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Research Article

Influence of Adopting Nutrient Management Practices in Rice Crop (*Oryza sativa* L.) Under Different Establishment Methods

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ABSTRACT

The present investigation was carried out to find the effect on growth and yield of Rice (Oryza sativa L.) by adopting nutrient management practices under different establishment method. The experiment was conducted in A_2 block at N. E. Borlaug Crop Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar, District Udham Singh Nagar, Uttarakhand. The treatments consisting three establishment methods in main plots and five nutrient management practices in sub plots (fifteen combination) was laid out in split plot design (SPD) with three replications. The result revealed that, the values for plant height were not influenced by establishment methods however tallest plants were obtained under transplanting method at harvest. Application of 150%RDF led to tallest plants but various nutrient management treatments could not establish significant effect on plant height at harvest. Number of shoots/m^2 was significantly less due to transplanting method. RDF+5tFYM/ha, RDF and RDF (LCC based N) caused similar but significantly more number of shoots/m^2 compared to remaining treatments at harvest.The lowest sterility (%) was found in transplanting method and higher in aerobic and wet-direct seeded methods. RDF+5tFYM/ha recorded lower sterility (%) compared to remaining treatments. Transplanting method of establishment and application of RDF+5t FYM/ha being at par with RDF (LCC based N) significantly increased the yield attributes, grain yield, straw yield and biological yield.

Key words: *Rice Crop (Oryza sativa L.), Nutrient Management, Establishment Methods.*

INTRODUCTION

Rice (*Oryza sativa* L.) is recognized as a supreme commodity to mankind, because it is truly a life, a culture, a tradition and a means of livelihood to millions of people. It is also an important staple food providing 66-70 per cent body calorie intake of the consumers which are about 50 per cent of the world's population residing in Asia, where 90 per cent of the world's rice is grown and consumed. In India, it is estimated that the demand, of rice will be of 140 million tonnes in 2025.

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At present, India has 42.41 million hectare of land under rice cultivation with a production of 106.04 million tonnes (Economic survey of India, 2014). To assure food security in the rice consuming countries 50 per cent increase in the rice production is required by 2025, which will have to be produced on reduced land, labour and chemicals (Zheng et al., 2004).

Alteration in rice establishment methods can be used to reduce cost of cultivation even the productivity remains the same or increased.Transplanting method is the common practice of rice establishment in most of the irrigated areas in the world. Due to resource constraints, especially water and labourers, dry seeding under dry condition is now emerging new trend in rice cultivation. Aerobic method of rice cultivation, where fields remain unsaturated throughout the season like an upland crop offers an opportunity to produce rice with less water and tillage operations and rapid reduction in total water usage from 27-51% with increased productivity of 32-88% (Bouman et al., 2002). This practice is an alternative to the conventional rice cultivation system in regions where rainfall and fresh water resources are limited and becoming popular as it reduces the cost of production, by reduced irrigation and realizing good yields and water productivity**.** Input water savings of 35-57% can be achieved for dry seeded rice sown into non-puddled fields (Singh et al., 2003). Another method of direct seeding is wet-direct seeding, as it involves puddled condition for sowing pre-germinated rice seeds, in well puddle, well levelled and recently drained seed beds. (Tuong & Bouman, 2003).

Nutrient management is also a major component of soil and crop management system in rice. Knowing the required nutrients for all stages of growth and understanding the soil's ability to supply them is critical to profitable crop production. Among major nutrients like NPK, nitrogen is a key nutrient of rice production and requires proper application management (Nedunchezhiyan & Laxminarayan, 2011). In estimation it was found that 24 per cent of the increase in Asian rice was attributed to use of fertilizers, mainly nitrogen (Baker et al., 1985), (Alam et al., 2005). Precise application of N fertilizer based on plant need and location in the field greatly improves fertiliser use efficiency in rice and the optimum use of N can be achieved by matching N supply with crop demand. Leaf colour intensity is directly related to leaf chlorophyll content which, in turn, is related to leaf N status. The concept is based on results that show a close link between leaf chlorophyll content and leaf N content (Alam et al., 2005). Thus, one of the N management approaches is estimating the leaf N concentration based on measurement of leaf greenness. Among the different tools available to measure the leaf greenness, the non-destructive measurement of leaf green colour intensity using Leaf Colour Charts (LCC) is gaining importance (Ravi et al., 2007). Also indiscriminate use of high analysed fertilizers often leads to imbalance in nutrients especially micronutrients, which ultimately cause deterioration of soil physio-chemical properties and steadily decreases crop yield (Gupta et al., 2002). Continuous use of inorganic fertilizers has brought loss of vital soil fauna and flora. This calls for the development of integrated nutrient management systems (INMS) where reduced amount of chemical fertilizer is supplemented through organic sources for improvement and maintenance of soil fertility leading to sustained crop production, as organic manures modify the soil physical behaviour and increases the efficiency of applied nutrients (Pandey et al., 2007).

