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Effect of Different Methods and Planting Density on the Growth and Yield of Spring Rice at Tikapur, Kailali

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Abstract

A field experiment was conducted at Agronomy farm, Far Western University, Tikapur-1 to study the effect of different planting methods and density on yield of spring rice variety (chaite-4), when sown a month earlier than normal time. The research was laid out in randomized complete block design (RCBD) with seven treatments and three replications during Feb-June, 2022. The treatments consisted of planting methods viz. early broadcasting (T_1), early line sowing (T_2) on the day of nursery bed (1st Feb), transplanting 20 hills m^{-2}(T_3), transplanting 30 hills m^{-2} (T_4), transplanting 40 hills m^{-2} (T_5), late broadcasting (T_6) and late line sowing, (T_7) on the day of transplanting (2nd Mar). The results showed that transplanting significantly outperformed broadcasting method of rice planting in terms of yield attributing traits and yield. Broadcasting method showed significant reduction in tiller number, biological yield and grain yield than line sowing. But performance of late line sown rice was better than early line sown rice. Similarly transplanting 30 hills m^{-2} showed significant effect in early tiller formation followed by 20 hills^{-2}resulting in significant increase in grain yield of spring rice as compared to transplanting 40 hills m-2. There was no difference in tiller number between line sown rice either early or late. This study recommends sowing of 30 hills m-^{2} and suggests further research on line sowing of spring rice at different dates ranging from 1st February to 3rd March at same planting density to define appropriate time for preponing planting time under similar condition.

Keywords: Transplanting, direct seeding, broadcasting, Chaite Dhan

Introduction

Rice (Oryza sativa) occupies special place in Nepalese diet as well as its culture and hence is cultivated in 73%, 24% and 4% in different ecological zone i.e. Terai, Hills and Mountain respectively (Banos, 2018). Rice contributes 18 % to the agriculture GDP of the country and is grown across agro ecological zones ranging from 50-3000 masl during both the spring and rainy season in Nepal (Choudhary et al., 2022). Spring rice, also called Chaite Dhan in Nepal, is cultivated in 50 districts covering an area of 112313 ha, out of which 69.67% land area lies in Terai region only. Similarly, out of 1703 ha land area under spring rice in Far Western Province, Kailali has the largest area (637ha) followed by Darchula, Kanchanpur, Baitadi and Doti respectively (CDD, 2015). The area under spring rice is very low as compared to rainy season rice, but the production per unit area is higher i.e. 4.66 ton per ha than rainy season rice i.e. 3.74 ton per ha (Jaishi et al., 2020). Despite the higher production per unit area of spring rice, farmers prefer to grow rainy season rice over spring rice due to lack of irrigation water, no choice of fine aromatic disease resistant rice varieties, and lack of drying and storage facilities for spring rice. As the harvesting time of spring rice coincides with rainy season, the harvested products or bi-products could not be stored and used properly. So, preponing the transplanting time and identifying proper method of sowing or transplanting may improve this situation.

With the expansion of irrigation facilities and developing the practices of early sowing through different methods, spring rice could open windows for improving food production and reducing the import of rice in Nepal. As summer heat stress has been identified as the key environmental factor in limiting the yield of rice, growers are more concerned to avoid this stress at least at flowering and grain filling stages (Wang et al., 2019). So, in the context of fluctuating temperature and seasonal variation, it is important to identify appropriate proper time for sowing/transplanting for overcoming the heat stress of summer and harvesting spring rice before the onset of monsoon.

