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Azolla (*Azolla filiculoides*) compost improves grain yield of rice (*Oryza sativa* L.) under different irrigation regimes

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ABSTRACT

The effect of azolla (*Azolla filiculoides*) compost application on the mitigation of the effect of water deficit stress on rice (*Oryza sativa* L.; cv. Hashemi) growth and yield was studied for two growing seasons. Azolla compost was applied in the soil at the rates: 0% (control), 2.5%, 5.0%, and 7.5% of soil weight (w/w) and the effect on rice growth and grain yield was studied under i) continuous flooding (CF), ii) intermittent irrigation and withdrawal at flowering until soil moisture reached field capacity (IWF-100FC), and iii) intermittent irrigation and withdrawal at flowering until soil moisture reached 80% of the field capacity (IWF-80FC). The application of azolla compost at 2.5, 5.0 or 7.5% of soil weight (w/w) resulted in a higher tiller number by 16.0, 37.8, and 38.9%, respectively, in the first year and by 18.5, 27.8, and 30.2%, respectively, in the second year, compared with the non-amended control. Moreover, the application of azolla compost at 2.5, 5.0 or 7.5% of soil weight (w/w) resulted in higher spike weight by an average (over irrigation regimes) of 8.6, 20.8, and 21.1%, respectively, in the first year and 34.7, 50.4, and 52.5%, respectively, in the second year, compared with the non-amended control. The application of azolla compost at 5.0% of soil weight provided the highest grain yield, which was on average 13.8% higher than that of the non-amended control. The increase of grain yield might be due to efficient absorption of nitrogen and possibly of other nutrients with azolla, which promoted production and translocation of assimilates from source to sink. Overall, azolla compost can be regarded as a desirable managerial practice in rice production, particularly under water deficit conditions. Considering the agronomic benefits and water saving, azolla compost could contribute to the development of low-input cropping systems for rice production.

1. Introduction

In rice production, farmers often apply more nitrogen (N) fertilizers than those required for maximum crop growth and grain yield (Peng et al., 2002). However, the continuous use of chemical fertilizers inflicted deleterious effects on soil organic matter reserves, creating further N deficiency. Long-term use of inorganic fertilizers in conventional agricultural systems has led to soil acidification, nutrient imbalance, and loss of organic matter, thus causing disturbances in chemical and biological balance (Bobul'ska et al., 2015; Amanullah and Hidayatullah, 2016 Amanullah et al., 2016), reducing cation exchange capacity of the soil, and enhancing salt accumulation (Matocha et al., 2016). In view of the above problems, application of organic amendments is an environmentally friendly approach for crop fertilization that has been well documented by many researchers (Okur et al., 2016). Organic amendments have a positive role in vigorous crop growth and yield enhancement (Amanullah et al., 2016) and, therefore, a global interest in these substances as alternatives and supplements to chemical N fertilizers has been raised.

Poor levels of organic matter in agricultural soils increased the use of organic wastes as organic soil improvers (organic amendments) to restore soil fertility (Clapp, 2007). Organic wastes enhance soil organic matter, provoke soil microbial activity, improve soil physical characteristics, thereby amending soil structure, and raise aeration and water holding capacity (Plaza et al., 2004; Tejada et al., 2009). In addition to these benefits, organic wastes also represent a major source of

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Table 1
Analysis of the soil and compost used in the pots.

Variable	1st year	2nd year
Soil texture	Clay	Clay
Clay (%)	52	50
Silt (%)	27	26
Sand (%)	21	24
K (ppm)	14.6	191
P (ppm)	9.7	9.0
N total (ppm)	0.171	0.197
Ca (ppm)	267.7	255.5
OM (%)	1.94	1.70
pH	7.4	6.9
Compost analysis		
CEC (Meq/100 g)	55	
K (ppm)	9,300	
P (ppm)	2,200	
N total (ppm)	28,300	
OM (%)	3.35	
pH	6.4	

OM: organic matter; fresh soil from a different field point was used to fill pots in the second year.

nutrients for plants and microorganisms and thereby promote crop production (Tejada and Gonzalez, 2006; Hernandez et al., 2014). The use of composted organic materials as fertilizers can be a good alternative to inorganic fertilization in crop production for a sustainable agriculture (Amanullah and Khan, 2015). Compost is a general term referring to plant-based biowaste or sludge materials used as soil amendments after aerobic decomposition under controlled conditions (Martínez-Blanco et al., 2013). In general, its use on agricultural land improves several parameters, including plant growth and crop yield (Hall and Bell, 2015; Abdou et al., 2016; Padilla et al., 2017), soil carbon concentration (Jaiarree et al., 2014; Shin et al., 2017; Farina et al., 2018), and microbial activity in the soil (Tian et al., 2015; Jindo et al., 2016; Trupiano et al., 2017). This material is the most common organic soil amendment. Composting transforms fresh organic materials (known as feedstocks) into stable forms that release nutrients slowly (Amanullah et al., 2015). Therefore, compost has a unique ability to improve soil characteristics. This material promotes soil structure by increasing the stability of soil aggregates, particularly in sandy soils. However, there is limited information on the influence of compost on rice growth and yield under conventional production systems.