The use of farmyard manure and compost to improve rice yield is recognized by farmers for many centuries. By recycling of all the organic wastes, China has been able to grow in a sustainable manner for decades with no micronutrient problems and has provided healthy environment to their people (FAO, 1977). In India too, there is tremendous potential of recycling organic waste (Gaur et al., 1990).

MATERIALS AND METHODS

The experiment was conducted in A_2 block at N. E. Borlaug Crop Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar, District Udham Singh Nagar, Uttarakhand during the *kharif* season of 2015. This experiment was laid out in spilt-plot design keeping establishment method in main plots and nutrient management practices in sub-plots with three replications. The details of treatments in this study are given below:

Treatments:- (split plot design)

Establishment methods (Main Plot)

T1 : Aerobic (Direct seeded rice)
T2 : Wet-direct seeding
T3 : Transplanting

Nutrient management practices (Sub Plot)

F1 : RDF (Recommended dose of fertilizer) (120:60:40) N: P_2O_5: K_2O kg/ha

F2 : 75%RDF (90:45:30) +FYM/ha (Equivalent to 25% N dose)

F3 : 150% RDF (180:90:60)

F4 : RDF (90:60:40) (LCC based N application)

F5 : RDF (120:60:40) + 5 tonnes FYM/ha (Location specific)

Note: - In Direct seeding and Wet direct seeding N was applied as ¼ basal + ½ tillering + ¼ PI and in Transplanted rice N was applied as ½ basal + ¼ tillering + ¼ PI.

Variety : HKR-47, Replication : 3, Treatments : 15, Total No. of plots : 45

Observation and sampling procedures

i). Pre-harvest crop growth studies:- In aerobic plot on one side, leaving the two rows as border, one meter row length of crop in the third row was marked from north and south direction for recording observations on the plant height, number of shoots and post-harvest studies. Also in wet-direct seeded plot, 0.5m x 0.5m area in each corner after leaving 0.5m border on both side of the plot were marked for recording above observations. In transplanted rice plots total 16 hills, 4 from each corner in third and fourth row were marked for observations of plant height, number of shoots and post-harvest studies. **ii). Plant height:-**The height of four randomly selected plants in net plot area at 30, 60, 90 days after sowing/ transplanting and at maturity was measured with a meter scale from the ground level to the tip of top most leaf at initial stage of crop growth and after heading up to the tip of the top most panicles, within one meter row length marked for observation in the beginning in each plot in aerobic rice plot and in wet-direct seeded plot from an area half meter quadrate marked for observation. While in transplanted plots, from the randomly selected 4 hills located at four corners plant height was measured with a meter scale. The mean of 4 plants was reported as cm/plant at 30, 60, and 90 days after sowing/transplanting and at maturity. **iii). Number of shoots:-**Total number of shoot were counted from sampling area marked for observation at 30, 60 and 90 days after sowing/transplanting and at maturity and then expressed as number of shoots/m^2.

Post- harvest studies (Yield attributing characters):-

i). Number of panicles:- The number of panicles was counted from the marked 2 m row length in aerobic, half meter quadrate marked in wet-direct seeded and 16 hills marked in transplanted rice and were expressed as number of panicles/m^2. **ii). Panicle length:- At maturity of the crop, 10 representative panicles were randomly selected from sampling area and length of each panicle was measured starting from the base (last node of the culm) of the first branch of rachis to the top of the panicle and is expressed in cm/panicle. iii).Total number of spikelets:-** The crop plants from marked sampling area were taken, for study after counting the panicle number. All the filled and unfilled spikelets were separated manually and weighed. A sample of 250 grain filled and 500 grain unfilled spikelets were weighed separately from each plot and converted to 1000-grain weight. The number of filled and unfilled spikelets was obtained by the following formula:

$$\text{(a) Number of filled spikelets /m}^2 = \frac{\text{Weight of filled spikelets /m}^2}{\text{Weight of 1000 Filled spikelets}} \times 1000$$

$$\text{(b) Number of unfilled spikelets /m}^2 = \frac{\text{Weight of unfilled spikelets /m}^2}{\text{Weight of 1000 unfilled spikelets}} \times 1000$$

$$\text{(c) Total number of spikelets/m}^2$$
$$= \text{Number of filled spikelets/m}^2 + \text{Number of unfilled spikelets/m}^2$$

