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Determination of the effect of numbers of seedlings and spacing on weed dynamics and vegetative growth of hybrid rice (US-312)

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Abstract
The aim of this study is to "determine the effect of numbers of seedlings and spacing on weed dynamics and vegetative growth of hybrid rice". The research was conducted in Thakre-11, Dhading district of Nepal. For this research 30 plots of 2mX3m of individual size were made. Plot 1, 2 and 3 with 10 individual sub-plots were made. In those 10 subplots, 5 subplots were planted with single seedling with the spacing of 15X20, 20X20, 25X25, 30X20, 30X30and same with remaining double seedlings plot. After plantation numbers of leaves in several plots, plant height (cm), number of tillers per square meter, panicle length, weed population per square meter, pest and disease observation as well as root growth and development were observed in detail. Initially, data of each plot was taken and observed as mean number of leaves in each plots after 45 days of plantation. In plot number 1, the average number of leaves of single seedling of rice was 28cm whereas those of double seedlings were 56. Similarly, in plot 2 the average number of leaves with single seedling was 32 and that of plot with double seedlings were 60. Similarly, in plot number 3, single seedling had leaf number of 29.3 and that of double seedlings were 57 in average. Also, the height of plant after 28 days of transplantation was measured. The measurement of average height in plot 1 was taken as 33.8cm and 33.2cm of single and double seedling plot respectively. In plot 2 with single seedling average of 32.8 cm and double seedling with 32cm was observed. Finally, plot with single seedling with height of 35.4cm and double seedling with height of 33.2cm were observed in plot no 3. Moreover, after 45 days of transplanting, the number of tillers per square meter was recorded. In plot 1 with single seedling, average of 8.3 and double seedling with 7.2 tillers were recorded. Similarly, in plot 2 with single seedling, tiller number of 7.8 and double seedling with 7.5 tillers were observed. Lastly, in plot no. 3, single seedling had 8.4 tillers and double seedlings with 7.6 tillers were observed. Again, to determine the number of leaves in tillers after 38 days of transplantation, rice leaf was counted. After the study it was found that in plot 1, 38.8 with single seedling and 38.2 numbers of leaves in plot 2 with double seedling was observed. Also, average of 37.9 and 37.8 numbers in single and double seedlings in plot number 2 were recorded respectively. In case of plot no 3, 39 and 38.7 average leaves per tiller were found in single and double seedlings as well. Furthermore, the amount of weed infestation was recorded in all 3 plots. The average number of 37 and 23, 31 and 26 and 36 and 16 were observed in 1squuare meter of planted single and double seedling in plot number 1, 2 and 3 respectively. Moreover, pest and disease infestation in plot of single seedling were observed more prevalent compared to that of double seedlings in all plots. Finally, after 42 days of transplantation, average growth and development of roots in plot number 1 were 22cm and 24cm long. Not only that average of 23 and 25, 24 and 21 were the length of roots in plots no 2 and 3 of single seedlings and double seedlings respectively.

Keywords: seedling, hybrid rice, vegetative growth, weed dynamics, root growth

Introduction
The rice planted area in the world is 157,000,000 ha. Half the world population eats it as staple food. Total production of Rice during 2020-21 is estimated at record 121.46 million tonnes. It is higher by 9.01 million tonnes than the last five years' average production of 112.44 million tonnes. There are 76,000 rice varieties in the International Rice Germplasm Center at International Rice Research Institute (IRRI). Rice (*Oryza sativa* L. var. Indica) is the most important cereal crop in agriculture and economy of Nepal. It shares about 20% to the agricultural gross domestic product (AGDP) and accounts about 53% of the total food grain production and covering more than 50% of the agricultural land area (NARC, 2007). It is the main diet of Nepalese people and meets more than 50% of their total calorific requirements (Central Department of Environment Science, Tribhuvan University, Kathmandu, 2016). Nepalese rice landraces have high level of genetic diversity that will be very important input for future improvement and sustainability of rice based production system Using molecular

markers, and Bajracharya *et al.* (2004) [3] concluded that Nepalese rice landraces have unique gene pool. Vast diversity on rice landraces is the major characteristics of the Nepalese rice germplasm. Panicle and grain characteristics are major criteria to access the variation in rice germplasm. Only a small amount of rice (*Oryza glaberrima* St.) is grown in Africa, mostly in the south-western and central part of the continent (Rajbhandari, 2008) [18].

