EFFECT OF WATER-SAVING IRRIGATION PRACTICES ON FATE OF INORGANIC NITROGEN, PLANT GROWTH AND YIELD IN RICE

SHAH MOINUR RAHMAN

Global demand for water has risen sharply over the last century. In addition, irrigated agriculture accounts for about 70 percent of freshwater withdrawals throughout the world. Increase of water scarcity will result in the decline of irrigated areas, which will further influence the agricultural production. Decreasing water availability for agriculture threatens the productivity of agricultural crops and ways must be sought to save water and increase the water productivity of agricultural crops. Many studies on water-saving irrigation managements have been conducted such as (1) mid-season drainage, (2) intermittent irrigation followed by shallow water management (3) shallow water depth. (4) alternate wet and dry periods throughout the crop cycle, (5) internal drainage, (6) continuous soil saturation and others. However, during the aerobic period of alternate flooding, NH_4-N is rapidly nitrified due to the availability of oxygen in the soil pores. Nitrification provides the substrate (NO_3-N) for denitrification when the soil is re-flooded, resulting N losses increased. On the other hands, the drying phase of rhizosphere will help root growth and its sustainability for water transport to rice plants even under low soil moisture conditions. The fate of N fertilizer, rice growth and yield under water-saving management practices is still poorly studied. Therefore, this study was conducted to examine the impacts of different irrigation practices on the N uptake and root activities and too evaluate an irrigation system to save water and grain yield of rice.

In experiment I, short term drainage on root physiological activities, N uptake and yield of rice in North East Japan were compared in 2009 and 2010. In experiment II, long term drainage and controlled irrigation effect on the fate of inorganic N, growth and yield in rice were investigated in 2011, 2012 and 2013.

Experiment I

The amount of soil moisture percentage in MSD or EMSD was similar in 2009 and 2010. The dryness tendency was higher in both EMSD20 and EMSD10 than MSD and Flooded treatments in 2009 and 2010.

N uptake was higher in MSD at 41 DBH than EMSD10 and Flooded treatment in 2010 while 46 and 36 DBH was similar among the treatment. N uptake in the year 2009 at 51, 46, 41 and 31 DBH showed the similar trend among the treatment. Therefore, the trend of N uptake in plant was larger in MSD treatments during the drainage period compare to EMSD and conventional practices.

The respiration rate of rice root was significantly (5% level) higher in MSD than EMSD20 and Flooded treatment at 31 DBH in 2009. The overall trend of root respiration rate was MSD followed by EMSD20, followed by Flooded. Rice root respiration rate was same among the treatments at 38 DBH and 11 DAH in the year 2009. Similarly, respiration rate was also significantly higher in MSD than EMSD10 and Flooded treatment at 36 DBH in 2010. Other respiration rate at 24 DBH and 70 DAH stages had no difference observed among the treatment in 2010. Therefore, the trend of root respiration rate was higher in MSD than EMSD and Flooded treatments at different growth stages and thus, revealed that MSD drainage had some positive responses to respiration rate.

The xylem exudation rate was higher in MSD than EMSD and Flooded treatments during 38 DBH and 11 BAH in 2009. Similar trend of xylem exudation rate was observed in 2010 at 37, 23 DBH and 8 DAH compare to the conventional practices.

Root physiological activities in EMSD20 and EMSD10 were lower than MSD and higher than Flooded treatments.

Yield and yield components data mentioned that drained duration (EMSD20 or EMSD10), drained timing (EMSD and MSD) and drainage had no adverse effect on yield.

The grain yield of EMSD20 was 594 gm^{-2} which was larger than MSD but smaller than Flooded treatment in 2009. On the other hand, the yield of EMSD10 (623 gm^{-2}) was smaller than MSD and Flooded treatments in 2010.