(d) Sterility percentage was calculated by following formula:

$$\text{Sterility (\%)} = \frac{\text{Number of unfilled spikelets/m}^2}{\text{Total number of spikelets/m}^2} \times 100$$

RESULTS AND DISCUSSION

Plant height

The values for height (cm) recorded at various stages are presented in Table 1.

The rice grew taller as the age of crop advanced and the height was similar in wet-direct seeded and aerobic methods, but increased significantly under transplanting method compared to other methods. Also, at all other stages the transplanting method of rice cultivation was significantly superior over other establishment methods in respect of plant height except at maturity. At maturity, these differences were not found however, the shorter plants were recorded in aerobic method at all the crop growth stages.

Among nutrient management treatments no significant difference in plant height was observed at all the growth stages except at 60 DAS/DAT where RDF+5t FYM/ha, being *at par* with RDF (LCC based N), caused significant increase in plant height compared to other treatments.

Table 1: Plant height (cm) as influenced by the treatments at different crop growth stages

Treatments	Days after sowing/transplanting			
	30	**60**	**90**	**Maturity**
Establishment methods				
Wet direct seeded	36	71	91	107
Aerobic	36	69	90	105
Transplanted	57	80	95	112
S.E.m ±	0.9	0.7	0.8	2.0
C.D. (5%)	4	3	3	Ns
Nutrient management				
RDF	42	72	92	107
75%RDF+FYM(equiv.to25%N)	43	70	91	107
150%RDF	45	73	94	110
RDF(LCC based N)	43	75	91	109
RDF+5tFYM/ha	43	78	92	107
S.E.m ±	0.9	0.5	0.8	0.8
C.D. (5%)	Ns	2	Ns	Ns

Number of shoots

Data pertaining to number of shoots/m^2 at various stages are given in Table 2 .At 30 days stage, significantly more shoots were observed in transplanting method compared to remaining methods while at other stages wet-direct seeded and aerobic methods remained *at par* but resulted in significantly more shoots. Due to different nutrient management treatments no effect on the number of shoots was noticed at 30 days stage while at 60 and 90 days stages different nutrient management treatments differed significantly. At 60 days stage, RDF treatment caused significantly more shoots compared to remaining treatments. At 90 days stage RDF+5tFYM/ha being *at par* with RDF and RDF (LCC based N) treatments caused significant enhancement in number of shoots compared with other treatments.

The interaction between establishment methods and nutrient management with respect to number of shoots/m^2 was significant at all the stages.

At 30 days stage under aerobic method the treatment RDF being *at par* with 75%RDF+FYM (equivalent to 25%N), resulted in significantly more shoots but these differences disappeared under wet-direct seeded method. Under transplanted method RDF resulted in significantly less shoot compared to other treatments which were statistically similar. Under all the nutrient management treatments, number of shoots was significantly more in transplanting method compared to remaining methods.

At 60 days stage, under wet-direct seeded method, the treatment RDF (LCC based N) being *at par* with RDF+5tFYM/ha and RDF, caused significantly more shoots compared to remaining nutrient management treatments. Under transplanting method, RDF+5tFYM/ha being at par with RDF (LCC based N) and RDF, recorded significantly more shoots compared to remaining treatments. Under aerobic method, these differences due to nutrient management treatments disappeared.

