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Productivity and Profitability Assessment of Drought Tolerant Rice Cultivars under Different Crop Management Practices in Central Terai of Nepal

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***Abstract*— *Reduction in productivity has led to lower profitability of rice production in Nepal. Proper selections of resource conservation technologies and drought tolerant cultivars are being potential strategies determining productivity of rice in drought prone areas. Thus, a field experiment was accomplished in central-terai of Nepal during 2014 to assess the productivity and profitability of drought tolerant rice cultivars under different crop management practices. The experiment was carried out in strip-plot design with three replications consisting four drought tolerant rice cultivars and three crop management practices. The analyzed data revealed that SRI (System of Rice Intensification) produced significantly higher grain yield (5.28 t ha^{-1}) than other management practices. The straw yield of SRI (5.12 t ha^{-1}) was also significantly higher than other management practices. The cultivars had no influence on grain yield, but the straw yield was significantly influenced by cultivars, with the highest straw yield in Sukkha-3 (5.21 t ha^{-1}). Similarly, SRI management practice also had significantly higher gross returns (NRs. 144652 ha^{-1}), net return (NRs. 56647 ha^{-1}) and B:C ratio (1.64:1). Thus, SRI management practice can be adopted as adaptation approach for obtaining higher productivity and profitability in central terai and similar agro-climatic regions of Nepal.*

Keywords*— *B:C ratio, crop management practices, productivity, rice, SRI.

I. INTRODUCTION

Rice is the second most important staple food for more than half of the world's population (Delseny *et al.*, 2001; Feng *et al.*, 2013). Being a most important staple food of Nepalese people, rice ranks first crop for both acreage and production and production amounts to half of the total cereal grains in the country (Ghimire *et al.*, 2013). In Nepal, rice is grown in about 1.42 million hectares with total production about 4.50 million tons, and 3.17 t ha^{-1} productivity (MoAD, 2013). The share of agriculture and forestry for national gross domestic product (GDP) is 33.03%, and therein rice alone contributes 20.75% of the agriculture gross domestic product (AGDP) and 10.2% of total GDP (Poudel, 2011).

In Nepal, more than 70% of the total rice area is grown under rainfed condition (CBS, 2003), whereas only 21 % rice production is under partially or fully irrigated conditions (NARC, 2008). Rice production relies on ample water supply and thus is more vulnerable to drought stress than other crop. The temperature of Nepal has increased by 0.04-0.06 ºC annually on an average during 1977-2005 (MoE, 2010). Increase in temperature due to climate change has resulted an increase in evidences of drought stress in crop production including rice (Karn, 2014). According to statistics, the percentage of drought affected lands areas more than doubled from the 1970s to the early 2000s worldwide (Isendahl and Schmidt, 2006). Further, increased temperature may decrease rice potential yield up to 7.4% per degree increment of temperature (Murdiyarso, 2000). Several other factors like weeds, low factor productivity and reducing resource use-efficiency due to deteriorating soil health are causing the lower productivity of rice in Nepal. Reduction in production has led to lower profitability of rice in Nepal. Among various approaches to climate change adaptation in drought prone areas, proper selections of resource conservation technologies like (SRI, ICM, etc.) (Islam *et al.*, 2014b) and drought tolerant rice cultivars (Basnet, 2015) are potential strategies determining yield of rice. Thus, the present investigation is planned, executed and accomplished with the objective of pursuing the productivity and profitability of various drought tolerant rice cultivars under different crop management practices in central terai of Nepal.

II. MATERIALS AND METHODS

This study was carried out at Dhauwadi VDC, Nawalparasi (235 masl) from June to October 2014. The experimental site is suitated at 27°48'43" N latitude and 84°4'58" E longitude, where it received 1045 mm of rainfall during the experimental period. The experiment was carried out using a strip plot design, in the fields of three farmers, considering each farmer as a replication. The treatment consists of combination of the column factor (three rice management practices: System of Rice Intensification-SRI, Integrated Crop Management-ICM and Puddled transplanted-conventional) and row factor (four rice cultivars: Sukkha-3, Sukkha-4, Sukkha-5 and Hardinath-2). The size of each plot was 12 m^2, and the net plot was determined after leaving one border row in each side, one destructive sampling row and one guard row. The space between two plots was 0.5 m, and the bund of 0.5 m was made between each management practices to check the flow of water and nutrients between them. The experiment on three management practices were set up considering the production factors (Table 1). Vermicompost was used as a source of organic manure, whereas Urea, DAP and MOP were used as sources of N, P_2O_5 and K_2O, respectively. Full doses of phosphorus and potassium and half dose of nitrogen were applied as basal dose at the time of transplanting. The remaining half dose of nitrogen was applied in two split doses: one-fourth N at 30 DAT and the remaining one-fourth at booting stage. The crop from net plot area was harvested manually with the help of sickles. The whole plant was cut at 2 cm above ground for all varieties, except Hardinath-2 that was harvested by hand picking of panicles due to heavy rainfall during harvesting period. The grains were weighted at their exact moisture content and were adjusted at 14% moisture level. The biometric observations (plant height, tillers number per square meter, LAI, above ground dry matter), yield attributing characters and yields of all the treatments were recorded. These recorded datas were tabulated in MS-Excel which was subjected to ANOVA (Gomez and Gomez, 1984), after analysis through MSTAT-C and mean separation for significant variables were done by Duncan's Multiple Range Test (DMRT) at 5% level of significance.

