

RESEARCH ARTICLE

CROP INTENSIFICATION PRACTICES FOR BETTER FINGER MILLET GROWTH

Menuka Pandey^{a*} Hemant Raj Awasthi^a, Roshan Subedi^a, Kamal Joshi^b^aInstitute of Agriculture and Animal Science (IAAS), Lamjung, Nepal^bInstitute of Agriculture and Animal Science (IAAS), Gokuleshor, Nepal*Corresponding Author Email: pandeymenuka303@gmail.com

This is an open access article distributed under the Creative Commons Attribution License CC BY 4.0, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

ARTICLE DETAILS

Article History:

Received 23 September 2023

Revised 15 October 2023

Accepted 18 November 2023

Available online 22 November 2023

ABSTRACT

The success of System of Rice intensification (SRI) has been extrapolated to numerous crops in the name of System of Crop Intensification (SCI). Similar to SRI, SCI practices tend to have beneficial effects, especially on the performance of tillering crops by optimizing tiller production. Therefore, a field experiment was conducted at a farmer's field in Sundarbazar, Lamjung from July 2018 to January 2019 to evaluate the influence of SCI practices on the performance of finger millet. The experiment was laid out in split plot design with three replications, comprising five varieties (Okhle-1, Dalle-1, KabreKodo-1, KabreKodo-2 and Local) as main plot factors and planting methods (Direct Sowing (DS) at 20 cm × 10 cm, Conventional Transplanting (CT) at 10 cm × 10 cm with 30 days old seedling and System of Crop Intensification (SCI) at 25 cm × 25 cm with 15 days old seedling) as sub-plot factors. Growth attributes like plant height, tillering habit and growth rates were recorded maximum in SCI method resulting in highest yield (2.75 tons/ha). The yield obtained from CT and DS was 14.90% and 29.69% less than SCI. Kabrekodo-1 variety recorded maximum height at harvest and growth rate during both vegetative and reproductive phases also the yield of this variety was higher than other varieties. Thus, the study revealed Kabrekodo-1 as potential variety of the area and SCI as a better option to increase performance of finger millet.

KEYWORDS

Conventional Transplanting, Crop establishment method, Direct Sowing, System of Crop Intensification, System of Rice Intensification

1. INTRODUCTION

Finger millet (*Eleusine coracana*) is small seeded, self-pollinated, robust, tufted and tillering, annual cereal crop belonging to family Poaceae (Michaelraj and Shanmugam, 2013). It is an important staple cereal food crop for millions of people in the semi-arid region of the world, particularly in Asia and Africa, especially those who live by subsistence farming (Shinggu et al., 2009). Africa (Ethiopian highland) is the center of origin and India is secondary center of diversity of finger millet (Gangaiah, 2016).

Owing to its ability to adjust to different agro-climatic conditions and inherent ability to recover against temporary abiotic stress, without appreciable deterioration in grain quality for nutritional ability, it has been indispensable part of dryland farming system. It withstands three challenges i.e. warming stress, water stress and nutrition stress so finger millet is called as Climate Change Compliant Crop (CCCC) (Ferry, 2014). It is an important crop of Nepal next to rice, maize and wheat and is cultivated in 267,071 ha of land with production of 339,462 tons and yield of 27 tons/ha (MoALD, 2022). It is grown up to 3150 masl. Its cultivation is an indispensable part of Nepalese farming system, especially in the mountain terrain of Nepal where agricultural land is limited and food deficit is a major problem (Subedi et al., 2009). The importance of the crop is more in subsistence farming system where it is grown without external input in marginal land and provides a sustaining diet for rural people (Khadka et al., 2013). It is superiorly nutritious food compared to other cereals (Bhandari et al., 2005; Dida and Devos, 2006). The grain contains 9.2% proteins, 1.29% fats, 76.32% carbohydrates, 2.2% mineral, 3.90%

ash, and 0.33% calcium. The straw of the plant is used as an important fodder for livestock mainly, during feed deficit months.

