Study of the effect of tillage, seed priming and mulching on direct seeded rice variety sukhadhan-5 in mid hills of Nepal

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Article Info

ABSTRACT

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An experiment was conducted to assess the growth, productivity and profitability of direct seeded rice (DSR) under different tillage, mulching and priming practices. The experiment was laid out in three factors Randomized Complete Block Design (RCBD) with three replications. The experiment comprises of three factors such as tillage (zero and minimum tillage), seed priming (primed and non-primed) and mulching (mulched and non-mulched) with eight treatments: Zero tillage + primed seed + mulching (T₁), Zero tillage + primed seed + non-mulching (T₂), Zero tillage + non-primed seed + mulching (T₃), Zero tillage + non-primed seed + non-mulching (T₄), Minimum tillage + primed seed + mulching (T₅), Minimum tillage + primed seed + non-mulching (T₆), Minimum tillage + non-primed seed + mulching (T₇) and Minimum tillage + non-primed seed + mulching (T₈). The phenological, growth, yield and yield attributing characters were observed in the experiment. The results revealed that T₃ matured earlier (115 days) compared to other tested treatments. The maximum grain yield (3.64 t ha⁻¹) was obtained in T₅ which was supported by high number of effective grains per panicle (139 grains) with high test weight (28 g) while the lowest grain yield (2.29 t ha⁻¹) was obtained from T₁ (zero tillage, primed seed and mulching). Similarly the highest straw yield (7.58 t ha⁻¹) was obtained from T₅ (minimum tillage, primed seed and mulching) which is supported by higher plant height, high no. of tillers per unit area. Among different tested treatments, T₅ was found superior compared to others.

INTRODUCTION

Rice rank in first position in term of area, production and productivity among major cereal crop in Nepal. It is the most preferred staple food crop and fulfils more than 50% of the calorie requirement of the Nepalese people (Gautam et al. 2018). Out of total rice cultivated land, 69.92% is under irrigated condition and 30.08% under rain fed condition, yield under

irrigated and rain fed condition is 3497 and 2359 kg ha⁻¹, respectively (MoAD 2016).

Direct Seeded Rice (DSR) is the technology of establishing the crop from seeds sown in the field rather than by transplanting seedlings from the nursery (Farooq et al. 2011). DSR is the major opportunity to change production practices to attain optimal plant density and high-water productivity in water scarce areas. There has been a shift from conventional rice transplanting (TPR) to DSR in several countries of Southeast Asia (Pandey and Velasco 2002). DSR is established earlier than transplanted rice (TPR) without growth delays and hastens physiological maturity and reduces vulnerability to late-season drought, due to avoidance of transplant injury. Higher grain yield was recorded in DSR (3.15 t ha⁻¹) than TPR (2.99 t ha⁻¹), which was attributed to the increased panicle number, higher test weight and lower sterility percentage (Sarkar and Das 2006). Direct seeding has potential to decrease CH₄ emissions (Wassmann et al. 2004). Three basic operations, namely, puddling (a process where soil is

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compacted to reduce water seepage), transplanting and maintaining standing water avoided in direct seeded rice (Pandey and Velasco 2002).

Mulch is a good option for rice residue management under upland condition (DSR), especially with reduced or zero tillage. Mulch can increase yield, water-use efficiency and profitability, while simultaneously decreasing weed pressure. Through proper mulching, the problems of surface evaporation and soil moisture deficit in dry season can be solved to a great extent (Du and Tuong 2002; Sarangi et al. 2010). Green leaves from trees like shiris (*Albizia lebbeck*) and dhaincha (*Sesbania bispinosa*) can be used as mulching material. Mulching materials are spread over the sown seeds, so that the seeds can be preserved from the birds and moisture can be maintained in the soil and, thus, helps in overall good growth and high yield.

Seed priming is low cost hydration techniques in which seeds are partially hydrated to the point where pre-germination metabolic activities start without actual germination and then re-dried until close to the original dry weight (Pandita et al. 2007; Asal and Taheri 2012). In primed seeds, metabolic reactions are activated which speed up the germination and reduced the natural heterogeneity in germination (Rowse 1995). Therefore, this experiment was designed with the objective of assessing phenological, growth and yield of rice by using different tillage, mulching and seed priming practices on Sukhadhan-3 variety of rice under rainfed condition in mid hills of Nepal.