Methodology

This experiment was conducted in Agronomy Farm, Faculty of Agriculture, Far Western University, Tikapur, Kailali (28° 30' 0.00" N Latitude and 81° 07' 59.99" E Longitude) during the month of February-June 2022. The soil was sandy loam with very gritty texture, and low organic carbon content. The maximum and minimum temperature of this location during the growing season was 40.8 ^{0}C during May and 8.3 ^{0}C during February respectively. The site received rainfall of 21.73 mm during the growing period. The pH of soil was neutral having normal to dry moisture content and soil temperature during first sowing was 22.22 ^{0}C. The experiment was laid out in Randomized Complete Block Design with three replications and seven treatments. Each plot receiving a treatment was 5mx5m. Chaite-4 variety recommended for Terai region of Nepal was treated with Trichoderma and Pseudomonas 6 hrs prior to sowing. Dry bed was prepared for both nursery bed and direct sowing of rice seed. Crop was fertilized with half dose of N and full dose of P and K with Urea, Single super phosphate and Muriate of potash at the rate of 120:40:40 kg NPK/ha and Zinc Sulphate at the rate of 25kg/ha at the time of land preparation. On February 1st seeds were broadcasted uniformly in T_1 plots, seeds were sown continuously in rows prepared 15cm apart in T_2 plots and seeds were sown in nursery beds simultaneously. On 2nd March, two seedlings were transplanted maintaining 30 hills m^{-2} (T_3), 20 hills m^{-2} (T_4) and 40 hills m^{-2} (T_5). On the same day, seeds were broadcasted uniformly (T_6) and seeds were sown continuously in rows prepared 15cm apart as (T_7) treatments. For weed control, Petrilachlor was applied in the field 2 days after sowing and manual weeding was done twice to control weeds. Harvesting was done as and when the crops were mature.

Important growth parameters like plant height (ground to tip of the plant), tiller count m^{-2} were recorded at 48 days of transplanting and at the time of harvest. Similarly, all yield components like plant population m^{-2}, effective tillers m^{-2}, length of panicles, no. of grains per panicle, grain yield, above ground biomass were recorded at the time of harvest. Recorded data were analysed using R-studio and treatments were compared using least significant difference test at 5% level of significance.

Results and Discussion

Plant establishment was poor in the early broadcasted treatments due to lower temperature of about 8.5^0C during the day time for a week after sowing. Germination also delayed about 12 days in the main plots than the nursery bed, which received intense care and higher temperature due to mulching. However, seedling growth at both the early broadcasted treatments and nursery bed were very poor due to exposure to cold temperature. Loss in seedling vigour, increased plant mortality and low number of seedlings due to low temperature at early stages has been reported by Baruah et al. (2009) & Nishad et al. (2018). Similarly, in the late broadcasting and late line sowing, plant stand and early tiller count was very poor owing to severe weed crop competition at early growth stages despite weed control measures.

Total Tiller Count

On an average, early tiller count ranged from 9 to 13 with the highest count from 30 hills m^{-2} followed by 20 hills m^{-2} and line sowing late which recorded 10.46 and 9.66 tiller $plant^{-1}$ respectively. The number of tiller $plant^{-1}$ was lowest at early broadcasting. While line sowing early and late as well as broadcasting late was at par with 40 hills m^{-2} in bearing number of tillers plant^{-1}. Early and late broadcasting treatments were at par in generating number of early tillers per plant.

Significantly higher number of tillers m^{-2} as well as panicle bearing tillers were obtained from the transplanted treatments over the broadcasted treatments whether late or early, at the time of harvest as shown in table 1. At the time of harvest, 421 tillers m^{-2} was observed from the treatment with 40 hills m^{-2}, which was statistically at par with all the transplanted treatments.

Table 1

Plant height, tiller number and effective tillers^{-2} of rice at different planting density and methods

Treatments	Plant Height (cm)	Total Tiller Count m^{-2}	Number of Effective tiller m^{-2}
40 hills m^{-2}	71.45^{abc}	421.00^{a}	292.00^{a}
30 hills m^{-2}	74.75^{a}	352.00^{a}	301.00^{a}
20 hills m^{-2}	73.48^{ab}	404.00^{a}	253.00^{ab}
Early Broadcasting	66.63^{bc}	250.00^{b}	87.00^{c}
Early Line Sowing	64.37^{c}	168.00^{b}	140.66^{bc}
Late Broadcasting	65.90^{bc}	184.30^{b}	139.00^{bc}
Late Line Sowing	65.53^{bc}	174.00^{b}	171.60^{bc}
C.V.	6.57	17.99	39.12
$LSD_{0.05}$	8.05	89.32	137.77
F-test	0.07.	0.01**	0.03*

Number of Effective Tillers

However, the number of effective tillers m^{-2} was the highest at 30 hills m^{-2}, which was 301 followed by 40 hills m^{-2} (292) and 20 hills m^{-2} (253) respectively. This result is in line with the findings by Faruk et. al. (2009) who also reported significantly lower yields when transplanted at lower density. Due to larger canopy cover and less exposure of sandy loam soil to direct sunlight for quick drying of soil might have supported for better performance of these treatments whereas chilling injury after emergence may be the reason for lesser number of tillers at early broadcasted treatments (Sthapit, 1992). Significantly lowest number of effective tillers m^{-2} was found at early broadcasting with only 87 tillers. Lesser number of tillers in broadcasting or line sowing at both the dates might be due to higher competition among the plants for sunlight, water and nutrients (Tao et al., 2007 & Wang et al., 2017).