At 90 days stage, under aerobic method, RDF resulted in significantly more shoots compared to remaining nutrient management treatments while under wet-direct seeded method 150%RDF caused significantly less shoots compared to other nutrient management treatments, which were statistically similar. Under transplanting method, RDF+5tFYM/ha caused significantly more shoots compared to remaining treatments while RDF (LCC based N) caused significantly more shoots compared to 75%RDF+FYM (equivalent to 25%N) and 150%RDF. Under all the nutrient management treatments the number of shoots was similar in wet-direct seeded and aerobic methods but significantly more than transplanting method while at maturity under aerobic method the number of shoots were similar due to 150%RDF, RDF (LCC based N) and RDF+5tFYM/ha but significantly more than 75%RDF+FYM (equivalent to 25%N). Under wet-direct seeded method RDF caused significantly more shoots compared to remaining nutrient management treatments. Also 75%RDF+FYM (equivalent to 25%N) and 150%RDF caused similar number of shoots but significantly less than RDF (LCC based N) and RDF+5tFYM/ha. Under transplanting method RDF+5tFYM/ha caused significantly more number of shoots compared to all other nutrient management treatments. Under all the nutrient management treatments wet-direct seeded and aerobic methods resulted in similar number of shoots compared to transplanting method, except under 150%RDF, where wet-direct seeded method resulted in significantly more number of shoots than transplanting method and significantly less than aerobic method.

Table 2: Interaction effect of establishment methods and nutrient management treatments on number of shoots/m^2

Nutrient Management \ Establishment method	30 DAS/DAT				60 DAS/DAT				90 DAS/DAT				Maturity			
	DSR	WDS	TP	MEAN	DSR	WDS	TP	MEAN	DSR	WDS	TP	MEAN	DSR	WDS	TP	MEAN
RDF	129	104	160	131	360	335	270	322	322	317	243	294	298	294	230	274
75%RDF+FYM (equivalent to 25%N)	115	100	191	135	337	319	260	305	303	307	240	283	283	276	230	263
150% RDF	103	100	189	131	328	317	264	303	312	302	240	285	294	276	231	267
RDF (LCC based N application)	93	110	190	131	324	341	274	313	312	315	255	294	286	290	235	270
RDF+5tFYM/ha	103	98	199	133	330	335	283	316	310	308	271	296	291	285	259	278
Mean	109	102	186	132	336	329	270	312	312	310	250	291	290	284	237	270
	S.E.m ±		**C.D (5%)**		S.E.m ±		**C.D (5%)**		S.E.m ±		**C.D (5%)**		S.E.m ±		**C.D (5%)**	
To Compare main plot treatments	1.2		5		2.7		11		3.1		12		7		8	
To Compare sub-plot treatments	3.5		NS		3.4		10		2.8		8		8		7	
To Compare nutrient management treatments at same level of establishment method	18				17				14				13			
To Compare establishment methods at same or different level of nutrient management treatments	17				19				18				14			

Yield attributes of rice

Number of panicle

The influence of different establishment methods on number of panicles/m^2 was significant (Table 3). The aerobic method registered significantly higher number of panicles than that obtained under transplanting method which registered significantly less panicles compared to other establishment methods. However, aerobic method was *at par* with wet-direct seeded method in respect of number of panicles. Various nutrient management treatments also had a significant effect on the number of panicles. The treatment comprising RDF+5tFYM/ha caused significantly higher number of panicles compared to RDF (LCC based N), 150%RDF and 75%RDF+FYM (equivalent to 25%N). However, RDF+5tFYM/ha treatment was *at par* with RDF.The interaction between establishment methods and nutrient management treatments for number of panicles was significant. Under aerobic method, 150%RDF treatment caused significantly more panicles compared to 75%RDF+FYM (equivalent to 25%N), but found *at par* with other treatments. Under transplanting method significantly higher number of panicles were obtained due to RDF+5tFYM/ha treatment and lowest being in RDF treatment. Under wet-direct seeded method, the treatment RDF, being *at par* with RDF (LCC based N) and RDF+5tFYM/ha, caused significantly more number of panicles compared to remaining treatments. Under nutrient management treatments, aerobic and wet-direct seeded methods resulted in similar panicles but significantly higher than transplanting methods. Under 150%RDF panicles were significantly less due to transplanting method compared to remaining methods.