System of Rice Intensification (SRI) is a holistic agro-ecological crop management technique of agronomic manipulation based on some agronomic principles that work synergistically with others to achieve higher grain yield and also improves physiological activities of the plant and provides better environmental condition (Uphoff et al., 2002). It is based on six principles transplanting of young seedlings i.e. 8 - 12 days old seedlings to preserve growth potential, transplanting single seedling with wider spacing i.e. from 20 cm × 20 cm to 50 cm × 50 cm, controlled flooding (alternate drying and wetting), frequent weeding and use of organic manure (Stoop et al., 2002; Stoop, 2011). The success of SRI is based on synergetic development of both tillers and roots which comes from the combined interaction of all SRI practices (Defeng et al., 2002). With the adoption of these principles the production of rice has been reported to increase from 50 to 100 % (Uphoff, 2011). The success of SRI practices is being extrapolated to various crops like wheat, tuff grass, maize, sorghum, finger millet, soybean, blackgram, kidney bean, lentil, mustard, sugarcane, tomato, brinjal, chili, potato, carrot and onion in the name of the System of Crop Intensification (SCI) (ISD, 2009). Similar to SRI, SCI practices have also proved to increase twice the yield levels of the crops (Uphoff et al., 2011). In recent years, SCI has emerged in a several Asian and African country, raising the productivity of the land, water, seed, labor, and capital resources that farmers invest can for growing a wide range of crops (Abraham et al., 2014).

The productivity of finger millet is very low compared to production potential of the area. Low productivity is attributed to low organic matter

Quick Response Code



Access this article online

Website:
www.rfna.com.my

DOI:
[10.26480/rfna.02.2023.71.77](http://doi.org/10.26480/rfna.02.2023.71.77)

in soil, lack of suitable variety selection and faulty or inappropriate planting methods. The planting method is one of the most important non-monetary inputs to increase production per unit area of finger millet (Kumar, 2018). Due to lack of scientific studies on finger millet an appropriate agronomic package of practices is yet to be created that could increase productivity (Anitha, 2015; Dereje et al., 2016). Planting methods vary from place to place and farmer to farmer. Broadcasting and transplanting are the two major methods of cultivation that are widely adopted which only increase the input but final output is very low as compared to SCI (Legesse et al., 2013). Farmers often overlook the critical aspect of spacing frequently transplanting crops randomly or broadcasting unevenly which leads to inappropriate plant population and triggers competition for essential resources such as water and nutrients among the plant and weed species. To date finger millet is grown in marginal land with traditional knowledge and variety where farmers are unaware to other recommended varieties like Okhle-1, Dalle-1, KabreKodo-1 and KabreKodo-2 (LIBIRD, 2014). Moreover, there is no systematic research on SCI which could raise productivity of finger millet.

It is necessary to adopt appropriate cultivation techniques since the yield of finger millet is poor due to improper planting methods. Thus, there to be enough study on SCI. The SCI practices have increased twice the yield levels of the crops (Uphoff et al., 2011). SCI technique enhances the plants growing condition by reducing the recovery time of seedling after transplanting and also decreasing the crowding and competition among the plant (Mans et al., 2016). With the adoption of SCI practices in finger millet, the production also increased (Abraham et al., 2014). Finger millet cultivated with SCI principles had significantly superior growth and yield attributes as compared with conventional and direct seeding methods of establishment (Bhatta et al., 2017). SCI does not only increase the yield but also increases the quality of finger millet. SCI approach can give a substantial yield when applied in marginal lands where irrigation and other inputs are not available. Further research and improvement efforts are needed to identify the potential benefits of SCI for finger millet cultivation, which would then explore the potential of finger millet to increase agricultural production, crop diversification and a better nutritional environment. Land degradation due to poor crop cultivation practices and low land availability for cultivation due to increased population are also triggering the need for identification of novel methodology for finger millet cultivation.

1.1 Objectives

1.1.1 Broad objective

- To study the influence of SCI practices on performance of finger millet.

