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Effect of Transplanting on Rice in Northwestern Ethiopia

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Abstract

Rice transplanting experiment was conducted for two years in Fogera plain, northwestern Ethiopia, so as to give transplanting recommendation for rain-fed lowland rice production system. Two varieties (X-Jigna and Gummara /IAC-164/), two seedling stages (2nd and 4th leaf stages, two spacings (25 cm x 20 cm and 25 cm x 25 cm) and two number of seedlings (2 and 3 plants/hill) were factorially combined and tested in randomized complete block designs with three replications. Besides, dry broadcast sowing of the two varieties was used as control treatment. The comparison of transplanting with dry seed sowing showed that the former outsmarted the latter in yield and other yield components. Transplanting gave an average grain yield of 4140.8 kg ha^{-1} while dry sowing had an average yield of 3008.1 kg ha^{-1}. Transplanting was observed to have a grain yield advantage of 1132.7 kg ha^{-1}(37.7%) over dry sowing. Concerning the other yield components, transplanting gave higher number of tillers/ hill and higher number of fertile panicles/hill as compared to dry seeding. The economic analysis showed that transplanting was advantageous over dry sowing. The different transplanting methods gave net benefit of Birr 7796 to Birr 9454. Compared to the lowest net benefit obtained from dry seed sowing, a maximum increase in net benefit of Birr 1934 was obtained because of transplanting. From this experiment it is recommended that in northwestern Ethiopia and other similar agro ecologies, rice seedlings should be transplanted at 4 leaf stages with a spacing of 25 cm x 20 cm by planting 3 seedlings per hill.

Key words: Dry seeding; Plants per hill; Seedling age, Transplanting.

1. Introduction

Rice is one of the most important cereal crops and is the staple food for the majority of the world people (Ahmad *et al.*, 2009). It is the most important food grain in the diets of hundreds of millions of Asians, Africans and Latin Americans living in the tropics and subtropics (Tari *et al.*, 2009).

Basically, there are two methods of rice plant establishment namely; transplanting and direct seeding (Abeysiriwardena *et al.*, 2005). Stand establishment depends on climate, soil, the availability of water, the availability and cost of labor and the choice of variety. Transplanting is the practice of raising seedlings in a nursery and planting them into a separate field. The crop is grown without disturbance thereafter (Singh and Singh, 2000). On the other hand, direct sowing is the practice of sowing seeds directly in the main field, eliminating the process of seedling raising. Direct sowing is the main crop establishment practice in all the upland sub-ecosystems. It could also be used in wet soils. The seeds are sown either by broadcast or in lines in the furrows (Singh and Singh, 2000).

Broadcasting is the only method of rice planting being used in Fogera plain. However, transplanting is the major means of rice planting used in other parts of the world (Morris, 1980; Patel and Charugamba, 1981; and Uphoof, 2003). Patel and Charugamba (1981) stated that transplanted rice is capable of yielding 30% more than broadcasted rice. The other advantage of transplanting is effective utilization of rainy season and faster maturity of the rice crop particularly in rain-fed lowland rice ecosystems since the crop partly passes some of its growth stage in nursery (Morris, 1980; Abeysiriwardena *et al*., 2005). As compared to broadcasted rice, transplanted rice competes better with weeds (Uphoof, 2003). Labor intensiveness at the time of planting is the only drawback of transplanting compared to direct seeding (Morris, 1980 and Uphoof, 2003). Though transplanting is mainly used in areas with irrigation facilities, it could also be used for rain-fed rice by constructing water harvesting soil bunds around leveled fields (Morris, 1980 and Patel and Charugamba, 1981).

Ages of seedlings, spacing and number of seedlings per hill during transplanting are among the major factors that determine the extent of the system's advantage (Morris, 1980; and Uphoof, 2003). To improve the yield and quality of fine rice, seedlings need to be transplanted at their optimum age. Numerous evidences have confirmed that recommendations on transplanting; particularly on age of seedlings, spacing and number of seedlings per hill vary considerably with varietal differences of which tillering capacity being the governing factor (Morris, 1980; Viraktamath *et al.*, 1998 and Uphoff, 2003). Shortage of cultivable land, availability of labour resource, and plain land in the Fogera plain allow rice production intensification practices like transplanting. This study was conducted to give recommendations on transplanting to Fogera plain rain-fed lowland rice production system.

2. Materials and Methods

A rice transplanting experiment was conducted for two years (2005-2006) in Fogera plain. Fogera, which is found in South Gondar Zone of the Amhara Region, is situated 60 km North-East of Bahir Dar Town. The experimental site is located at Latitude of 13^0 19’, Longitude of 37^0 03’ and at an altitude of 1815 m.a.s.l. The climatic data of Woreta shows that the mean annual minimum temperature is 11.5^0C and the mean annual maximum temperature is 27.89^0C and the annual mean temperature is nearly 18.3^0C. Rainfall of the area is uni-modal; usually occurring during June to October, and the average mean annual rainfall reaches to 1300 mm.