MATERIALS AND METHODS

The experiment was carried out in Bhanu-1, Rupakot, Tanahun district which is located at 28° 7' to 28° 10' North and longitude from 84° 24' to 84° 28' East at an altitude of 800 m above sea level. The study area is selected as a representative of farming system that resembles mostly mid hills in case of Nepal. During the rainy season, the site receives ample rainfall from June to September. The total annual rainfall is reported as 2800 mm, and maximum temperature is reported as 28-39 °C and minimum temperature is 6-10 °C (Kandel et al.

2019). The research is designed in three factor RCBD. In the experiment, the first factor was tillage practices (zero tillage and minimum tillage), second factor was seed priming (primed and non-primed seed) and factor third was mulching (mulched and non-mulched). Treatment combination is shown in table 1. During a field preparation, the weeds were controlled by using contact non selective herbicide "Glyphosate". The gross plot size of each plot was 3m×2m = 6m² while the net plot size was 2.2m×2m = 4.4m². Seeding was done on 30th of June 2017 at 50kg ha⁻¹. The spacing 20cm×20cm was maintained. Well decomposed FYM at 10 t ha⁻¹ plus 60:30:20 kg NPK ha⁻¹ was applied in the experiment. Half dose of N (30 kg ha⁻¹) plus full dose of P and K was applied as basal dose and remaining half dose (30 kg N) was applied in two split doses as 1st top dressing at 30 DAS and 2nd at 40 DAS just after first and second weeding. Phenological, growth, yield and yield attributing characters were recorded before crop harvesting

RESULTS AND DISCUSSION

Phenological and growth attributing characters

Maturity days

Statistically non-significant effect was found on maturity days of rice by tillage (factor A), seed priming (factor B) and mulching (factor C). The grand mean of the maturity day was 117 days, which was shown in table 2. Zero tilled rice matured in 116 days while minimum tilled rice mature in 118 days (Table 2). Almost all the treatments were matured at the same time and harvested in the same day. Similarly, there was statistically non-significant interaction effect was found between different factors on maturity days of crop. The direct effect of seed priming was reported by Harris et al. (2001) in crops like rice, wheat and maize which included faster emergence, better and uniform plant stand, less need to re-sow, more vigorous plant, better growth tolerance, earlier flowering, earlier harvest and higher grain yield but significance effect was not found in the experiment

Table 1. Treatment combination used in the experiment during 2017

Treatment	Treatment combination	Symbol
T ₁	Zero tillage DSR + Primed seed + Mulching	T ₀ P ₁ M ₁
T ₂	Zero tillage DSR + Primed seed + Non-mulching	T ₀ P ₁ M ₀
T ₃	Zero tillage DSR + Non-primed seed + Mulching	T ₀ P ₀ M ₁
T ₄	Zero tillage DSR + Non-primed seed + Non-mulching	T ₀ P ₀ M ₀
T ₅	Minimum tillage DSR + Primed seed + Mulching	T ₁ P ₁ M ₁
T ₆	Minimum tillage DSR + Primed seed + Non-mulching	T ₁ P ₁ M ₀
T ₇	Minimum tillage DSR + Non-primed seed + Mulching	T ₁ P ₀ M ₁
T ₈	Minimum tillage DSR + Non-primed seed +Non- mulching	T ₁ P ₀ M ₀

Plant height (cm)

There was significant effect of tillage on plant height while there was non-significant effect of seed priming and mulching on the plant height (Table 2). The tillage operations improve physical condition by manipulating and pulverizing the soil, which provides suitable environment to the germinating seeds and emerging seedlings and also supplies free oxygen and availability of soil moisture and essential nutrients to plants and ultimately improves the plant height. The results are in close conformity with the findings of (Arora et al. 1991). The grand mean of plant height was 94.62. Plant height was ranged from 90.67 to 98.57 cm where minimum tillage showed higher plant height (98.57) compared to zero tillage. The interaction of tillage and priming shows significant effect on the plant height. The variety Sukhadhan-3 has semi dwarf plant type which has positive response with production inputs like fertilizer and irrigation and has non lodging effect.