1.1.2 Specific objectives

- To study the performance of different varieties of finger millet.
- To evaluate the performance of different varieties of finger millet in different planting methods.

2. MATERIALS AND METHODS

2.1 Details of the Experiment

The experiment was carried out at the farmer's field in Sundarbazar, Lamjung, under rainfed condition from July 2018 to January 2019. Sundarbazar is located 700 masl. Geographically it is located at 28° 12' N latitude, 84° 22' E longitude.

The experiment was laid out in a split plot design assigning different varieties of finger millet into main-plot and planting methods to sub-plot factors. The treatments were replicated into three blocks enabling easy handling of agricultural operations.

Table 1: Different factors that were used in experiment			
S.N.	Main-Plot Factors	S.N.	Sub-Plot Factors
1	KabreKodo-1 (V1)	1	Direct Sowing (DS)
2	KabreKodo-2 (V2)	2	System of Crop Intensification (SCI)
3	Dalle-1 (V3)	3	Conventional Transplanting (CT)
4	Okhle-1 (V4)		
5	Local (V5)		

2.2 Field layout

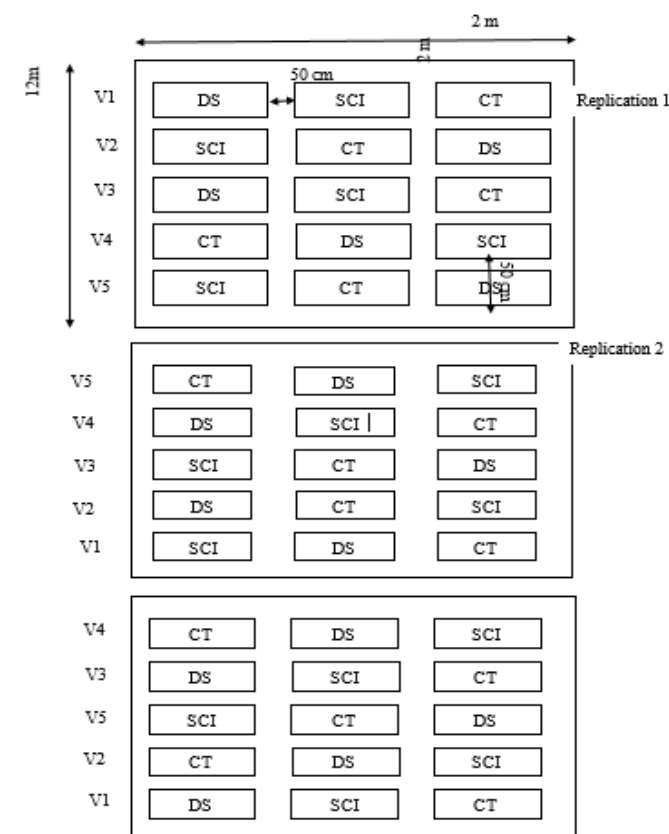


Figure 1: Experimental field layout

2.3 Cultural Practices

2.3.1 Nursery Preparation

Five raised beds of 1m² were well prepared and the seeds were mixed with sand for uniform sowing of seeds. Different varieties were sown in different seed beds at a depth of a half inch and covered with thin layer of soil. Mulching was provided to prevent excessive rainwater as per necessity.

2.3.2 Main Field Preparation

The main-plots of 14m² and sub-plots of 4m² were prepared. The inter-plot distance was maintained at 50 cm.

2.3.3 Manure And Fertilizer

Only chemical fertilizers, urea, Diammonium phosphate (DAP) and Muriate of Potash (MOP) were applied in the field at the dose of 50:30:20 kg NPK/ha.

2.3.4 Direct Sowing

Direct Sowing was done on the same day of nursery preparation, maintaining 20 cm distance between rows. Later 10 cm plant to plant distance was maintained at 15 days after sowing.