Plant Height

Plant height at the time of harvest ranged from 64.36cm to 74.75cm with the tallest obtained from the treatment 30 hills m^{-2} and the lowest from treatment early line sowing. Statistically the differences among the treatments on plant height was non-significant. Plant height from treatment 20 hill m^{-2} was found to be taller than plants from 40 m^{-2} and broadcasting methods, whether it be late or early due to greater spaces for nutrient and water uptake at early stages. Plant height from early line sowing was inferior than early broadcasting.

Table 2

Grain weight, panicle weight, filled grains per panicle of rice at different planting density and methods

Treatments	Grain weight gm m^{-2}	Panicle weight gm m^{-2}	Number of filled grains $panicle^{-1}$	% of filled grain
40 hills m^{-2}	68.00^{bc}	120.00	4.66	3.09
30 hills m^{-2}	132.00^{a}	135.33	6.62	5.18
20 hills m^{-2}	98.00^{ab}	139.00	8.75	5.04
Early Broadcasting	27.66^{c}	30.00	3.94	3.79
Early Line Sowing	64.00^{bc}	93.00	4.97	3.09
Late Broadcasting	25.00^{c}	56.66	4.29	3.66
Late Line Sowing	61.66^{bc}	76.66	4.30	3.38
C.V.	41.93	45.78	51.97	50.90
$LSD_{0.05}$	50.80	75.76	4.96	3.52
F-test	0.01**	0.06.	0.39	0.72

Spikelet Per Panicle

Highest number of spikelet $panicle^{-1}$ was observed from 20 hills m^{-2}, which was 172.6 followed by early line seeding (147.6) and 40 hill m^{-2} (135.5). The lowest number of spikelet was observed from the treatment late broadcasting, which was only 103.36.

Filled Grains Per Panicle

The number of filled grains per panicle ranged from 1 to 11 with the highest number of filled and unfilled grains from 20 hills m^{-2} which was on an average of 8.75 and 166.57 respectively. Similarly, the lowest number of filled grains was observed from the field with early broadcasting (3.94) and late broadcasting (4.3). Higher day temperatures of around 40^0C during the panicle initiation and flowering time i.e. May 17-19 were the key reasons for lower number of filled grains due to spikelet infertility. Prasad et al. (2006) reported that the heat episodes can increase spikelet sterility, which is also emphasized by Prasad et al. (2017) who reported that increased temperature damages the reproductive processes in cereal crops. All the direct seeding practices yielded lesser number of filled grains at an average of 4 per panicle. At the time of booting, low anther dehiscence and pollen shedding onto the stigma and drying of flowers can cause spikelet infertility (Hussain et al., 2019), leading to more unfilled grains $panicle^{-1}$. The treatment with 40 hills m^{-2} also yielded same number of filled grains as line sowing. Severe heat and moisture stress during and post flowering were the major cause of lesser number of filled grains per panicle. High temperature aggravates spikelet degeneration and destroy floral organ development (Wang et al., 2019).

Table 3

Grain yield, straw yield and harvest index of rice at different planting density and methods.

Treatment	Biological yield (t/ha)	Grain yield (t/ha)	Harvest Index
20 hills per sq.m	9.18^{a}	0.78^{ab}	0.08^{ab}
30 hills per sq.m	9.59^{a}	1.05^{a}	0.11^{a}
40 hills per sq.m	8.58^{a}	0.54^{bc}	0.07^{bc}
Early Broadcasting	3.70^{c}	0.20^{c}	0.05^{cd}
Early Line Seeding	5.04^{bc}	0.51^{bc}	0.10^{a}
Late Broadcasting	6.68^{abc}	0.22^{c}	0.03^{d}
Late Line seeding	8.10^{ab}	0.49^{bc}	0.06^{bc}
C.V.	25.25	41.93	19.03
$LSD_{0.05}$	3.26	0.40	0.02
F-test	0.01*	0.01**	0.00***

