GM to soils with low Zn availability (Zn: from 67 to 121 µg, Cd: from 1.51 to 2.74 µg). In these soils, isotope mass balances revealed that the increased transfer was mainly caused by an indirect effect through solubilization of these metals from the bulk soil (Zn: + 39 µg, Cd: + 1.07 µg), but also directly through the addition of the metals with GM (Zn: + 16 µg, Cd: + 0.16 µg). Our data suggest that the increased soil-plant transfer of Zn and Cd was mainly caused by the decomposition of GM that (i) released organic compounds which solubilized Zn and Cd from the bulk soil, (ii) improved N supply in the initial phase of wheat growth, which led to a better soil exploitation and enhanced root exudates.

This study showed that GM amendments to soils can increase the soil-wheat transfer of Zn but also the transfer of Cd. A combination of agronomic biofortification measures, such as GM addition and mineral Zn fertilization could contribute to a healthier balance of Zn and Cd in wheat grains.
Keywords: Zinc, Cadmium, Wheat, Green Manure, Organic Fertilizer, low Zinc availability, Zinc deficiency, Stable Isotopes

PS-2.2-03

Marine and Fungal Biostimulants (DPI4913 and AF086 Extracts) Improve Grain Yield, Plant Nitrogen Absorption and Allocation to Ear in Durum Wheat Plants

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Abstract: Durum wheat culture requires a high fertilization rate to achieve sufficient protein concentration for semolina and pasta quality, contributing to losses through atmosphere and water. Optimizing plant capacity to use N could help improve its agroenvironmental balance
Our objective was to study the impact of the marine extract DPI4913 and the fungal extract AF086 on growth, N absorption and fluxes in durum wheat.

Three experiments were conducted in France: under standard N

fertilization in a first field (Carbonne, 43.333328 N, 1.33333 E), under varying N supply in a second field (Mervilla, 43.503451 N, 1.472316 E) and under varying water conditions in greenhouse (Toulouse, 43.527272 N, 1.501492 E).

Various ^{15}N labelling experiments were performed at flag leaf fully emerged stage to follow N fluxes until maturity. In Carbonne, $^{15}NO_3^-$ and $^{15}NH_4^+$ were injected in the soil to investigate the effect of biostimulants on allocation to grains of soil mineral N. In greenhouse, some plants were $^{15}NH_4^+$ labelled on the flag-leaf to follow N remobilization. For other plants, flag-leaf was removed at flag-leaf fully emerged stage to characterize flag-leaf implication in N translocation to grains. Flag leaf senescence was studied estimating leaf chlorophyll concentration with the SPAD-502 meter.

Under standard N conditions, biostimulants increased mean grain yield in the field (+1.8 % for DPI4913 and 4.0 % for AF086 in Carbonne; +5.5 % for DPI4913 and +3.9 % for AF086 in Mervilla; not significant). In greenhouse, under water standard conditions, biostimulants increased grain yield (+19.7% for DPI4913, +19.3 % for AF086), total N in plant and in ear (respectively +28.9 % and +44.6 % for DPI4913, +23.3 % and +32.7 % for AF086) and proportion of N in the ear (68.7 % for CONTROL, 77.1 % for DPI4913, 74.2 % for AF086). Biostimulants had no effect under N and water stress conditions.

In the field, DPI4913 increased soil mineral N accumulated in grains at maturity (^{15}N labelling). In greenhouse, flag leaf N was very mobile (^{15}N resorption of 98.2 %). Biostimulants increased the proportion of ^{15}N applied to the flag leaf recovered in grains (40.9 % for Control, 52.5 % for DPI4913, 47.2 % for AF086, p-value=0.09) and accelerated leaf senescence (SPAD-measurements). Flag leaf key-role in grain filling processes was revealed by the fact that flag leaf ablation decreased N amount in grains more than flag leaf N content at the time of ablation (respectively - 5.9 mg and - 2.7 mg).

The increase in N remobilization from flag leaf represented 4.3 % of the supplementary amount of N found in grains for plants treated with DPI4913 and 0.6 % with AF086. Biostimulants mainly increased mineral N root uptake rather than remobilization.

In conclusion, it is suggested that DPI4913 and to a lesser extent AF086 – which promote plant growth, N uptake and remobilization – could be used in standard N and water conditions to optimize durum wheat N fertilization.

Keywords: Biostimulants, Durum Wheat, Nitrogen

PS-2.2-04

Effect of Selenium and Zinc Fertilization on Yield and Mineral Composition of Alfalfa

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Abstract: The mineral composition of alfalfa and other forage crops directly affect the nutritional aspect of livestock and due to the lack of certain elements in their diet, some disease may occur. Microelements in plants are in low concentrations; however, the needs of animals for microelements are usually much higher than the concentration in the plants. Alfalfa has a great demand for mineral nutrition since it produces a large amount of biomass during the year. The soil is the main source of nutrients for plants and in the case when the soil cannot satisfy the plant's needs, natural deficiency of some elements can be compensated by fertilization. A field experiment was conducted in the growing season of 2014 at a private farm in Subotica, Serbia, to investigate the effect of Se and Zn foliar fertilizers on the yield, Se, and Zn content, as well as on the status of other nutrients in alfalfa biomass. Treatments were as follows: control without fertilization, Se in two rates of 5 and 10 g Se ha^{-1} (as Na_2SeO_4), Zn in rates 0.5 and 1 kg Zn ha^{-1} (as $ZnSO_4$) and the combination of these two elements (0.5 kg Zn ha^{-1} and Se 10 g ha^{-1}). Fertilization doses were divided into two applications. The first application was carried out when plant were 10 cm tall, and the second application was seven days after first. The results show that foliar application of Se and Zn had no effect on alfalfa fresh and dry yield or on Ca, Mg, Cu, Fe, Mn, Mo and Co contents in alfalfa biomass. However, Se and Zn fertilizers increased alfalfa Se and Zn contents, respectively. In comparison with the control, significantly higher Se content (by 108%) was measured only on the 10 g Se ha^{-1} treatment. Application of 5 and combination Se+ Zn increased Se content by 70 and 51%, respectively, but not statistically significant. Also, on all treatments with Zn application (0.5 kg Zn ha^{-1}; 1 kg Zn ha^{-1} and Se+Zn) significantly higher Zn content (33.1; 50 and 29.1 mg Zn kg^{-1} DM, respectively) was found compared to control (15.6 mg Zn kg^{-1} DM). In conclusion, Se and Zn fertilizers effectively improved the Se and Zn contents in plant biomass, but in the case of combined application of these elements, the higher dose of Se should be applied.

Keywords: microelements, Se, Zn, foliar fertilization, yield