Table 3: Interaction between different Establishment method and nutrient management treatments on panicle number/m^2

Establishment method / Nutrient Management	Aerobic	Wet-direct seeded	Transplanted	Mean
RDF	284	290	221	265
75%RDF+FYM(equivalent to 25%N)	274	264	223	254
150% RDF	287	266	228	260
RDF(LCC based N application)	276	281	230	262
RDF+5tFYM/ha	281	278	251	270
Mean	280	276	231	
To compare Main plot treatments	S.E.m ±		CD (5%)	
	2.1		8	
To compared sub-plot treatments	2.3		7	
To Compare nutrient management treatments at same level of establishment method			11.7	
To Compare establishment methods at same or different level of nutrient management treatments			13.2	

Panicle length of rice crop was not affected by different establishment methods and nutrient management treatments. However, transplanting method resulted in higher values of panicle length compared to remaining treatments. Statistically significant difference in grain weight/panicle was noticed due to establishment methods. Transplanted method caused significantly higher grain weight/panicle as compared to remaining treatments. Among nutrient management treatments, RDF+5tFYM/ha treatment being at par with RDF (LCC based N) caused significantly higher grain weight/panicle compared to other treatments and lowest grain weight/panicle was observed due to RDF treatment. The difference in the number of filled spikelets was statistically higher due to transplanting method compared to remaining methods. Wet-direct seeded and aerobic methods resulted in statistically similar filled spikelets. Application of RDF+5tFYM/ha caused similar filled spikelets to that of RDF (LCC based N) but significantly more than other treatments. RDF treatment alone caused significantly less filled spikelets compared to remaining nutrient management treatments. The difference amongst the establishment methods was significant in minimizing the sterility of rice spikelets. The significantly lower sterility was noticed in transplanting method compared to aerobic method. However, aerobic and wet-direct seeded methods resulted in similar sterility of spikelets. Among nutrient management treatments RDF caused significantly more sterility, while RDF+5tFYM/ha caused significantly less sterility of rice spikelets.

From above results on yield attributes, it was observed that transplanting method registered higher mean panicle length, significantly higher 1000-grain weight and filled spikelets and also significantly lower number of unfilled spikelets and lesser sterility and found superior to wet-direct seeded and direct seeded methods of rice cultivation. The superiority of transplanting method over establishment method might be attributed to fairly spaced planting of rice seedling facilitating better root growth and better canopy structure with high leaf area resulting in greater light interception and better availability of nutrients in submerged field compared to aerobic condition. These findings are alike to earlier finding (Aslam et al., 2008; Kanungo & Roul, 1994; Sharma & Mitra, 1991). Due to these factors rice crop under transplanted system produced higher filled spikelets which have directly proved helpful in reducing the panicle sterility and also helped in increasing the 1000-grain weight of rice. Delayed senescence with enhanced photosynthesis was also responsible for supplying more assimilates toward the roots for maintaining their higher activity. These features might also have contributed to the improvement in grain filling and reducing the sterility in spikelets. Lower 1000-grain weight and lower number of filled spikelets in aerobic and wet-direct seeded may probably be due to poor root development of plants under drilled/broadcasting method respectively. Transplanting method increases the number of filled spikelets and also the 1000-grain weight through optimum utilization of resources which had direct bearing on reduced sterility and increased grain weight (Luzes, 1991; Farooq et al., 2011; Gitsopanios and Williams, 2004; Awan et al., 1989; Song et al., 2009 and Sudhir et al., 2007; Jaiswal and Singh, 2001).

Among, nutrient management treatments in the present investigation, it was observed that RDF+5tFYM/ha treatment caused higher 1000-grain weight, lower sterility and superiority of other yield attributing characters compared to RDF and other treatments consisting inorganic sources of nutrients. It might probably be due to the better integration of inorganic and organic source of fertilizer, which facilitates longer time availability of both macro and micro nutrients to crop during all the important developmental stages of rice crop (Kumar, 2001) and ultimately helped in producing higher healthy spikelets with higher grain weight and reported that application of organic nutrient sources in conjunction with inorganic nutrient sources exhibit a significant increase in yield contributing attributes compared to fertilization through inorganic sources alone (Singh et al., 1996). Integration of farm yard manure with inorganic sources would have resulted in slow release of nutrient and increased availability which in turn might have enhanced more photosynthates production and the translocation from source to sink and improved the yield attributing characters (Ramamoorthy et al., 2000 and Balamurali, 2006). The supply of required nutrients through FYM or other inorganic source facilitated balanced nutrition to crop which might have resulted in enhanced yield attributes in rice (Jayabal et al., 1999). The inorganic nitrogen nourished the plant at initial stage and boosted the growth, while the incorporated FYM released the nutrients slowly and made available upto reproductive stages of crop (Dahiphale et al., 2003). The decomposition of applied FYM might have solubilised the soil native phosphorus and potassium which led to availability of balanced nutrients (Subramanian, 1997). FYM with inorganic N leads to higher uptake of phosphorus due to the solubilisation of insoluble phosphorus as phosphorus plays a vital role in the translocation of assimilates to panicles and also as a constituent of protoplasm (Ishizuka, 1971). This explains the reason for the increased length of panicle, panicle weight and reduced sterility, which ultimately helped to produce higher yield attributing characters in RDF+5tFYM/ha treatment compared to inorganic source of nutrient alone (RDF).