Table.1: Production factors considered in different management practices

Production factors	SRI	ICM	Conventional
Crop geometry	25 cm × 25 cm	20 cm × 20 cm	20 cm × 15 cm
Seed rate	7.5 kg ha^{-1}	20 kg ha^{-1}	40 kg ha^{-1}
Seedling age	14 days old	21 days old	28 days old
Seedling/hill	1	2	3
Organic manure	10 t ha^{-1}	5 t ha^{-1}	None
NPK	20:15:10 kg ha^{-1}	40:30:20 kg ha^{-1}	80:60:40 kg ha^{-1}
Water management	Alternating wetting and drying	Intermediate condition	Flooded condition

III. RESULTS AND DISCUSSIONS

3.1 Grain yield

The grain yield was significantly influenced by management practices, but the cultivars and its interaction with management practices had no influence on grain yield (Table 2). The grain yield of SRI management practice (5.28 t ha^{-1}) was significantly higher than conventional management practice (4.49 t ha^{-1}), but it was statistically at par with ICM management practice (4.73 t ha^{-1}). The grain yield of ICM was also significantly higher than under conventional (228 m^{-2}) management practice. The higher grain yield of SRI management practice was because of significantly higher number of effective tillers (318 m^{-2}) than ICM (387 m^{-2}) and conventional management practices. Panicle weight, panicle length and filled grains per panicle of SRI management practice were also significantly higher than ICM and conventional management practices. Further, sterility percentage was significantly lower in SRI (14.97%) than ICM (15.13%) and conventional (16.23%) management practices. Higher number of effective tillers, panicle weight and filled grains per panicle were reported in SRI than conventional management practice (Rao *et al.*, 2013; Islam *et al.*, 2014a; Ahmed *et al.*, 2015; Jana *et al.*, 2015). The higher grain yield of SRI was also due to higher LAI as compared to other management practices. The grain yield of rice is also determined by assimilates deposited mainly in vegetative stage, which is directly contributed by leaf area. Carbohydrates produced before heading mainly accumulate in the leaf sheath and stem and translocate to the panicles during grain filling (Fageria, 2007). The contribution of carbohydrates produced before heading to the final grain yield appeared to be in range of 20-40 % (Murata and Matsushima, 1975).

It was revealed that SRI practice produced 17.49% more yield than conventional practice. Although SRI and ICM practices were statistically similar, SRI produced 11.63% more yield than ICM practice. Moreover, ICM produced 5.35 % more grain yield as compared to conventional management practice. The increase in grain yield of 11.8 % was reported under SRI management practice over conventional (Gulshan and Sarao, 2009). Similarly, increase in grain yield under SRI and ICM management practices was 209.9 % and 185.4 % higher, respectively over conventional management practices (Islam *et al.*, 2014a). Moreover, 100-200 % increase in grain yield was also reported under SRI compared to conventional management practice (Munda *et al.*, 2012).

Table.2: Grain yield, straw yield and harvest index of various cultivars of rice as affected by management practices at Dhauwadi VDC, Nawalparasi, Nepal, 2014

Treatment	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
Management		
SRI	5.28 ^{a}	5.12 ^{a}
ICM	4.73 ^{ab}	4.73 ^{b}
CON	4.49 ^{b}	4.06 ^{c}
SEm (±)	0.145	0.057
LSD (0.05)	0.57*	0.23**
Cultivars		
Sukkha-3	4.79	5.21 ^{a}
Sukkha-4	4.73	4.43 ^{b}
Sukkha-5	5.16	4.49 ^{b}
Hardinath-2	4.64	4.42 ^{b}
SEm (±)	0.236	0.108
LSD (0.05)	ns	0.37**
CV (%)	10.81	5.1
Grand Mean	4.83	4.64

(Treatment means followed by common letter/letters within column are not significantly different among each other based on DMRT at 0.05; **= significant at 0.01 level, *= significant at 0.05 level and ns= non-significant at 0.05 level)

3.2 Straw yield

The straw yield (5.12 t ha^{-1}) of SRI practice was significantly higher than ICM (4.73 t ha^{-1}) and conventional practices (4.06 t ha^{-1}). The straw yield of ICM practice was also significantly higher than conventional practice. This might be due to longer plant height in SRI and ICM management practices over conventional management practices. Moreover, early vigorous growth due to wider spacing which resulted less competition in space, nutrition and other factors for growth might have resulted higher straw yield in SRI management practice. Further, the higher straw yield in SRI might also be due to higher number of tillers in SRI than other management practices (Wijebandara et al., 2008). The significant higher straw yield in SRI than in conventional management practices was also reported by Wijebandara *et al.* (2008) and Jeyapandiyan and Lakshmanan (2014).