Factorial combinations varieties, seedling stages, spacings and the number of seedlings per hill were tested in RCB design with three replications. Two varieties (X-Jigna and Gummara /IAC-164/), two seedling stages (2^{nd} leaf stage which is about 12 days after emergence and 4^{th} leaf stage which is about 14-30 days after emergence), two spacings (25 cm × 20 cm and 25 cm ×25 cm) and two number of seedlings (2 plants/hill and 3 plants/hill) were factorially combined and tested. Dry broadcast sowing at a seed rate of 100 kg ha^{-1} of the two varieties was included as control treatment.

In order to raise the seedlings, first a mixture of soil and rice husk at a volume ratio of 8:1 was prepared. Then, the mixture was spread on the plastic covered seed bed at a thickness of about 5 cm. The rice seeds were broadcasted at a rate of 15 kg seed/ 150 m^2 seed bed. Finally, the seeds were covered with very thin layer of soil and dry grass. The grass was removed when the seeds started to emerge. The seed bed was watered every day both in the morning and at night till the transplanting. Urea was applied at a rate of 50 kg/ha on all plots few days after transplanting (just after the seedlings recover from the transplanting shook). Gross and net plot sizes were 4 m × 3 m and 3 m × 2 m, respectively. The central twelve rows were taken as net rows for the row planted plots. Data on maturity date, plant height, number of tillers of fertile and infertile panicles, thousand seeds weight, grain yield, labor cost for planting and labor cost for weeding were collected. The collected data were subjected to Analysis of Variance using Statistical Analysis System (SAS) Version 9.2 (SAS Inc., 2002). The grain yield was further subjected to partial budget analysis following CIMMYT (1988). A rice seed and grain price of Birr 2.5/kg was used for the economic analysis.

3. Results

In 2005, the comparison among transplanted treatments indicated that there was statistically equivalent response for most of the parameters. However, the comparison of transplanting with the control (dry sowing) showed that there was significant difference for most of the yield components including the grain yield. X-Jigna gave an average grain yield of 3493 kg ha^{-1} during transplanting while 2347 kg $ha^{-1}$by dry sowing. Similarly, Gumara gave an average grain yield of 4304 kg ha^{-1} when transplanted but it gave 2616 kg ha^{-1} when dry sown.

The two years combined analysis of variance indicated that the transplanted treatments did not have significant effect on grain yield and other yield components. However, the comparison of transplanting with dry seed sowing showed that the former significantly out yielded the latter in terms of yield and other yield components (Tables 1-3). Transplanting gave an average grain yield of 4140.8 kg ha^{-1} while dry sowing had an average yield of 3008.1 kg ha^{-1} (Table 1). Transplanting showed a grain yield advantage of 1132.7 kg ha^{-1} (37.7%) over dry sowing.

With respect to the spacing between hills and number of seedlings per hill, 25 cm x 20 cm spacing and 3 plants at each hill, respectively, were found to be better. Concerning the age of the seedlings, transplanting seedlings at 4 leaf stage (about 14-30 DAE) is more advisable than younger seedlings at 2 leaf stage (about 12 DAE) so as to reduce the risk of failure due to moisture stress just after transplanting.

Concerning the other yield components, transplanting gave higher number of tillers $hill^{-1}$ than dry seed sowing did (Table 2). Similarly, the number of fertile panicles $hill^{-1}$ was higher in the case of transplanting than in the dry seeding (Table 3). Compared with transplanting, the dry sown rice was having lesser number of fertile panicles. In the case of dry sowing, the growth of the panicles was less uniform in that the majorities of the panicles were matured and near to shatter while some were still immature and harvested as are infertile. On the other hand, for the transplanting, most of the panicles were found fertile with lesser number of the infertile during maturity.

The economic analysis had also indicated that transplanting was advantageous over dry sowing. The different transplanting methods gave net benefit ranging from Birr 7796 to Birr 9454 as compared to the lowest net benefit (Birr 7520) obtained from dry seed sowing (Table 4).