Materials and Methods

The research was carried out at Thakre-11, Dhading district which is 35 km from capital city Kathmandu of Nepal. The research was carried out from June 2nd to August 15th, 2021. Experimental site possesses semi temperate climate type having average 27 ºC -29 ºC during the time of cultivation. Total annual rainfall reported was 1600 mm with the highest rain in the month of July as 60-90% of the annual rain. The average humidity reported was 60%. The soil status of the site was loam to clay loam in texture with slightly acidic in reaction (pH 5.5-6.5).

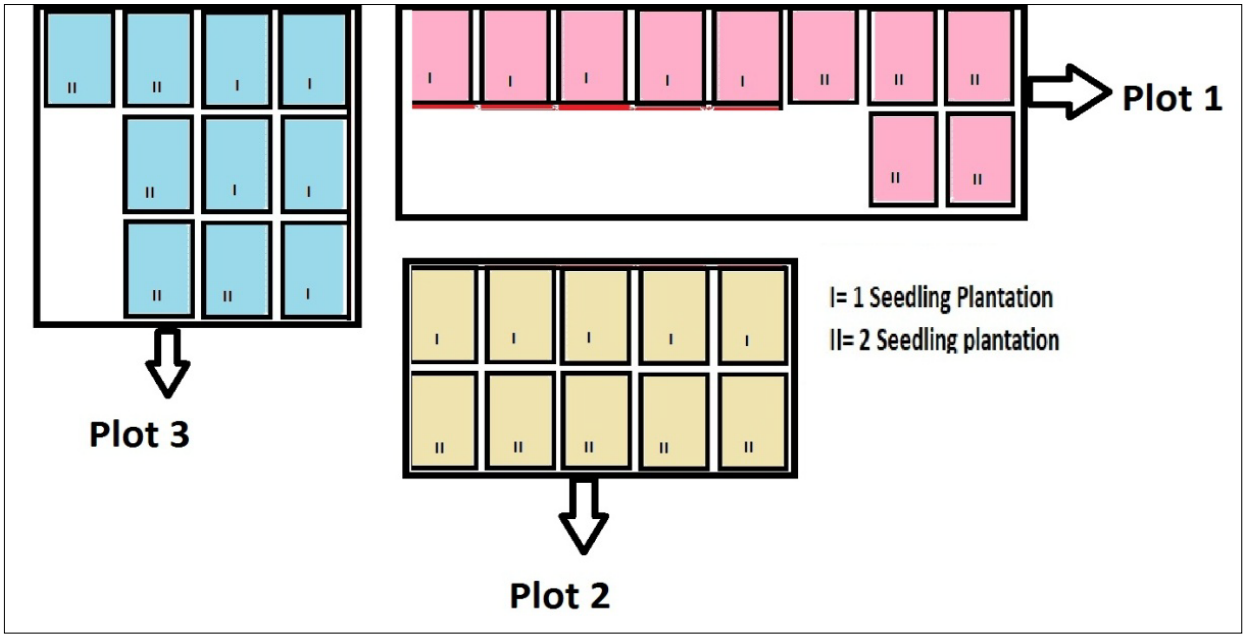
A nursery bed of length 3mX2m was made and seeds were broadcasted in raised bed. The variety of rice was US-312. When the seedlings were 25 days old, transplantation was done. The field was divided into 3 equal plots for replication. Each replicated plot was again subdivided into 10 individual plot of size 3mX2m each. Out of 10 replicated plots, 5 plot was transplanted with single seedling and remaining 5 plots with double seedlings of spacing 15cmX20cm, 20cmX20cm, 25cmX25cm, 30cmX20cm, 30cmX30cm.

Data of various parameters were taken during the experiment and evidences were recorded, tabulated and statistically computed. The data on the analysis of variance after statistical analysis are given in the appendix section. The results are illustrated with detailed diagrams.

The main aim of the research is to evaluate the rice performance in vegetative stages. Rice was planted in several plots in several distances. Altogether 7 parameters of genotypes of rice with three replications were studied. All the parameters under study were statistically analyzed to determine if there is any significant difference within the observations. The data collected were shown on bar- diagram too.