Azolla is an aquatic fern that is usually found in paddy water, streams, and pools in symbiosis with *Anabaena azollae* alga. The importance of azolla for paddy fields was first discovered in northern

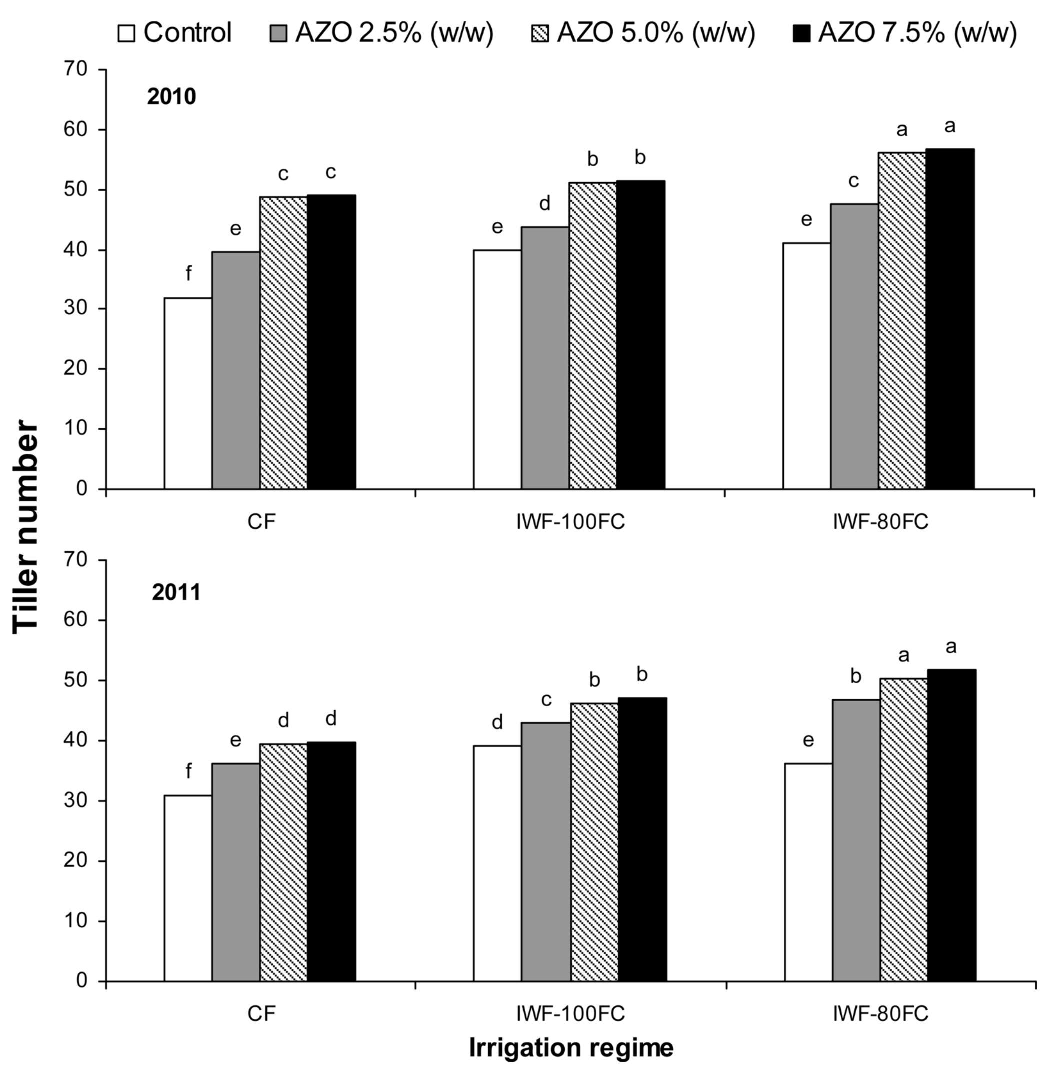

Fig. 1. Number of tillers at the vegetative stage under continuous flooding (CF), irrigation withdrawal at flowering until soil field capacity (IWF-100FC), and irrigation withdrawal at flowering until 80% of soil field capacity (IWF-80FC). Different letters indicate significant differences at $P < 0.05$.