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DIFFERENT ESTABLISHMENT METHODS OF ASSESSMENT OF ENERGETICS OF RICE WITH IRRIGATION AND NITROGEN MANAGEMENTPRACTICES

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A B S T R A C T

A field experiment was conducted on a clay loam soil at Indian Institute of Rice Research (IIRR) formerly Directorate of Rice Research (DRR), Rajendranagar, Hyderabad, Telangana during the *kharif* seasons of 2015 and 2016 to study the "Assessment of production potential of rice with irrigation regimes and nitrogen management practices under different establishment methods". The treatments consisted of three establishment methods Normal transplanting (NTP), Mechanized System of Rice Intensification (MSRI) and Drum seeding (DS) as main plot treatments, two irrigation regimes continuous flooding, Alternate wetting and drying at 5cm depletion as sub plot treatments and two nitrogen management practices (RDN - 100 % through inorganic and RDN - 75 % inorganic and 25 % organic) as sub-sub plot treatments summing upto 12 treatment combinations laid out in split-split plot design with three replications. Normal transplanting method required higher input energy. The gross energy output, net energy, energy use efficiency, energy productivity and energy intensity in economic terms recorded were significantly higher in MSRI than other establishment methods. Continuous flooding treatment recorded higher input energy, gross output energy and net energy. Energy use efficiency, energy productivity and energy intensity in economic terms recorded were higher with irrigation at 5cm depletion and these were at par with flooding method. The highest input energy consumed was with RDN (75 % inorganic and 25 % organic) management practice. The gross energy output, net energy, energy use efficiency, energy productivity and energy intensity in economic terms recorded were significantly higher with nitrogen application through RDN (75 % inorganic and 25 % organic) than inorganic N source.

Introduction

Rice [*Oryza sativa* (L.)] is one of the most important staple food crops in the world. In Asia, more than two billion people are getting 60-70 per cent of their energy requirement from rice and its derived products. In India, rice occupies an area of 44.10 million ha with an average production of 105.3 million tones with a productivity of 2.38 t ha^{-1} against the world's average yield of 4.36 t ha^{-1} (FAO STAT, 2014). Manual transplanting is the most common practice of rice cultivation in South and South East Asia. In India, 44 per cent area (19.6 million ha) is under transplanting in irrigated lowlands. It is not only time consuming, but also laborious requiring about 30 man days ha^{-1} besides causing drudgery to women folk. To overcome these difficulties transplanting can be substituted by direct seeding which could reduce labour needs by more than 20 per cent. As a solution to labour shortages and to reduce the production costs of rice farming, mechanization is one of the solutions. Water and nitrogen are two of the most important inputs in rice production.

Saving water in rice production is crucial for food security in Asia, where more than 75% of the rice comes from the irrigated system. Among the various methods of water-saving irrigation, the most widely adopted is alternate wetting and drying (AWD) irrigation (Li *et al.,* 2003). The AWD irrigation aims in reducing water input and increasing water productivity while maintaining grain yield (Tabbal *et al.,* 2002). The combined use of organic manures and inorganic fertilizers help in maintaining yield stability and application of farm yard manure (FYM) to soil improves the physical, chemical and biological properties thereby improving the nutrient availability in soils.

Materials and Methods

The field experiments were carried out during *kharif*, 2015 and 2016 at Indian Institute of Rice Research (IIRR) formerly Directorate of Rice Research (DRR) farm, Rajendranagar, Hyderabad. The experimental soil was clay loam in texture, alkaline in reaction. The fertility status of the experimental soil was low in organic carbon and available nitrogen, medium in available phosphorous and high in potassium.

The experiment was laid out in a split-split plot design with three establishment methods Normal transplanting (NTP), Mechanized System of Rice Intensification (MSRI) and Drum seeding (DS) as main plot treatments, two irrigation regimes continuous flooding, Alternate wetting and drying at 5cm depletion as sub plot treatments and two nitrogen management practices (RDN - 100 % through inorganic and RDN - 75 % inorganic and 25 % organic) as sub-sub plot treatments summing upto 12 treatment combinations and replicated thrice. The experimental field was provided with irrigation channels as shown in layout plan and the individual plots were demarcated by bunds In drum seeding sprouted seeds were sown with manually operated rice drum seeder. Mechanical transplanting requires a special method of raising seedlings called "Dapog" or "mat type" seedlings. Recommended dose of nitrogen was applied through urea and organic source through vermicompost. The regular common irrigation practice was followed till 40 DAS for proper establishment. After 40 DAS, the irrigation schedules were adopted as per the treatment requirements. The energy input was calculated as the summation of energy requirement for labour, farm machineries, seed, fertilizers and irrigation used in system and expressed in (GJ ha^{-1}).