2.3.5 Transplanting Of Seedling By System Of Crop Intensification (SCI)

Single 15 days old seedlings were transplanted at plant geometry of 25 cm x 25 cm.

2.3.6 Transplanting Of Seedling By Conventional Method

Seedlings of 30 days old were transplanted at plant geometry of 10 cm x 10 cm.

2.3.7 Weed Management And Soil Loosening

Chemicals were not used for weed management. Hand weeding was done every 30 days, along with soil loosening.

2.3.8 Harvesting And Threshing

The matured crop was harvested and threshed manually.

2.4 Observation Recorded

2.4.1 Plant Height

Randomly 7 plants were selected from the sub-plot area at the time of harvest. The plant height was taken by measuring the distance from the ground to the upper-most tip of the plant and average mean of height was recorded.

2.4.2 Number Of Tillers

The total number of tillers at the time of harvest was recorded from the marked area of 1m².

2.4.3 Dry Plant Weight

Two plants from each sub-plot were uprooted from the sampling row, cleaned and oven dried for 48 hours at 72°C. The plants were uprooted at regular interval of 30 days and finally at harvest. Then the oven dry weight of plant was noted. Later Crop Growth Rate and Absolute Growth Rate of plant were calculated using formula:

$$\text{I. Absolute Growth Rate (AGR)} = (W_2 - W_1) / (T_2 - T_1)$$

$$\text{II. Crop Growth Rate} = (W_2 - W_1) / P(T_2 - T_1)$$

Where, W1 and W2 are whole plant dry weight at time T1 and T2

respectively.

P is the ground area on which W1 and W2 are recorded.

2.4.4 Grain Yield

The heads harvested from the central 1m² area were sun dried and threshed manually. Grain was cleaned by winnowing and grain weight was taken by using electric balance, while moisture percent was determined by using portable moisture meter. Finally, the grain yield was adjusted at 12% moisture by using the formula given below (Paudel, 1995).

$$\text{Grain yield at 12\% moisture (kg/Ha)} = \frac{(100 - MC) \times \text{plot yield (kg)} \times 10000}{(100 - 12) \times \text{net plot area (m}^2\text{)}}$$

Where,

MC = moisture content of grain in percentage

2.5 Statistical Analysis

All the data collected were tabulated according to replication and treatment. Data entry and tabulation were accomplished by using MS Excel. R studio was used for running statistical analysis. To test the significant difference, ANOVA was used for each parameter. The F-test was done at 5% level of significance.

Table 2: ANOVA table for split-plot design in randomized blocks with factor A in main-plots and factor B in sub-plots

Source of variation	Degree of freedom	Sum of Square	Mean Square	F-value	Tabular F
Replication	r-1 = 2				
A	m-1 = 4				
Error(a)	(r-1)(m-1) = 8				
B	s-1 = 2				
AB	(m-1)(s-1) = 8				
Error(b)	m(r-1)(m-1) = 40				
Total	rms-1 = 44				

3. RESULTS AND DISCUSSION

3.1 Plant Height At Harvest

The result revealed that plant height varied significantly with planting method in the case of all varieties except local. SCI method produced taller plants than other planting methods due to availability of adequate sunlight and space for canopy expansion under wider spacing (Rajbhandari, 2007). Height of finger millet progressively increased with increase in spacing (Dereje et al., 2016). In addition, transplanting younger seedlings encouraged vigorous aerial and underground plant development due to absence of transplanting shock (Samshiri et al., 2018). These results conformed to Bhatta et al. (2017), Prakasha et al. (2018), Kumar (2018). Similar results were observed in the case of SRI by Patwardhan and Patel (2008), Avasthe et al. (2012), Priyanka et al. (2013).