The straw yield of Sukkha-3 (5.21 t ha^{-1}) was significantly higher than other varieties, whereas the straw yield of other cultivars were at par (Table 2). Higher straw yield of Sukkha-3 might be due to longer plant height of this cultivar. Higher straw yield in the cultivars with longer plant height was also reported by Haque and Pervin (2015). Higher dry matter accumulation in Sukkha-3 might also have contributed to its higher straw yield. Further, there was significant influence of interaction of cultivars and management practices in straw yield. The mean straw yield was found highest in Sukkha-5 with SRI (5.66 t ha^{-1}), followed by Sukkha-3 with ICM practices (5.31 t ha^{-1}). The lowest mean straw yield (3.56 t ha^{-1}) was observed in Sukkha-5 with conventional practice.

3.3 Economic Analysis

3.3.1 Cost of cultivation

The data on cost of cultivation is presented in Table 3. The data on cost of cultivation revealed that SRI practice had the lowest cost of production (NRs. 88,005 ha^{-1}), followed by ICM (NRs. 95207 ha^{-1}) and conventional (NRs. 111909 ha^{-1}) practices, respectively. The mean cost of cultivation was NRS. 98374 ha^{-1}.

3.3.2 Gross return

The total monetary value of the economic produce and the byproducts obtained from the crop is called gross return. It is calculated based on the local market price of the products (Reddy and Reddi, 2005). The gross return was significantly influenced by management practices, but the cultivars and interactions of cultivars and management practices had no influence in gross return (Table 3). The gross return of SRI practice (NRs. 144652 ha^{-1}) was significantly higher than ICM (NRs. 129941 ha^{-1}) and conventional (NRs. 121931 ha^{-1}) practices. Higher gross return in SRI practice has also been reported by Islam *et al.* (2014b).

3.3.3 Net return

The ultimate product remained after subtracting the cost of cultivation from the gross return is called net return (Reddy and Reddi, 2005). The net return was significantly influenced by management practices, but the cultivars and interactions of cultivars and management practices had no influence in net return. The net return of SRI practice (NRs. 56647 ha^{-1}) was significantly higher than ICM (NRs. 34733 ha^{-1}) and conventional (NRs. 10022 ha^{-1}) practices (Table 3). Higher net return in SRI practice has also been reported by Islam *et al.* (2014b).

3.3.4 Benefit cost (B: C) ratio

Benefit cost (B: C) ratio is defined as the ratio of the gross returns to the cost of cultivation which can also be expressed as return per rupee invested. For any enterprise relating with agriculture sector to be economically viable, a minimum B: C ratio of 1.5 is fixed. Therefore for any agriculture enterprise to be sustainable, it should maintain a B: C ratio of 1.5 (Reddy and Reddi, 2005). The benefit cost ratio was significantly influenced by management practices, but the cultivars and interactions of cultivars and management practices had no influence in benefit cost ratio. The benefit cost ratio of SRI practice (1.64:1) was significantly higher than ICM (1.37:1) and conventional (1.09:1) practices (Table 3). Higher benefit cost ratio in SRI practice has also been reported by Wijebandara *et al.* (2008) and Islam *et al.* (2014b).

Table.3: Cost of cultivation (NRs. 000 ha^{-1}), gross return (NRs. 000 ha^{-1}), net return (NRs. 000 ha^{-1}) and B:C ratio of various cultivars of rice as affected by management practices at Dhauwadi VDC, Nawalparasi, Nepal, 2014

Treatment	Cost of production (NRs. 000 ha^{-1})	Gross return (NRs. 000 ha^{-1})	Net return (NRs. 000 ha^{-1})	B:C ratio
Management				
SRI	88.01	144.65 ^{a}	56.65 ^{a}	1.64 ^{a}
ICM	95.21	129.94 ^{b}	34.73 ^{b}	1.37 ^{b}
CON	111.91	121.93 ^{b}	10.02 ^{c}	1.09 ^{c}
SEm (±)		3.387	3.387	0.036
$LSD_{(0.05)}$		13.30*	13.30*	0.14*
Cultivars				
Sukkha-3	98.37	133.30	34.95	1.38
Sukkha-4	98.37	129.03	30.65	1.33
Sukkha-5	98.37	139.55	41.18	1.44
Hardinath-2	98.37	126.82	28.45	1.31
SEm (±)		5.730	5.730	0.061
$LSD_{(0.05)}$		ns	ns	ns
CV (%)		9.39	34.28	9.51
Grand Mean	98.37	132.18	36.20	1.365

(Treatment means followed by common letter/letters within column are not significantly different among each other based on DMRT at 0.05; **= significant at 0.01 level, *= significant at 0.05 level and ns= non-significant at 0.05 level)

IV. CONCLUSION

The results showed that grain yield was significantly influenced by management practices, where SRI management practice recorded the highest grain yield than other management practices. But, the rice cultivars and the interaction of management practices and cultivars had no influence on grain yield and major yield attributing characters. Similarly, SRI management practice had the higher gross return, high net return and B:C ratio. Thus, SRI management practice can be adopted as adaptation approach for obtaining higher productivity and profitability in central terai and similar agro-climatic regions of Nepal.

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