Weight of Panicle

Average weight of panicle was recorded highest from 20 hills m^{-2} followed by 30 hills m^{-2} and 40 hills m^{-2} with an average of 139gms, 135 grams and 120 grams respectively. The average weight of panicle m^{-2} ranged from 30 to 139 gm with the highest from 20 hills m^{-2} and the lowest from the treatment where seeds were broadcasted early. Our findings corroborate with the research conducted at Iran on rice, which also reported the highest grain yield when planted at 33.3 hills m^{-2} (Alipour Abookheili & Mobasser, 2021). Similarly, number of filled grains $panicle^{-1}$ was the highest in the treatment 20 hills m^{-2} as compared to all other treatments. Due to extreme temperature rise during booting and flowering of the crops at different time periods, grain yields were several folds lower than expected. Among the treatments, grain weight from the treatment 30 hills m^{-2} (132 gm) was significantly higher than 20 hills m^{-2} (98 gm) followed by other treatments.

Grain Yield (t/ha)

Statistically treatments viz. 40 hills m^{-2}, late and early line sowing were at par in yielding grain weight m^{-2}. This result is in line with the finding by Halder et al., (2018), who reported increased plant yield at spacing of 20cm x 20cm in aromatic rice than at higher planting density. As shown in Table 3, lower planting density exhibited significant effects on grain yield and its components. The highest grain yield was obtained from 30 hills m^{-2}, which was 1.32 t ha^{-1}followed by 0.98 t ha^{-1} from 20 hills m^{-2}. This result contradicts with the findings by Amin et al., (2004) who reported significant increase in yield at higher planting density. Grain yields obtained from the plots with 20 hills m^{-2} was almost two times lower that that obtained from 30 hills m^{-2} indicating lack of effective tillers at later growth stages, when planted at lower density. Grain yield was significantly at par among the treatments viz. 20 hills m^{-2}, early and late line seeding, which were near to 0.68 t ha^{-1}. Akhagari & Kaviani (2011) also reported nearly equal grain yields from direct seeded and transplanted rice with similar planting density. The lowest grain yield (0.25 t ha^{-1}) was obtained from early broadcasting due to lesser number of effective tillers, spikelet number per panicle and filled grains per panicle. Several researches have shown significant effect of planting time on growth and yield of spring rice (Poudel et al., 2020; Regmi et al., 2020).

Biological Yield (t/ha)

All the transplanted treatments were statistically at par in total biological yield with an average of 9 t ha^{-1} over broadcasting methods. The treatment late line sowing was statistically superior to late broadcasting, early broadcasting and early line sowing. Broadcasted rice at the time of nursery bed preparation i.e. early broadcasting yielded significantly biological yield., only 3.70 t ha^{-1} as compared to that broadcasted at the time of transplanting 6.68 t ha^{-1}. It implies that broadcasting at cooler months i.e., early February yields almost 50% less biomass than when broadcasted later at Tikapur condition. Transplanted rice at all the planting density provided significantly higher biological yield than directly sown rice under both late and early sown condition. Our findings contradict with the results obtained by Gill et al. (2006), who reported increased dry matter accumulation, leaf area and effective tillers from direct seeded rice as compared to transplanted rice. Similarly, line sowing performed significantly better in providing biomass than broadcasted rice whether it be early or late sown.

Harvest Index

Harvest index also showed significant differences among the treatments compared. Early line sowing and 30 hills per square meter were statistically at par in yielding harvest index, which was also greater than all other treatments. Transplanted rice were efficient in accumulating dry matters in grains as compared to broadcasted rice.

Conclusion

The study shows that transplanting of spring rice is far better than direct seeding whether it be on line or broadcasted. Transplanting 30 hills m^{-2} is highly recommended to farmers for obtaining better yield. It was observed that broadcasting method yielded significantly lesser amount of grain i.e. about 20 percent lesser than line sowing indicating that broadcasting paddy for spring rice is not recommended in similar soil and climatic condition. Since, the weather condition was so much harsh that all the treatments performed poorly so much so that the yields are several times lower than expected. The impact is so high that the absolute results are difficult to comprehend however further research on line sowing of spring rice at different dates ranging from 1st February to 3rd March at same planting density is recommended to define appropriate time for preponing planting time.

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Conflict of Interest

The author(s) declared no potential conflict of interest with respect to the research, authorship and/or publication of this article.

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