Various parameters under study

- Number of leaves in tiller
- Plant height (cm)
- Number of Tillers per square meter
- Panicle length
- Weed population per square meter
- Pest and disease observed
- Root growth and development



In these 3 replicated plots average number of leaves in tiller, plant height of different plots, number of Tillers per square meter, panicle length (cm), weed population per square meter, pest and disease along with root growth and development was observed. The data was taken at different time for different treatments. Counting the number of leaves in tiller was done after 45 days, plant height was taken after 28 days, number of tillers per square meter was counted after 45 days, number of leaves in tiller was counted after 38 days, weed population per square meter after 40 days, pest and disease after 30 days and root growth and development after 42 days. The plot was designed in Photoshop and data was analyzed at MS-EXCEL and mean and mode.

Result and Discussion

This section includes the results of the findings after its analysis and interpretation. It deals with the findings of the experiment entitled “determination of the effect of numbers of seedlings and spacing on weed dynamics and yield of hybrid rice”, conducted during the rainy season of year 2021. Various intercultural operations were carried out from nursery bed preparation, transplantation, weeding and so on.

Table 1: Observations from single and double transplanted rice seedling

Single seedling												
S. No.	**Spacing**	**Plot**	**Average height of individual plant**	**Average height of all plot**	**Average tiller per square meter per plant**	**Average no. of tiller of all plots**	**Average no. of leaves in tiller**	**Average leaves of all plots**	**Weed population per square meter**	**Average weed of all plot**	**Root growth & development**	**Average root length of all plot**
1	15X20	1	37	34	8	7.06	40	35.33	33	29.33	21	22.1
2		2	33		7.2		36		27		23	
3		3	32		6		30		28		22.3	
4	20X20	1	36	33	7	7.5	35	37.5	31	32.66	24	23.33
5		2	31		8.1		40.5		30		26	
6		3	32		7.4		37		37		20	
7	25X25	1	35	34	7.87	7.1	39.35	35.53	37	30.66	22	22.36
8		2	34		6.45		32.25		33		21.8	
9		3	33		7		35		22		23.3	
10	30X20	1	33	33.33	8	7.33	40	37.5	27	28.66	25.8	23.55
11		2	32		7		35		29		24.54	
12		3	35		7.5		37.5		30		20.33	
13	30X30	1	31	31.33	7.2	7.066	36	35.33	36	33.66	23.5	23.16
14		2	33		7.8		39		34		24	
15		3	30		6.2		31		31		22	

Table 2: Observations from double transplanted rice seedling

Double seedling												
S. No.	**Spacing**	**Plot**	**Average height of individual plant**	**Average height of plant of all plots**	**Average tiller per square meter per plant**	**Average no. of tiller of all plots**	**Average no. of leaves in tiller**	**Average leaves of all plots**	**Weed population per square meter**	**Average weed of all plot**	**Root growth and development**	**Average root length of all plot**
1	15X20	1	31	32.66	6	6.4	33	35.2	31	31.33	22.7	20.9
2		2	33		5.8		31.9		33		21	
3		3	34		7.4		40.7		30		19	
4	20X20	1	32	33.33	6.4	6.466	35.2	35.56	35	28.66	16	18.66
5		2	34		6		33		27		19	
6		3	34		7		38.5		24		21	
7	25X25	1	35	36.3	7.6	6.98	41.8	38.4	26	31	22	21.8
8		2	36		6.35		34.9		32		22.4	
9		3	38		7		38.5		35		21	
10	30X20	1	35	34	7.7	6.896	42.35	37.9	32	33.33	23	21.33
11		2	34		6.64		36.52		35		20	
12		3	33		6.35		34.9		33		21	
13	30X30	1	32	31.66	7	6.6	38.5	37.3	36	35.3	20.47	20.82
14		2	32		6		33		36		23	
15		3	31		6.8		37.4		34		19	

Number of leaves in tiller

The counting of number of leaves was done after 45 days of transplantation. The plant had started producing several leaves as well as increase in size and number of tillers as well.