4. Discussion

The observed increase in rice grain yield due to transplanting is in line with the findings of many authors. An experiment comprised of transplanting and direct seeding treatments indicated that transplanting resulted in maximum paddy yield than the direct seeding methods

(Ehsanullah *et al.*, 2000). The report of Patel and Charugamba (1981) indicated that transplanted rice is capable of yielding 30% more than broadcasted rice. Mitchell *et al.*, (2004) have also indicated a highly significant positive correlation between the performance of genotypes in direct seeding (DS) and transplanting (TP) experiments in which TP rice had a 6-30% yield advantage over DS rice. Similarly, Uphoof (2003) reported that rice yield could be increased by 1.35 to 2.48 t ha^{-1} by transplanting rather than seed broadcast sowing. As stated by Singh *et al.*, (2002), direct dry seeding of rice reduced yield by 23–41% on flat land and by 41–54% on raised beds compared with transplanted rice. Major problems of direct seeded rice attributed to its low yield are poor crop establishment, dominance of weeds, pests and lodging (Fukai *et al.*, 1998; Mitchell *et al.*, 2004).

In the present investigation the yield increase of transplanting over dry seed sowing is associated with the increase in the number of effective tillers and increased number of fertile panicles. In line with this, Mobasser *et al.*, (2007) reported that transplanting of healthy seedlings ensures better rice yield by promoting better tillering and growth. Apart from tillers and fertile panicles, Singh *et al.*, (2002) and Mitchell *et al.*, (2004) explained that the yield difference between the two planting methods is attributed to lodging, pest and weed problems during dry seed sowing. Fukai *et al.*, (1998) had also reported that major problems of direct seeded rice are poor crop establishment and presence of weeds. The loss in grain yield of direct-sown rice caused by unchecked weed growth ranged from 18.2 to 59.2% in the different years, and was greater when N fertilizer was applied (Sharma, 1997).

Age of seedling at the time of transplanting is an important factor for uniform stand establishment of rice. In the present investigation it was observed that transplanting rice seedlings at 4 leaf stage seedling age is better yielding than 2 leaf stage seedlings. This finding is different from the reports of Uphoff and Erick (2002); Zheng *et al.*, (2004) and Uphoff (2006) who recommended 2 leaf staged rice seedling transplanting. However, the present finding is in line with numerous reports. A report stated that seedlings are ready to be pulled out when they attain the stage of 4-5 leaves, about 18 days after sowing in the case of short duration varieties and 20-25 days after sowing in the case of medium duration varieties (Anonymous, 2002). Agronomic research aimed at developing technologies to improve lowland rice yields in Laos indicated that, to obtain high yields from rain-fed lowland transplanted rice, high-yielding seedlings should be 25 days old when transplanted (Sipaseuth, 2000). From their experiment in Iran, Mobasser *et al.*, (2007) stated that when the age of seedlings is less than optimum, the tender seedlings may die in greater number due to high temperature and ultimately the plant population is reduced. Pasuquin *et al.*, (2004) stated that if the age of seedlings is more than optimum, the seedlings produce fewer tillers and thereby result in poor yield. Transplanting seedlings at optimum age induced higher tiller production and higher plant shoot dry matter accumulation and hence ensure higher rice grain yield (Pasuquin *et al.*, 2004).

From the economic analysis of this study, transplanting is found to be more profitable than the direct seed sowing. Although it is labor intensive, requires pre-harvest labor ranging from 72 to 79 man-days, transplanting is still the predominant method of rice production (PRRI, 2006). In the current experiment it is mainly the higher yielding ability which makes transplanting economically advantageous over dry seed sowing. Moreover, the lower seed requirement of transplanting makes it economical. Similar to the present observation, Singh and Singh (2000) reported that lower seed requirement is also the other advantage of transplanting over direct seeding. Direct sowing requires more seed than transplanting does, 50 to 100 kg/ha depending on the method of sowing and the rice variety (Singh and Singh, 2000).

Beside its better weed control advantage and higher yields, there are also other reasons which make transplanting a preferred method of rice establishment. After conducting research in Bangladesh by sowing seeds in nursery for transplanting and sowing the direct seeded rice in field both in the same day, Mazid *et al*., (2002) indicated that rice established by dry seeding matured 7–10 days earlier than transplanted rice. In case of rain fed-lowland rice, for farmers practicing the seedling raising during off-seasons, transplanting is effective in utilization of rainy season since the crop partly passes some of its growth stage in nursery compared to seed broadcasting (Morris, 1980). Transplanting may have also helped farmers to deal with the low temperature that can adversely affect the performance of direct-seeded rice at higher altitudes (Pandey and Velasco, 2002). Despite its long history of rice production, Japan's rice production industry is still practicing transplanting unlike most other Asian countries, mostly because of the climate (the land is subject to a cold temperate winter) (Maruyama, 2005). Direct seeding technologies are, generally speaking, not compatible with the Japanese climate (cool temperate), since direct seeding results in slow germination and the short elongation of rice in cooler temperatures (Maruyama, 2005). Rice requires a hot and humid climate. High altitude and low temperature delay its flowering and maturity. Temperature ranging from 21^0C to 35^0C throughout the life cycle is conducive to its growth and development (Datta and Patrick, 1986). With regard to its temperature, Fogera plain is a bit cooler for rice production. The mean minimum and maximum temperatures at Fogera during the critical rice growing period (June-September) are 12.3^0C and 26.2^0C respectively (Sewnet, 2005). Therefore, transplanting is an appropriate technology for rice production in the area.