Effective tiller per m²

Statistically significance differences was observed due the effect of tillage while non - significance differences was observed due to the effect of seed priming and mulching (Table 2). Among various yield and yield attributing characters, number of effective tillers is the most important to shape the final yield of rice plant. More number of tillers (143 tillers m⁻²) was found in minimum tillage treatment followed by zero tillage treatment (134 tillers m⁻²). The grand mean

of the effective tillers was 138.21. There was statistically non-significant interaction effect was found between different factors on effective tillers m⁻². Zheng et al. (2002) observed that seed priming produced more number of tillers per unit area in rice and wheat over non primed seed which is similar with the result of this experiment.

Panicle weight (g)

The panicle weight has direct correlation with the yield so it is important yield attributing character. Statistically significance difference was found in tillage factor while statistically non significance was found in seed priming and mulching factors (Table 2). The highest panicle weight was measured in minimum tilled plot (3.69 g/panicle) while 3.39 g was obtained in non-tilled plot. The interaction effect showed that there was non-significance effect observed between tillage, Seed priming and mulching. Minimum tilled plots produced heavier panicles compared to non-tilled plot while no significance influence on priming and mulching plots.

Effective grains per panicle

Statistically significant effect was found due the effect of tillage on effective grains per panicle while non-significant effect was found on mulching and seed priming plots (Table 2). The higher effective grains per panicle (135 tillers) were found in minimum tilled plots while only 122 effective grains per panicle in zero tilled plot. However, significant effect was found due to the interaction

Table 2. Effect of tillage, seed priming and mulching on phenological, growth, yield and yield attributing characters of rice in the experiment during 2017

Treatments	Maturity Days	Plant height(cm)	Panicle weight (g)	Effective grains / panicle	Straw yield (t ha ⁻¹)
1.Tillage:					
a.Zero	116	90.7 ^b	3.39 ^b	122 ^b	6.42 ^b
b.Minimum	118	98.6 ^a	3.69 ^a	135 ^a	7.39 ^a
F-test (at 5%)	NS	**	**	**	**
2.Seed priming:					
a .Primed	117	94.0	3.63	129	6.94
b. Non primed	117	95.2	3.46	127	6.87
F-test (at 5 %)	NS	NS	NS	NS	NS
A×B	NS	**	NS	*	NS
3.Mulching :					
a.Mulching	117	95.2	3.575	129	6.89
b.Non-mulching	117	94.1	3.51	127	6.92
F-test (at 5 %)	NS	NS	NS	NS	NS
A×C	NS	NS	NS	**	**
B×C	NS	NS	NS	*	*
A×B×C	NS	NS	NS	NS	*
LSD	2.81	3.40	0.25	5.03	0.52
CV%	1.37	12.1	3.99	12.24	14.31
Grand mean	117	94.6	138.20	128.08	6.90

Note *=Significant at 5%), **=Highly significant at P(0.05%), NS= non significant
LSD= least significant different

Table 3. Effect of tillage, seed priming and mulching on phenological, growth, yield and yield attributing characters

Treatment	Sterility (%)	Test weight (g)	Harvest index (%)	Grain yield (t ha ⁻¹)
1.Tillage:				
a.Zero	8.81	26.93	29.44	2.69
b.Minimum	5.78	27.48	31.87	3.46
F-test (at 5%)	**	NS	NS	**
2.Seed priming:				
a .Primed	7.51	26.93	30.87	3.13
b. Non primed	7.08	27.48	30.44	3.02
F-test(at 5 %)	NS	NS	NS	0.46
A×B	*	NS	NS	NS
3.Mulching:				
a.Mulching	7.61	27.38	30.55	3.07
b.Non-mulching	6.98	27.03	30.76	3.09
F-test (at 5 %)	NS	NS	NS	NS
A×C	*	*	NS	*
B×C	NS	NS	NS	*
A×B×C	NS	*	NS	*
LSD	1.75	0.66	3.24	0.46
CV%	13.17	1.39	6.03	18.47
Grand Mean	7.30	27.21	30.65	3.10

Note: *= Significant at 5% **, = highly significant at 5%, NS= non significant
LSD= least significant difference

of tillage and seed priming, tillage and mulching.