Statistically similar plant height was observed in direct sowing and conventional transplanting. The increase in plant height in CT was probably caused due to stem elongation and increase in number of nodes per plant due to mutual shading (Oh et al., 2007; Pendersen and Lauer, 2003). In addition, high plant density in CT led to competition among plants which encouraged self-thinning of lateral branches and enhanced vertical growth rather than horizontal growth (Thavaprakash, 2017). The results conformed to findings of Anitha (2015) Bhatta et al. (2017). Among different varieties, Kavrekodo 1 showed the highest plant height at harvest which was statistically similar to Dalle-1 and Okhle-1. This might be attributed to genetic composition of the variety. Plant height is an imperative yield trait that is controlled by the genetic makeup of the plant as well as growing conditions (Sarwar et al., 2011).

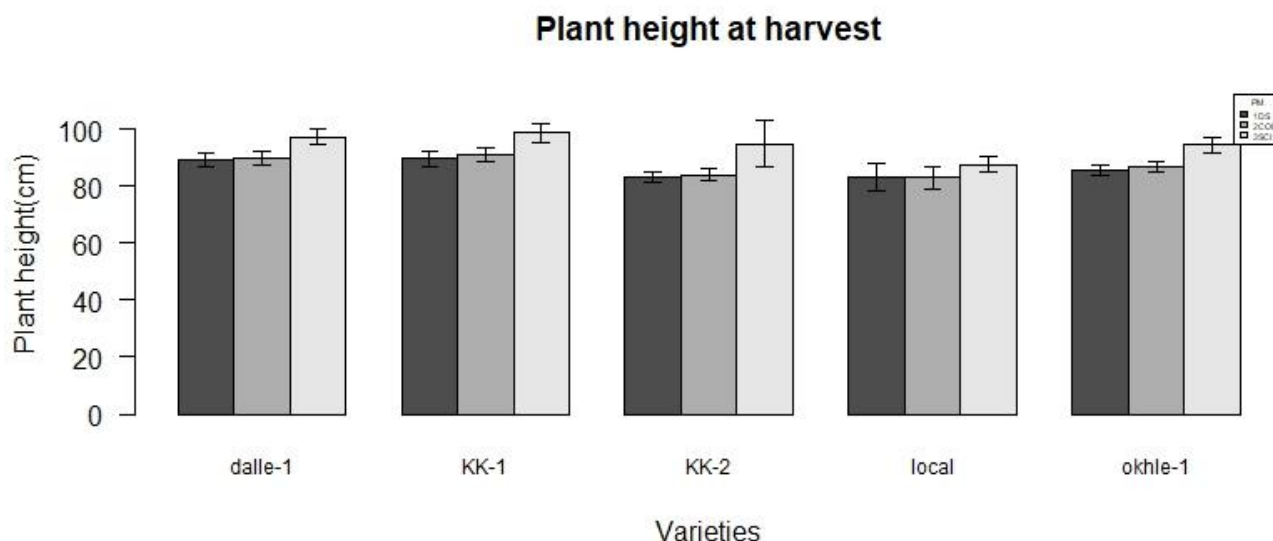


Figure 1: Plant height as affected by planting methods and varieties

3.2 Tiller Per m² At Harvest

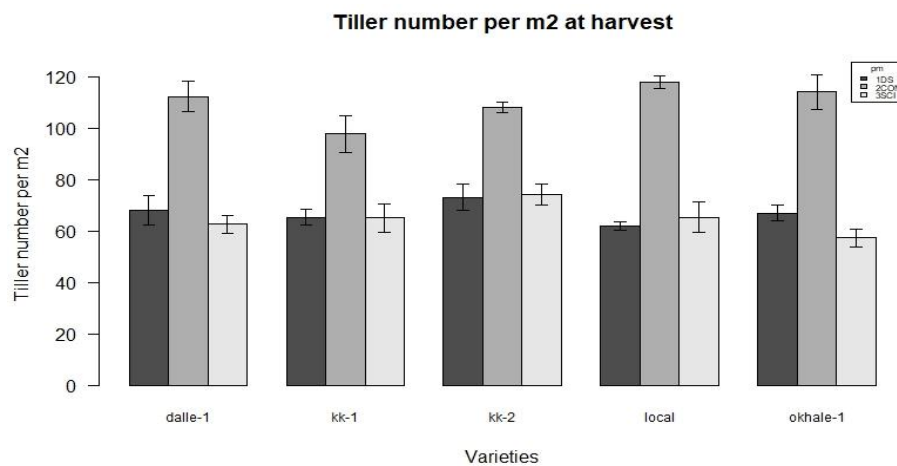


Figure 2: Number of tillers per m² as affected by planting methods and varieties

The number of tillers per m² at harvest was significantly influenced by planting methods in the case of all varieties. Among varieties, Kabrekodo-2 showed the highest number of tillers per unit area. The tiller per m² at harvest was found to be maximum in CT due to high plant density. Despite the low plant density in SCI (almost 6.15 times less than CT), the number of tillers per m² in SCI was significantly high due to presence of more tillers per plant. This was due to transplanting of young seedlings in SCI which preserved the plant's potential for tillering and root growth (Uphoff, 2001). The tiller production is optimized by transplanting seedlings at

younger ages compared to direct seeding (Pasuquin et al., 2008). Similarly, the wider spacing preferably square planting exerted less competitive pressure among plants in the field so each plant got the advantages of adequate space, nutrients and other growth resources resulting in healthy plant growth with more tiller formation (Samshiri et al., 2018). Similarly, findings of increased number of tillers per hill under wider spacing were reported by Nayak et al. (2003), Kalaraju et al. (2011), Dahal and Khadka (2012), Bhatta et al. (2017) and Prakasha et al. (2018).

