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Influence of Seed Priming on Performance and Water Productivity of Direct Seeded Rice in Alternating Wetting and Drying

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Abstract: Direct seeded rice is promising alternative to traditional transplanting, but requires appropriate crop and water management to maintain yield performance and achieve high water productivity. Present study evaluated the effect of seed priming and irrigation on crop establishment, tillering, agronomic traits, paddy yield, grain quality and water productivity of direct seeded rice in alternate wetting and drying (DSR-AWD) in comparison with direct seeded rice at field capacity (DSR-FC). Seed priming treatments were osmo-priming with KCl (2.2%), $CaCl_2$ (2.2%) and moringa leaf extracts (MLE, 3.3%) including hydro-priming as control. Among the treatments, seed osmo-primed with MLE emerged earlier and had higher final emergence, followed by osmo-priming with $CaCl_2$. Tillering emergence rate and number of tillers per plant were the highest for seed priming with $CaCl_2$ in DSR-AWD. Total productive and non-productive tillers, panicle length, biological and grain yields, harvest index were highest for seed priming with MLE or $CaCl_2$ in DSR-AWD. Similarly, grain quality, estimated in terms of normal grains, abortive and chalky grains, was also the highest in DSR-AWD with MLE osmo-priming. Benefit cost ratio and water productivity was also the highest in DSR-AWD for seed priming with MLE. In conclusion, seed priming with MLE or $CaCl_2$ can be successfully employed to improve the direct seeded rice performance when practiced with alternate wetting and drying irrigation.

Key words: crop establishment; grain filling rate; seed priming; water productivity; yield; direct seeded rice; alternating wetting and drying; grain quality

Water saving and maintaining high grain yield are major challenges to sustainable rice production in irrigated ecosystems threatened with decreasing fresh water availability (Guerra et al, 1998; Belder et al, 2004, 2005). Transplanting or direct seeding are dominant methods of rice establishment in irrigated areas of Asia where paddy fields are usually kept flooded for most of crop growing period (Bouman and Tuong, 2001; Farooq et al, 2011).

With growing water scarcity, direct seeded rice (DSR) becomes viable option providing opportunity to farmers with advantages of reduced labor or water inputs, better use of monsoon rainfall by early crop establishment of direct seeded crop and increasing crop intensification by timely sowing of wheat (Tuong et al, 2000). Yields similar to transplanted puddled rice are harvested in DSR provided effective crop management for irrigation, weeds and nutrients depending on climate and soil types are adopted (Malik and Yadav, 2008; Farooq et al, 2011; Rehman et al, 2013). Dry seeding usually involves growing of rice in non-puddled soils maintained at field capacity 2–4 weeks

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after seeding (Farooq et al, 2011). Although, growing rice with soil moisture near field capacity saves water, but evaporation loss in early established direct seeded crop is so high that similar water productivity for transplanted puddled rice and DSR is reported by many researchers and further declined water productivity in DSR may also occur due to frequent irrigations (Sudhir-Yadav et al, 2011a).

Alternate wetting and drying (AWD) is water management system introduced to reduce water inputs and improve water productivity with non-submerged conditions maintained for several days until cracks appeare in plow sole (Cabangon et al, 2004). AWD is mature technology being adopted in many countries such as Bangladesh, India, Veitnam, the Phillipines and China with reported stable or even increased yield (Li and Barker, 2004).

Grower's interest is increasing for AWD in DSR because it economize water use by lowering evaporation loss in absence of continuous ponding, and prolonged duration between irrigations may help to schedule water management in DSR. For instance, DSR-AWD reduced irrigation water use by 30%–50% than transplanted puddled rice, maintaining similar grain yield. It was suggested that AWD can successfully maximize DSR grain yield and improve water productivity, when crop is irrigated at or below -20 kPa at 20 cm depth instead of daily irrigation to keep the soil saturated (Sudhir-Yadav et al, 2011a, b). Similarly, AWD with system of rice intensification improved morphological and physiological responses resulting in high grain yield and water productivity as compared to transplanted rice (Thakur et al, 2011).

Furthermore, uniform and vigorous crop stand in rice dry seeding is achieved by seed priming (Farooq et al, 2011). For rice priming, seeds are soaked in water or different salt solutions to complete pre-germination metabolic processes and re-dried or surface dried to permit routine handling (Farooq et al, 2006; Rehman et al, 2011b). Seed priming, a cost effective technology, has been successfully employed in different rice production systems, such as dry seeded rice, to improve performance in drought prone areas (Du and Tuong, 2002), seedling establishment under submerged condition by anaerobic germination tolerance (Ella et al, 2011; Sarkar, 2012), crop competitive ability against weeds in aerobic rice system (Anwar et al, 2013), earlier phenological development and higher yields under aerobic (Farooq et al, 2006; Rehman et al, 2011a), and saturated system of rice intensification conditions (Ahmad et al, 2013). Nonetheless, performance of seed priming in dry seeded rice with AWD (DSR-AWD) and further changes in tillering and yield formation when switched towards AWD from field capacity soil moisture are not studied. In addition, in present study, use of moringa leaf extracts being rich in zeatin, a naturally occurring cytokinin (Yasmeen et al, 2014), has been also exploited as organic source for rice seed priming together with inorganic osmo-tica ($CaCl_2$ and KCl). Thus, considering the potential benefits of DSR, AWD and seed priming, this study quantified the effect of seed priming in DSR-AWD on rice tillering, paddy yield formation and produce quality in comparison to dry seeding with soil moisture at field capacity. For farmer's practicability, benefit cost ratio and water productivity in both systems were also determined.

MATERIALS AND METHODS

Rice materials

Fine grain aromatic rice cv. Super Basmati obtained from Rice Research Institute, Kala Shah Kakoo, Sheikhupura, Pakistan, was used as seed source. The experiment was conducted at Experimental Research Station, University of Agriculture, Faisalabad-Pakistan during the summer of 2010. The experimental soil was sandy clay loam with pH 8.4, total exchangeable salts 0.43 dS/m, 1.23% of organic matter, total nitrogen 0.77 g/kg, available phosphorus 20 mg/kg, exchangeable potassium 104 mg/kg and exchangeable sodium 2.8 mg/kg. The experimental design was randomized complete block with split plot arrangement keeping production systems in main plots and seed priming treatments in sub-plots.

Experimental treatments and cultivation managements

For direct seeding, seedbed was prepared by ploughing field five times each followed by leveling with tractor drawn implements. The required soil moisture of field capacity was achieved by pre-saturation irrigation, and previous crop was wheat. Seeds osmo-primed with $CaCl_2$, KCl and moringa leaf extracts (MLE) including hydropriming as control were seeded in 22 cm spaced rows at field capacity level using single row hand drill. Rice was sown on 19 July 2010 with seed rate of 75 kg/hm^2. After soil analysis, 150 kg/hm^2 N, 90 kg/hm^2 P_2O_5 and 70 kg/hm^2 K_2O were applied using urea (46% N), diammonium phosphate (18% N, 46% P), sulphate of potash (50%