The minimum tilled plots showed good response from seeding to maturity of crop. Early germination, tall plant height, more number of effective grains, higher grain and straw yield compared to non-tilled plots.

Harvest index (%)

Statistically non- significant difference was found due to effect of tillage, seed priming and mulching on harvest index (table 3). Mustafa et al. (2018) on wheat reported that tillage practice and seed priming technique were statistically non-significant to harvest index which is also found in our findings too.

Grain yield (t ha⁻¹)

Statistically non- significant effect was found due to the effect seed priming and mulching on grain yield while significant effect was found due to tillage on grain yield (Table 3). The highest grain yield was found in minimum tillage (3.46 t ha⁻¹) while 2.69 t ha⁻¹ was obtained from no-tilled plot, while non-significant effect was found in priming and mulching treatment. The highest grain yield of minimum tillage plot may be due to highest number of effective grains per panicle, less sterility, more panicle weight and test weight. The significant effect was found due to interaction of tillage and mulching, seed priming and mulching and tillage, seed priming and mulching .The significant effect was found due to interaction of tillage and mulching may be due the effect of tillage on mulching. Higher grain yield also may be due to more availability of nutrients and soil moisture for

the longer period which might be minimized the sterility percentage of crop.

The increased grain yield attributes might be due to increased growth and development parameters which ultimately resulted in increased grain yield. These results corroborated the findings of Bhatt et al. (2004) and Hussain et al. (2013).

Sterility (%)

Statistically significant effect was found due to the impact of tillage on the sterility percentage. Regarding the seed priming and mulching non-significant effect was displayed on the sterility percentage. However, significant effect was found due interaction of tillage and seed priming and tillage and mulching

Test weight (g)

Statistically non- significant difference was found due to effect of tillage, seed priming and mulching on test weight (table 3). Mustafa et al. (2018) on wheat reported that tillage practice and seed priming technique were statistically significant to test weight. However, significant effect was found due to interaction of tillage and mulching and seed priming and mulching.

Straw yield (t ha⁻¹)

Statistically significant effect was found on the straw yield due to tillage which was found due to the highest plant height and the highest number of effective tillers per m². The highest plant height of 98.57 cm and the highest number effective tillers per m² of 143 were found in minimum tillage while the lowest plant height of 90.67 cm and the lowest

number of effective tillers per m² of 134 were found in zero tillage (Table 2). However, significant effect was found due to interaction of tillage and mulching, seed priming and mulching and tillage, seed priming and mulching

CONCLUSIONS

Minimum tillage, seed priming and mulching practices all are water conserving practices for drought condition rice. For grain yield, T₅ (Minimum tillage + seed priming + mulching) was found best among the tested treatments while the interaction between the factors i.e. tillage, seed priming and mulching was more efficient for yield and yield attributing characters. The interaction between primed seed and minimum tillage showed significant difference for plant height. Minimum tillage showed the highest grain yield among the tested factor while the seed priming and mulching have no distinct significance among treatments.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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REFERENCES