Output energy from the main product (grain) and by product (straw) was calculated by multiplying the amount of production and its corresponding energy equivalent. Expressed as (GJ ha^{-1}). The energetic indices were calculated by using the following formulas.

$$\text{Energy efficiency} = \frac{\text{Gross energy output (GJ ha}^{-1})}{\text{Total energy input (GJ ha}^{-1})}$$

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$$\text{Energy productivity} = \frac{\text{Grain + Straw yield (kg ha}^{-1})}{\text{Total energy input (MJ ha}^{-1})} \text{ (kg MJ}^{-1})$$

$$\text{Energy intensity in Economic terms} = \frac{\text{Gross energy output (MJ ha}^{-1})}{\text{Cost of cultivation (₹ha}^{-1})} \text{ (MJ ₹}^{-1})$$

Net energy = Gross energy output (GJ ha^{-1}) – Energy input (GJ ha^{-1})

Results and Discussion

Input energy (GJ ha^{-1})

The input energy required was lower in drum seeding (16.71, 17.02 and 16.86 GJ ha$^{-1)}$ and MSRI (17.77, 18.08 and 17.92 GJ ha$^{-1)}$ than NTP (18.23, 18.54 and 18.38 GJ ha$^{-1)}$ during 2015, 2016 and in pooled means, respectively. Though the machine transplanter consuming high input energy in MSRI whereas labour energy used was minimum, but in case of NTP using of more number of labours will increase the total input energy used hence more input energy was used in NTP than other establishment methods. Continuous flooding (18.05, 18.36 and 18.20 GJ ha^{-1}) treatment recorded higher input energy followed by irrigation at 5cm depletion with AWD (17.29, 17.66 and 17.48 GJ ha^{-1}) during 2015, 2016 and in pooled means, respectively. This was mainly due to higher number and amount of irrigations given in saturation than irrigation at 5 cm depletion. The highest input energy was recorded in RDN (75 % inorganic and 25 % organic) 18.31, 18.87 and 18.57 GJ ha^{-1} as compared to other nitrogen management practices. This was due to vermicompost had higher input energy than inorganic fertilizer sources. These results are in conformity with the findings of Yadav *et al.*, (2013). The lowest input energy was 16.83, 16.89 and 16.86 GJ ha^{-1} in RDN through inorganic source shown in Table 1.

Gross output energy (GJ ha^{-1})

Mechanized system of rice intensification recorded significantly higher gross output energy during both the years of study and in pooled means (Table 1). The MSRI had 4.26, 3.38 & 3.83 % and 10.78, 7.64 & 9.24 % higher gross output energy over NTP and DS during 2015, 2016 and in pooled means, respectively. Owing to higher grain and straw yield in MSRI led to higher gross output energy. These results could be substantiated with the findings of Jayadev *et al.,* (2010). Continuous flooding method of irrigation registered significantly higher gross output energy (180.67, 177.92 and 179.27 GJ ha^{-1}) which was at par with irrigation at 5 cm depletion (179.76, 175.72 and 177.74 GJ ha^{-1}) during 2015, 2016 and in pooled means, respectively. Higher gross output energy was attributed to higher grain and straw yields in saturation. Application RDN through 75 % inorganic and 25 % organic (184.45, 180.74 and 182.59 kg ha^{-1} in 2015, 2016 and in pooled means, respectively) recorded higher gross energy output over other nitrogen management practice. The higher gross output energy with RDN through 75 % inorganic and 25 % organic was attributed to maximum grain and straw yield during both the years of study. Ravi *et al.*, (2007) and Alam *et al.*, (2013) also found similar results.

Net energy (GJ ha^{-1})

Mechanized system of rice intensification recorded significantly higher net energy (171.96, 165.49 and 168.72 in 2015, 2016 and in pooled means, respectively) as compared to NTP and DS. The per cent increase in net energy in MSRI (4.92, 3.53 and 4.26 %) and

Normal transplanting method required higher input energy. The gross energy output, net energy, energy use efficiency, energy productivity and energy intensity in economic terms recorded were significantly higher in MSRI than other establishment methods. Continuous flooding treatment recorded higher input energy, gross output energy and net energy. Energy use efficiency, energy productivity and energy intensity in economic terms recorded were higher with irrigation at 5cm depletion and these were at par with flooding method. The highest input energy consumed was with RDN (75 % inorganic and 25 % organic) management practice. The gross energy output, net energy, energy use efficiency, energy productivity and energy intensity in economic terms recorded were significantly higher with nitrogen application through RDN (75 % inorganic and 25 % organic) than inorganic N source.

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