More the number of leaves more will be the rate of photosynthesis thus more will be production of food. In single seedling plot with a spacing of 20X20 and 30X20 has comparatively higher number of leaves per tiller. Similarly in case of double seedling plot, spacing of 25X25 has higher number of leaves. The data clearly shows that double seedling with a spacing of 25X25 has higher number of leaves as compared to that of single seedling having a spacing of 20X20 and 30X20. So, here plot with double seedling with spacing of 25X25 has higher number of leaves per tiller than any other spacing.

T. A. Ninad *et al.* 2017 [15] also reported in his experiment conducted at the research farm and laboratory of Crop Physiology and Ecology Department, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during April to August, 2016 to study the effect of spacing and number of seedlings on the yield of Aus rice variety showed that significant variations were observed in number of leaves at 55 and 75 DAT as influenced due to row spacing. In case of number of seedling, transplantation of 4 seedling showed highest number of leaves per hill while lowest number of leaves per hill from 1 seedling.

Plant height

Initially, the height of plant of each plot was observed. The observation was taken after 28 days of plantation. In single seeded plant, the plot with of 15X20 and 25X25 has comparatively faster growth and development of its height. And least height was 31.33 having a spacing of 30X30. Similarly for double seedling plot with spacing of 25X25 has higher growth and development than that of other spacing. Plot having spacing of 30X30 had comparatively least height. Different spacing and seedling number had great role in growth and yield characters of rice. S Pokharel, (2018) [17]. Thus, the best spacing for plant growth and development based on height is 25X25 with double seedling. But for single

seedling spacing of 15X20 and 25X25 shows best results.
The experiment conducted by T. A. Ninad *et al*. in 2017 [15] at the research farm and laboratory of Crop Physiology and Ecology Department, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during April to August, 2016 to study the effect of spacing and number of seedlings on the yield of Aus rice variety showed that plant height increased with decreasing row spacing. The tallest plant was recorded at 20 cm × 10 cm spacing while shortest plant was recorded at 20 cm × 25 cm spacing. The taller plant in densely populated plants might have resulted due to competition for sunlight than those of wider spacing as reported by Abbas *et al*. (1994) [1] Result showed that at 35, 55, 75 DAT and at harvest 4 seedlings showed the longest plant while 1 seedling showed shortest plant. The result was similar with the findings of results indicated that the longest plant was found in 20 cm × 10 cm spacing with 4 seedlings.

Number of tillers per square meter after 45 days
In this case, initially the measurement of 1 m square was marked in the field and number of tiller of each plant was counted.In case of single seedling, highest number of tiller was 7.5 in the plot with spacing of 20X20 after 45 days of transplantation. There was no significant different in number of tiller formation. But in double seedling the plot having the space of 25X25 has highest number of tillers of 6.98 in average. But this value is comparatively lesser than that of single seedling plot.
But, the results from other experiments conducted on different time frame by several researchers indicated various results. Faisul-ur-Rasoolm *et al.* (2013) [20] indicated that closer spacing of 15 cm x 10 cm, 15 cm x 15 cm and 15 cm x 20 cm were superior to wider spacing of 30 cm x 10 cm, 20 cm x 20 cm and 15 cm x 25 cm by producing more effective rice tillers per unit area, higher plant height, higher leaf area index and total dry matter accumulation. However, Bishnu *et al*. (2013) [4] on the other hand reported that wider spacing (25 cm x 25 cm, and 30 cm x 30 cm) produced significantly higher rice tillers, panicles per m^2, longer and weighty panicles, and higher grain yield than closer spacing (15 cm x 15 cm). While Ogbodo *et al.* (2010) [22] observed that plant height and number of rice tillers were significantly higher when crops were transplanted at 30 cm x 30 cm than at 10 cm x 10 cm and 20 cm x 20 cm. Nwokwu (2015) [16] on the contrary, reported that plant spacing at 40 cm x 40 cm only produced higher number of tillers, number of leaves, shorter days to 50% heading whereas plant spacing at 30 cm x 30 cm recorded longest panicles, more number of panicles and paddy yield but with no significant differences in plant height for the two different spacing.
In 2009, Mirza Hasanuzzaman conducted experiment at the Agronomy Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during August, 2008 to January 2009. From the study it was revealed that at initial stage (At 30 DAT) the tiller production was slow and it was not significantly affected by plant spacing. Maximum tillering occurred at 50 days after trans-planting and hence it was significantly affected by plant spacing. The maximum number of tillers at 50 DAT was due to the favorable and juvenile condition of rice plant to produce more tillers. After 50 DAT number of tillers decreased and trend continued up to harvest. This trend was due to tiller mortality. Garcia *et al*. 1994 [7] concluded that the tillering potential of the test varieties could be improved through appropriate plant spacing. Rodriguez and Ingram observed that tillers and productive tillers were influenced by row spacing.