- Asal M.B.A. Taheri G. (2012) Survey the effect of seed priming on germination and physiological indices of cotton khordad cultivar. 1. *Annals of Biological Research*, 3: 1003–1009.
- Arora V. K. Gajra P. R. Prihar S. S. (1991) Tillage effect on corn in sandy soil in relation to water retentivity, nutrient and water management and seasonal evaporability. *Soil and Tillage Research*, 21: 1-21.
- Bhatt R. Khera K.L. Arora S. (2004) Effect of tillage and mulching on yield of corn in the sub mountaneousrainfed region of Punjab, India. *International Journal of Agriculture and Biology*, 6(1):126-128.
- Du L.V. Tuong T.P. (2002) Enhancing the performance of dry-seeded rice: effects of seed priming, seedling rate and time of seedling. In S. Pandey, M. Mortimer, L. Wade, T.P. Tuong, K. Lopes and B. Hardy (Eds.). *Direct seeding: Research, strategies and opportunities*. 4. International Rice Research Institute, Inst. Manila, Philippines, pp: 241-256.
- Farooq M. Siddique K.H.M. Rehman H. Aziz T. Le Dong-Jin Wahid A. (2011) Rice direct seeding: Experiences, challenges and opportunities. 5. *Soil and Tillage Research*, 111: 87–98.
- Gautam D. Kandel B.P. Adhikari B.B. (2018) Performance of rice genotypes in western mid hill of Nepal. 6. *Journal of Plant Breeding and Genetics*, 6 (3): 111-116.
- Harris D. Raghuwanshi B.S. Gangwar J.S. Singh S.C. Joshi K.D. Rashid A. Hollington P.A. (2001a) Participatory evaluation by farmers of on farm seed priming in wheat in India, Nepal, and Pakistan. *Experimental Agriculture*, 37: 403-415.
- Hussain S. Ramzan M. Rana M.A. Mann R.A. Akhter M. (2013) Effect of various planting techniques on yield and yield components of rice. *The Journal of Animal and Plant Sciences*, 23(2):672- 674.
- Kandel G. Adhikari B.B. Adhikari R. Kandel B.P. (2019) Evaluation the growth, productivity and profitability of rice (Sukhadhan-3 variety) under different methods of weed management. *Journal of Research in Weed Science*, 2(4), 381-392. DOI: 10.26655/JRWEEDSCI.2019.4.8
- MoAD-Ministry of Agriculture Development. (2016/17) Stastical Information of Nepalese Agriculture. Ministry of agriculture development, Agriculture information and training centre, Hariharbawan, Lalitpur.
- Mustafa A. Ahmad R. Farooq M. Wahid A. (2018) Effect of Seed Size and Seed Priming on Stand Establishment, Wheat Productivity and Profitability under Different Tillage Systems. *International journal of agriculture and Biology*, 20: 1710–1716. DOI: 10.17957/IJAB/15.0656
- Pandey S. Velasco L. (2002) Economics of direct seeding in Asia: Patterns of adoption and research priorities. In “Direct Seeding: Research Strategies and Opportunities” (S. Pandey, M. Mortimer, L. Wade, T. P. Tuong, K. Lopez, and B. Hardy, Eds.), pp. 3–14. International Rice Research Institute, Los Ban~os, Philippines.
- Pandita V.K. Anand A. Nagarajan S. (2007) Enhancement of seed germination in hot pepper following presowing treatments. 13. *Seed Science and Technology*, 35: 282–290.

- Rowse H.R. (1995) Drum priming-A non-osmotic method of priming seeds. 13. Seed Science and Technology, 24: 281–294.
- Sarangi S.K. Saikia U.S. Lama T.D. (2010) Effect of rice (*Oryza sativa*) straw mulching on the performance of rapeseed(*Brassicacampestris*) varieties in rice–rapeseed cropping system. Indian Journal of Agricultural Sciences, 80 (7): 603–605.
- Sarkar R. and S. Das (2006) Yield of rainfed loaland rice with medium water depth under anaerobic direct seeding and transplanting. Journal of Tropical Science, 43(4):192-198.
- Tuong L. (2008) Studies on direct-seeding adaptability of Cambodian rice cultivars and development of cultivars with good eating quality. PhD thesis, Science of Plant and Animal Production, United Graduate School of Agricultural Science, Tokyo University of Agriculture and Technology, Japan.
- Wassmann R. Hien N.X. Hoanh C.T. Tuong T.P. (2004) Sea level rise affecting Vietnamese Mekong Delta: water elevation in flood season and implications for rice production. Climate Change, 66:89-107.
- Zheng H.C. Hu J. Zhi Z. Ruan S.L. Song W.J. (2002) Effect of seed priming with mixed- salt solution on germination and physiological characteristics of seedling in rice under stress conditions. Journal of Zhejiang University, 2: 175-178.