Table 4: Panicle length (cm/panicle), grain weight/panicle (g), 1000-grain weight (g), filled spikelets/m^2 and sterility (%) as influenced by the treatments

Treatments	Panicle length (cm/ panicle)	Grain weight / panicle (g)	1000-grain weight (g)	Filled spikelets/m^2	Sterility (%)
Establishment methods					
Wet direct seeded	22	2.02	25.28	24455	18.3
Aerobic	22	1.91	25.11	24662	18.7
Transplanted	23	2.53	25.40	26264	16.9
S.E.m ±	0.3	0.01	0.06	329	0.2
C.D. (5%)	NS	0.04	0.21	1285	0.6
Nutrient management					
RDF	23	2.01	25.23	22893	19.8
75% RDF+FYM(equiv. to 25%N)	22	2.10	25.01	24709	18.4
150%RDF	23	2.20	25.32	25346	17.8
RDF(LCC based N)	22	2.25	25.25	26042	17.3
RDF+5tFYM/ha	22	2.26	25.50	26645	16.6
S.E.m ±	0.5	0.03	0.04	2967	0.2
C.D. (5%)	NS	0.1	0.11	866	0.6

Yield of rice crop

Data pertaining to grain yield, straw yield, biological yield and harvest index are presented in Table 5.

Grain yield

Grain yield was significantly higher when rice crop was transplanted compared to wet-direct seeded and aerobic method. However, wet-direct seeded and aerobic methods resulted in similar grain yield. Loss in grain yield due to aerobic (5,497 kg/ha) and wet-direct (5,633 kg/ha) seeded methods accounted for 8 and 6 per cent compared to transplanting method.

Among nutrient management treatments RDF+5tFYM/ha, being *at par* with RDF (LCC based N), caused significantly higher grain yield while RDF alone caused significantly lower grain yield of rice compared to remaining treatments.

With the transplanting method the main factor responsible for the yield enhancement in these trials was longer panicles with more grains, significantly better grain filling, reduced sterility and a significant increase in grain weight. Transplanted rice had greater percentage of filled spikelets and increased grain weight than did rice grown under wet-direct and direct seeded methods. As, in wet-direct and aerobic methods a significantly greater number of unfilled spikelets had occurred, which led to significantly lower grain yield than that of transplanting method (Aslam et al., 2008). These observations are also supported by significant positive correlation of yield attributes viz. 1000-grain weight (r =0.693), filled spikelets (r = 0.959) and grain weight/panicle (r = 0.748) (Table 16). Competition for weeds during early stage of growth and less moisture under aerobic and wet-direct seeded might have been the reason for low grain yield. Increased grain yield under transplanting method mainly due to lesser weed problem and also attributed to good crop conditions, more availability of nutrients etc.

Further, the increased availability of nutrients to rice crop under transplanting method might be attributed to better spacing and lesser plant to plant competition for resources as compared to higher inter and intra-plant competition for resources under aerobic and wet-direct seeded method due to drilling/broadcasting of seeds where overcrowding persisted till harvest. These findings are supported by the results reported by Saikia et al. (1992) and Jaiswal and Singh (2001). This also might be due to better root development in transplanting method than in aerobic and wet-direct seeded methods which led to higher grain weight and reduced sterility in transplanted rice. These results are in lines with the findings of Luzes (1991) and Farooq et al. (2011).

Increase in grain yield due to RDF+5tFYM/ha was 14% compared to RDF alone. The treatment 75%RDF+FYM (equivalent to 25%N) also enhanced the grain yield over RDF treatment which was 5.5% more than RDF.