3.3 Absolute Growth Rate (AGR)

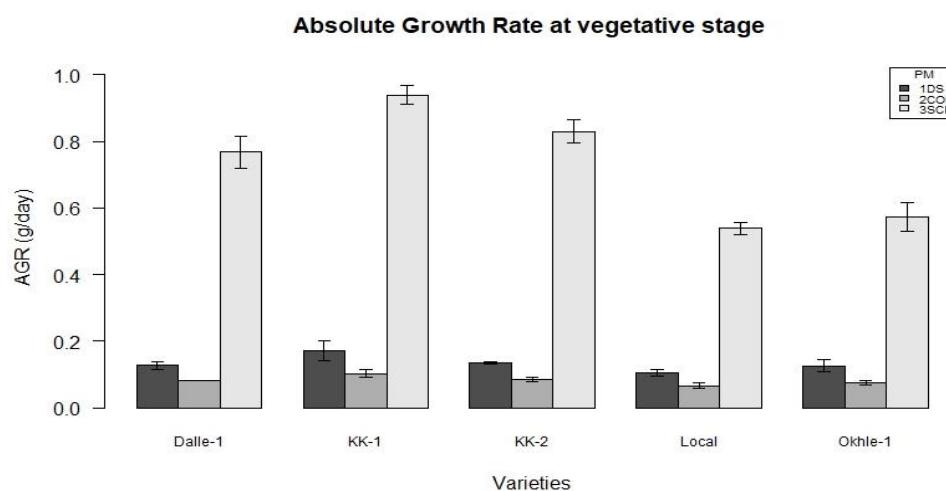


Figure 3: AGR at vegetative stage as affected by planting methods and varieties

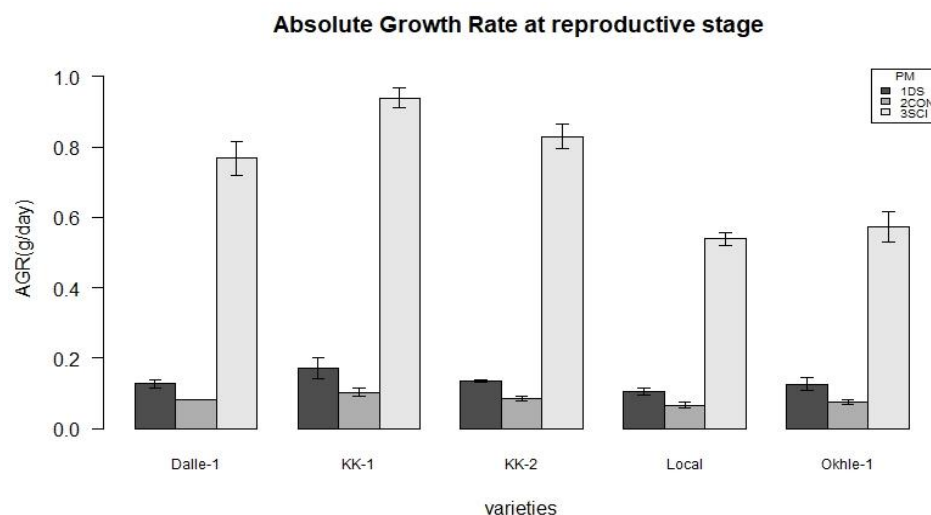


Figure 4: AGR at reproductive stage as affected by planting methods and varieties

The significant difference in Absolute Growth Rate (AGR) was observed among various varieties and planting methods. Among varieties, Kabrekodo-1 showed the highest AGR at both vegetative and reproductive stages which was due to its prolific growth during both stages. Similarly, among various planting methods, SCI showed the highest AGR at both phases followed by direct seeding and conventional method. Wider

spacing in SCI-furnished the prolific growth of the plant hence resulting in more accumulation of dry matter and ultimately improving AGR (Kumar, 2018). Narrow spacing and excessive competition resulted in lowest AGR in conventional system. The results conformed to the findings of Bhatta et al. (2017).