5. Conclusion

Transplanting of rice was found to be biologically and economically advantageous over dry seed sowing. From this experiment it is recommended that rice seedlings should be transplanted at 4 leaf stage age with a spacing of 25 cm x 20 cm and 3 seedlings per hill.

Table 1. Two-year combined effect of seedling age, spacing and number of plants per hill on grain yield (kg ha^{-1}) of transplanted rice

Number of plants per hill	X-Jigna (V1)				Gumara (V2)			
	25 cm × 20 cm		25 cm × 25 cm		25 cm × 20 cm		25 cm × 25 cm	
	4 leaf stage	2 leaf stage	4 leaf stage	2 leaf stage	4 leaf stage	2 leaf stage	4 leaf stage	2 leaf stage
2 plants/ hill	3839^{E-I}	3673^{GHI}	3921^{D-I}	3478^{I}	4511^{A-D}	4241^{A-G}	4241^{A-G}	4030^{C-I}
3 plants/ hill	4181^{B-H}	3998^{D-I}	3829^{F-I}	3635^{HI}	4716^{A}	4654^{ABC}	4677^{AB}	4629^{ABC}
Mean	4010^{C-I}	3835^{E-I}	3875^{E-I}	3556^{I}	4613^{ABC}	4448^{A-E}	4459^{A-E}	4330^{A-F}

Table 2. The two years combined effect of seedling age, spacing and number of plants per hill on number of tillers/ hill

Number of plants per hill	X-Jigna (V1)				Gumara (V2)			
	25 cm × 20 cm		25 cm × 25 cm		25 cm × 20 cm		25 cm × 25 cm	
	4 leaf stage	2 leaf stage	4 leaf stage	2 leaf stage	4 leaf stage	2 leaf stage	4 leaf stage	2 leaf stage
2 plants/ hill	9.9^{C-F}	9.7^{DEF}	9.7^{DEF}	11.1^{A-D}	11.9^{A}	9.8^{DEF}	10.7^{A-E}	11.0^{A-D}
3 plants/ hill	10.6^{A-E}	8.3^{F}	11.4^{A-D}	10.3^{A-E}	11.3^{A-D}	11.1^{A-D}	11.7^{AB}	11.1^{A-D}
Mean	10.2^{B-E}	9.0^{F}	10.6^{A-E}	10.7^{A-E}	11.6^{ABC}	10.5^{A-E}	11.2^{A-D}	11.1^{A-D}

Table 3. The two years combined effect of seedling age, spacing and number of plants per hill on number of fertile panicles/ hill

Number of plants per hill	X-Jigna (V1)				Gumara (V2)			
	25 cm × 20 cm		25 cm × 25 cm		25 cm × 20 cm		25 cm × 25 cm	
	4 leaf stage	2 leaf stage	4 leaf stage	2 leaf stage	4 leaf stage	2 leaf stage	4 leaf stage	2 leaf stage
2 plants/ hill	117^{GH}	116^{H}	121^{FGH}	109^{H}	144^{B}	126^{D-G}	134^{B-F}	135^{B-F}
3 plants/ hill	126^{D-G}	130^{C-G}	119^{GH}	125^{E-H}	141^{B-D}	149^{A}	140^{B-D}	120^{FGH}
Mean	121^{FGH}	123^{E-H}	120^{FGH}	117^{GH}	142^{BC}	137^{B-E}	137^{B-E}	127^{C-G}

Table 4. Economic analysis for transplanted and dry seeded rice

Treatment	Adjusted grain yield (kgha^{-1})	Labor cost for seedling raising	Labour cost for transplanting	TVC	Gross benefit	Net benefit
Ag1S1H1	3757.23	540	1200	1740	10436.75	8696.8
Ag1S1H2	3921.21	540	1200	1740	10892.25	9152.3
Ag1S2H1	3378.78	540	1050	1590	9385.5	7795.5
Ag1S2H2	3806.01	540	1050	1590	10572.25	8982.3
Ag2S1H1	3561.39	390	1200	1590	9892.75	8302.8
Ag2S1H2	3975.75	390	1200	1590	11043.75	9453.8
Ag2S2H1	3672.9	390	1050	1440	10202.5	8762.5
Ag2S2H2	3739.95	390	1050	1440	10388.75	8948.8
Dry Sown	2707.2	0	0	0	7520	7520.0

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