These effects might be due to the contribution of yield components such as productive tillers per, 1000-grain weight, higher filled spikelets and lower sterility. The regulated supply of nitrogen to rice crop through slow mineralization process with FYM helps in providing better physical condition for plant growth (Nambiar & Abrol, 1989). Chemical fertilizers offers, nutrients which are readily soluble in soil solution whereas nutrient availability from organic sources is due to microbial action and improved physical condition of soil (Sarker et al., 2004). Also, when the inorganic fertilizers are applied along with organics, the nutrient release becomes slow making long term availability of nutrients to plants. The increase in productive tillers, filled spikelets and reduced sterility in response to application of organic and inorganic sources to provide nutrients was probably due to enhanced availability of nutrients (Muhammad, 2008 and Mirza et al., 2010). In present experiment higher number of productive shoots and spikelets were observed in RDF+5tFYM/ha treated plots which also contributed to the increased grain yield. Apart from this, several rice workers observed significant increase in grain yield of rice with the use of FYM with inorganic nutrient sources (Salem, 2006; Miller, 2007 and Rakshit et al., 2008).

Straw yield due to transplanting method, being at par with aerobic method, resulted in significantly higher straw yield compared to wet-direct seeded method. However, wet-direct seeded and aerobic methods resulted in statistically similar straw yield. Different nutrient management treatments significantly influenced the straw yield. Use of RDF+5tFYM/ha caused similar straw yield to that of 150%RDF and RDF (LCC based N), but significantly higher than other treatments. Straw yield was significantly less due to RDF compared to remaining treatments. Straw yield under transplanting method was 4% more compared to wet-direct seeded method which might be due to higher plant height and use of aged seedlings (Rajput et al., 1995; Reddy and Shivraj, 1999 and Azad & Leharia, 2001) and differences were significant. The straw yield due to the treatment receiving nutrients through RDF+5tFYM/ha was 13% more than RDF. This might be due to favourable soil conditions and synchronized release of nutrients throughout the crop growth period resulted in enhanced yield attributes which in turn increased straw yield. These findings are supported by earlier findings (Murali and Setty, 2004 and Dahiphale et al., 2003). While, Biological yield was significantly higher due to transplanting method compared to other two establishment methods. However, wet-direct seeded and aerobic methods resulted in statistically similar biological yield. Application of RDF+5tFYM/ha resulted in similar biological yield to that of 150%RDF and RDF (LCC based N), but significantly higher than other treatments. RDF alone caused significantly less biological yield compared to remaining nutrient management treatments.There was 5.1% increase in biological yield due to transplanting method compared to aerobic method. The increased biological yield under transplanting method might be due to increased value of yield attributes (plant height, 1000-grain weight, filled spikelets and straw yield) as it is evident for significant positive correlation of 1000-grain weight (r = 0.602), filled spikelets (r = 0.940) with biological yield (Table 16). This result is in accordance with the findings of Ebaid and El-Refaee (2007). A significant difference in yield attributes and straw yield as affected by combination of FYM and inorganic fertilizer has been reported by Murali & Setty (2004).

Transplanting method of rice cultivation registered significantly high harvest index compared to aerobic method but remained statistically at par with wet-direct seeded method. However, aerobic and wet-direct seeded methods registered similar harvest index. There was no difference in harvest index due to nutrient management practices. More harvest index resulted under transplanting method might be due to more grain yield which has direct influence on the harvest index in rice crop. Also, the similar results of higher harvest index under transplanting method than aerobic rice cultivation method was reported by Ehsanullah et al. (2000).

Table 5: Grain yield (kg/ha), Straw yield (kg/ha), biological yield (kg/ha) and Harvest index (%) as influenced by the treatments

Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)	Biological Yield (kg/ha)	Harvest index (%)
Establishment methods				
Wet direct seeded	5633	6054	11686	0.48
Aerobic	5497	6151	11647	0.47
Transplanted	5982	6280	12262	0.49
S.E.m ±	42	48	84	0.001
C.D. (5%)	166	187	329	0.01
Nutrient management				
RDF	5223	5658	10880	0.48
75% RDF+FYM(equiv. To 25% N)	5525	6040	11565	0.48
150%RDF	5809	6298	12107	0.48
RDF(LCC based N)	5904	6340	12244	0.48
RDF+5tFYM/ha	6058	6472	12529	0.48
S.E.m ±	79	123	194	0.002
C.D. (5%)	231	360	567	Ns

CONCLUSION

Based on above studies, it is concluded that under normal condition, transplanting method along with application of RDF+5tFYM/ha and RDF (LCC based N) can be recommended for better gowth and yield.

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