Weed population per square meter
Rice is affected by several kinds of weed during its growth and development stages. During the research, plots have also been affected by several weed population. Weed such as *Echinocolacolona*, *Digitaria album*, *Cyprinusrotundus*, *Cynadondactylon*, *Cyprus iria* and so on was found after 40 days of transplantation. In case of weed population, single seedling plot with spacing of 30X30 has higher number and spacing of 30X20 has least number. Also, in case of double seedling plot with a spacing of 30X30 has higher number of weed infestation. But least infestation was found in plot with spacing of 20X20.
Chauhan, David, Bhagirath & Johnson (2011) [5] conducted field experiments during the wet season of 2009 and dry season of 2010 to determine the effects of row spacing and timing of weed control on weed growth and yield of aerobic rice. Rice grown in 30-cm rows had greater weed biomass and less grain yield than in 15-cm and 10–20–10-cm rows, weed growth and grain yields were similar between 15-cm and 10–20–10-cm rows.

Pest and disease
Rice is affected by different types of insects and pests, some of them are moths, rodents, birds, and caterpillar and so on. In our research, during the growth phase, some insects were spotted. Insects such as leaf eating caterpillar, moths were observed. But the spacing of seedlings was not significance with presence of insects and pest. As their numbers were less, they were controlled physically such as by using hands. Similarly to reduce blast infestation, field sanitation was conducted.
But the experiment which was conducted at farmer's fields in Kallar tract in Pakistan by Muhammad Asghar in 2020 concluded that the crop was free from the attack of rice plant hopper till 60 DAT. Their attack started 70 days after transplantation with significant high number (1.33 per plant) in 18 × 18 cm spaced crop. It is also evident that number of rice plant hoppers per plant increased gradually with the passage of time. It reached to a maximum level of 184 per plant at 100 DAT in 18 × 18 cm followed by 60 per plant in 23x23cm spacing. Statistically, these two treatments with narrow plant spacing were different significantly as compared to other two wide plant spacing i.e., 28 × 28 cm and 33 × 33 cm, where hopper population was low. On an average the number of hopper remained above ETL and was highest in 18 × 18 cm followed by 23x23cm spacing. It is clear that the incidence of RPHs remained high throughout the cropping season in those plants spacing where initial occurrence of the pest was high.
Deduction on similar patterns were made by Hong *et al*. (2017) [10] who stated that as all the rice pests are exogenous, and thus the initial population size of insect will directly affect the population development of the next generation. Therefore, the pest could be managed properly by reducing the initial population size and this in turn by increasing plant pacing. Such type of results were also described by Satpathi *et al*. (2012) [21] who attributed outbreaks of the brown plant hopper not only to heavy nitrogen fertilization, continuous cropping but also to high plant density. The results, however, were against those of Garcia and Sanchez (1994) [7] who investigated that hopper, insect predator and spider

populations were not significantly affected by rice crop variety and plant spacing.

Root growth and development

The status of root plays crucial role in plant growth and development. During research, roots of rice seedlings were carefully taken out and studied its growth and development. It was done at 42 days after transplantation to the field. In case of single seedling, plot having a spacing of 30X30 have comparatively higher growth of roots of 23.55cm. But the plot with spacing of 15X20 has lesser growth of roots of only 22.1 in average. In case of double seedlings, plot with spacing of 25X25 has higher length of roots of 21.8cm. But plot having spacing of 20X20 has lesser length of roots. Nitrogen (N) affects the seed quality by increasing proteins and decreasing oil concentration (Gudade *et al*. 2009) [9]. Sulphur (S) helps in the synthesis of cystein, methionine, chlorophyll, vitamins (B, biotin and thiamine), metabolism of carbohydrates, especially by its effect on the protolytic enzymes (Najar *et al*. 2011) [13].
Research carried by Yoichiro Kato *et al*. in 2007 [23] concluded that root length density and root weight density at 0-60 cm were highest in cultivar lemont, followed by Nipponbare and Yumeno-hatamochi. Root weight density at 30-60 cm was highest in cultivar lemont, but Root length density at 30-60 cm did not differ significantly among the cultivars.