Experiment II

The total amounts of irrigation water used from 20 to 57 DAT in the Flooding, SWD and Non-flooding treatments were 0.87, 0.54 and 0.25 m^3m^{-2}, respectively. The total amount of irrigation water used from 57 to 99 DAT were 0.84, 0.57 and 0.58 m^3m^{-2} in the Flooding, SWD and Non-flooding treatments, respectively, and the total amounts of irrigation water used from 20 to 99 DAT, were 1.71, 1.11 and 0.83 m^3m^{-2} in the Flooding, SWD and Non-flooding treatments, respectively.

The maximum soil temperature was lower and minimum soil temperature was higher for the Flooding than for the SWD and Non-flooding treatment in 2011 and 2012.

Based on the field observations, although the differences in the soil moisture percentage between the treatments were very small, the dryness trend was higher for the Non-flooding treatments in 2011 and 2012. This study found that, the soil moisture percentage in Non-flooding treatments was approximately 40.

Active soil iron (Fe^{2+}) content was same for all the treatments at 14, 24 and 36 DAT while significance differences in the amount of Fe^{2+} was observed for Non-flooding treatment at the 57 DAT.

Total NH_4-N contents and exchangeable NH_4-N derived from fertilizer were similar for all the treatments at 20, 24 and 48 DAT in 2011 and 24, 36 DAT in 2012, and the differences were not statistically significant.

Neither the plant heights nor the tiller numbers were significantly different at maximum tillering and heading stages in the year 2011 and 2012.

The xylem exudation rate was significantly higher for the SWD treatment (83.9 mg $tiller^{-1}$ h^{-1}) than for the Non-flooding (52.5 mg $tiller^{-1}$ h^{-1}) at tillering stages in 2011 and 2012. Similarly, SWD treatment had higher consistent xylem exudation rate (99.0 mg $tiller^{-1}$ h^{-1}) and the Flooding treatment (98.0 mg $tiller^{-1}$ h^{-1}) at heading stage in the year 2011 and

2012.

The above-ground biomass at maximum tillering (48 DAT in 2011 and 2012) was similar for the all treatment. The above-ground biomass (950.9 g m^{-2}) in the SWD was significantly higher than those in the Flooding (845.5 g m^{-2}) and Non-flooding (860.7 g m^{-2}) treatments at heading stage in the year 2011 and 2012.

Similarly, the N uptake at maximum tillering (48 DAT in 2011 and 2012) was similar for the all treatment. The N uptake (10.5 g m^{-2}) in the SWD was significantly higher than those in the Flooding (9.0 g m^{-2}) and Non-flooding (8.6 g m^{-2}) treatments at heading stage in the year 2011 and 2012.

Recovery efficiency of fertilizer N at maximum tillering stage did not vary by treatment while varied by treatment at heading stage in the year 2011 and 2012. SWD had the highest recovery efficiency (37.9%) than the Flooding (30.5%) and Non-flooding (32.0%) treatment, while the recovery efficiencies of Flooding (30.5%) and Non-flooding (32.0%) treatments were not significant different. Similarly, top-dressing recovery efficiency was higher for the SWD (54.2%) than for Non-flooding (43.5%) and Flooding (45.4%) treatment in the year 2011 and 2012.

The releasing pattern of N in sigmoid type slow-release N fertilizer and recovery efficiency in Flooding and Non-flooding treatment was low at each growth stage comparing SWD treatments while that value was not comparable to other studies.

In this experiment, significant difference in yield was observed among the treatments and SWD had the greater influenced of the yield than other two treatments. The yield obtained with SWD (6228 kg ha^{-1}) was significantly higher than Flooding (5774 kg ha^{-1}) and Non-flooding (5660 kg ha^{-1}) treatments. Thus, SWD can be concluding the following results:

i) An increase in spikelet’s number and subsequently the spikelet’s per unit area is a good indicator of increase potential for grain yield with increase in spikelet numbers.

ii) An increase in N absorption by plant and recovery efficiency of fertilizer N of paddy field at critical growth stages. Generally, bigger N demand by rice fall at mid-tillering, PI and flowering stage.

In conclusion, water-saving irrigation practices such as MSD, Non-flooding and SWD can save irrigation water while the fate of N fertilizer, N use efficiency and yield of rice were not reduced compared to the conventional irrigation practices.