Discussion

From the research it is now concluded that, there are several external as well as plant factor that is responsible for growth and development of rice. Among the several factor plant heights, number of tiller, number of leaves in tiller, weed distribution and pest effects on plant plays major role in rice production. According to an analysis, the best spacing for plant growth and development based on height of plant is in plot with spacing of 25X25 with double seedling. But for single seedling plot with spacing of 15X20 and 25X25 shows best result. The number of tiller formation in single seedling plot having the spacing of 20X20 has comparatively higher tiller than plot having spacing of 25X25 in double seedling. So Transplantation of single seedling at the spacing of 20X20 can produce higher number of tillers. Also, double seedling with the spacing of 25X25 has higher number of leaves as compared to that of single seedling having a spacing of 20X20 and 30X20. So, here plot with double seedling with spacing of 25X25 has higher number of leaves per tiller than any other spacing. For the analysis of weed infestation, the above evidence clearly shows that, plot with single seedling with an spacing of 30X30 have higher infestation of weed as compared to double seedling of same spacing. Least number of weed was found in double seedling with spacing of 20X20. So, double seedling with spacing of 20X20 seems to be best for less weed infestation and higher production. Finally, the higher number and length of roots growth is found in single seedling plot having a spacing of 30X30 which is about 2cm higher than plot with double seedling i.e. 21.8 cm on an average. Abdel-Sabour *et al*. (1999) [2] found that, dry matter of leaves, stem, flowers and economic part significantly increased by the application of organic manure due to the fact that, completely decomposed organic manure may have released the nutrients in available form.
Similar types of research was conducted in agronomy field of Lamjung campus during *kharif* season of 2017, titled "effect of spacing and number of seedling on grain yield and other agronomic traits of hybrid rice (U.S. 312) on late transplantation" (S. Pokharel, 2018) [17] revealed that the planting distance of 20X20 with triple seedlings showed desirable results.

Conclusion

From the research it is now concluded that, there are several external as well as plant factor that is responsible for growth and development of rice. Among the several factor plant heights, number of tiller, number of leaves in tiller, weed distribution and pest effects on plant plays major role in rice production. According to an analysis, the best spacing for plant growth and development based on height of plant is in plot with spacing of 25X25 with double seedling. But for single seedling plot with spacing of 15X20 and 25X25 shows best result. The number of tiller formation in single seedling plot having the spacing of 20X20 has comparatively higher tiller than plot having spacing of 25X25 in double seedling. So Transplantation of single seedling at the spacing of 20X20 can produce higher number of tillers. Also, double seedling with the spacing of 25X25 has higher number of leaves as compared to that of single seedling having an spacing of 20X20 and 30X20. So, here plot with double seedling with spacing of 25X25 has higher number of leaves per tiller than any other spacing. For the analysis of weed infestation, the above evidence clearly shows that, plot with single seedling with an spacing of 30X30 have higher infestation of weed as compared to double seedling of same spacing. Least number of weed was found in double seedling with spacing of 20X20. So, double seedling with spacing of 20X20 seems to be best for less weed infestation and higher production. The above evidence clearly shows that, single seedling with an spacing of 30X30 have higher infestation of weed as compared to double seedling of same spacing. Least number of weed was found in double seedling with a spacing of 20X20. So, double seedling with spacing of 20X20 seems to be best for less weed infestation and higher production. The higher number and length of roots growth occurs in single seedling plot having a spacing of 30X30 which is about 2cm higher than plot with double seedling. Amongst many factors responsible for its low productivity, the inadequate and imbalanced nutrition of essential nutrients is the most important. Again, the higher number and length of roots growth is found in single seedling plot having a spacing of 30X30 which is about 2cm higher than plot with double seedling i.e. 21.8 cm on an average.
Finally, Transplanting 25 days old single seedlings in different plots shows variable results which made it difficult to compare values. But in case of double seedlings the plot with spacing of 25X25 shows comparatively best combination for optimum crop production in vegetative stage.

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