3.4 Crop Growth Rate (CGR)

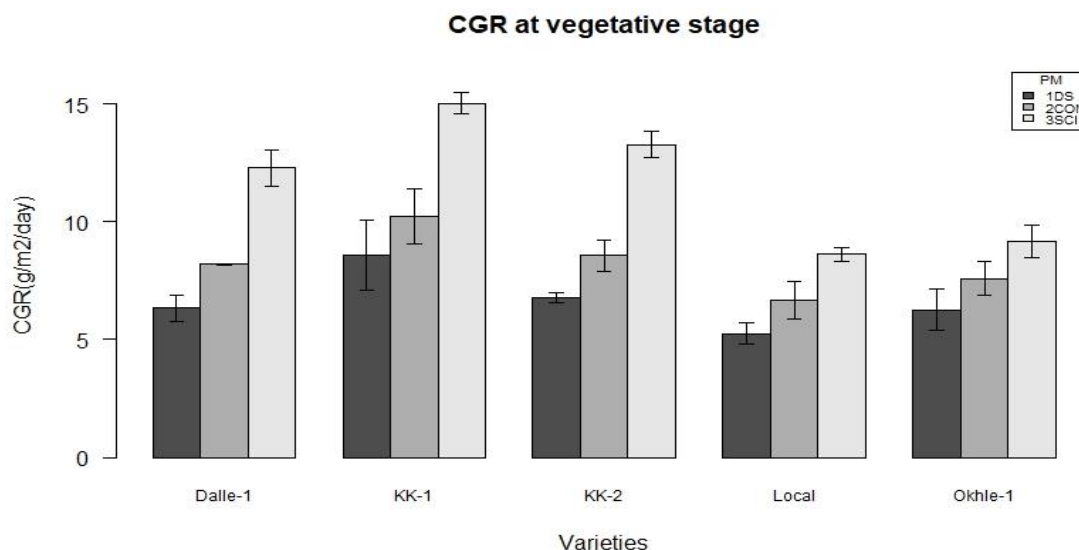


Figure 5: CGR at vegetative stage as affected by planting methods and varieties

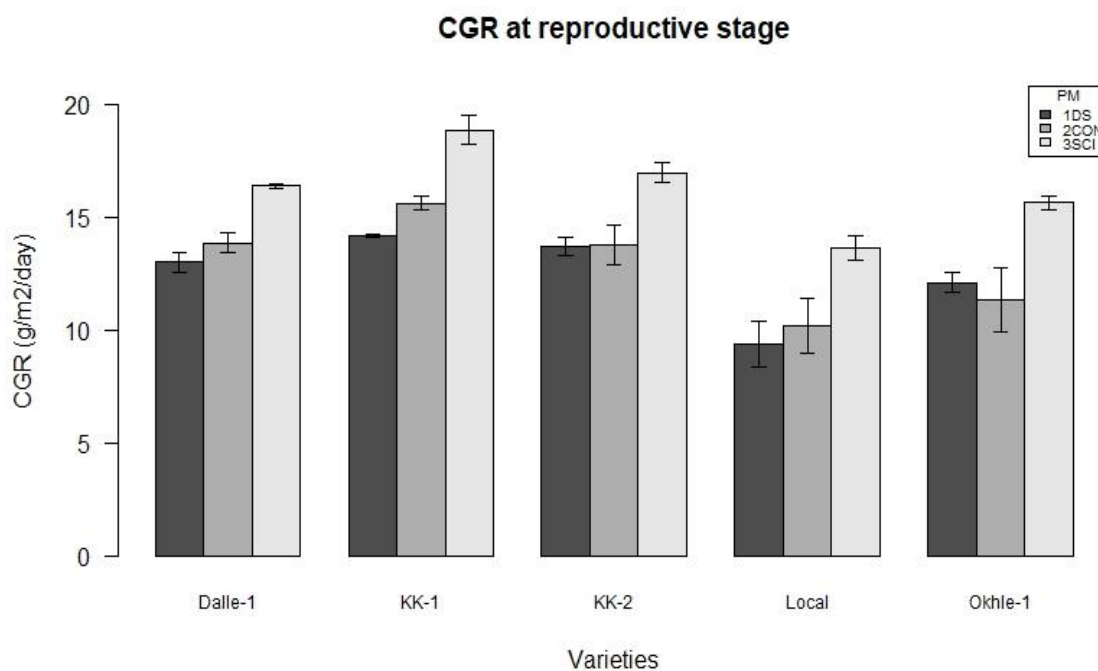


Figure 6: CGR at reproductive stage as affected by planting methods and varieties

The Crop Growth Rate (CGR) of finger millet was significantly influenced by varieties and planting methods during both vegetative and reproductive stages. Among varieties, the highest CGR during both phases was recorded in Kabrekodo-1 which was due to its prolific growth during both growth stages. Despite the high plant density in CT, maximum CGR was recorded in SCI method at both vegetative and reproductive stages. This was mainly due to higher plant canopy under wider spacing which increased photosynthetic activity, decreased the competition among plants, promoted better aeration which allowed individual plants to develop massive root system and resulted in healthy plant growth (Rajbhandari, 2007). Increase in growth indices at wider spacing resulted in high dry matter accumulation ultimately increasing crop growth rate (Kumar, 2018). Also, use of young seedlings exerted less trauma on the root and preserved the growth potential of the crop (Samshiri et al., 2018). The attachment of endosperm with seedlings reduced stress on seedlings

preserving potential for tillering and root growth (Hoshikawa et al., 1995). In SCI, similar results were reported by Nayak et al. (2003), Vijaykumar et al. (2006), Bhatta et al. (2017) and Kumar et al. (2018).

Statistically similar crop growth rate was observed in both direct sowing (DS) and conventional transplanting (CT). Close spacing in CT produced high biomass accumulation per unit area and more vertical growth than horizontal tillering thus improving CGR (Rajbhandari, 2007). The result was in accordance with earlier finding of Bhatta et al. (2017).

The crop growth rate was recorded higher in reproductive phase than vegetative phase which indicated that wider spacing influenced profuse growth of yield attributing characteristics as compared to vegetative growth (Rajbhandari, 2007). Similar results were reported by Nayak et al. (2003) and Bhatta et al. (2017).

3.5 Grain Yield

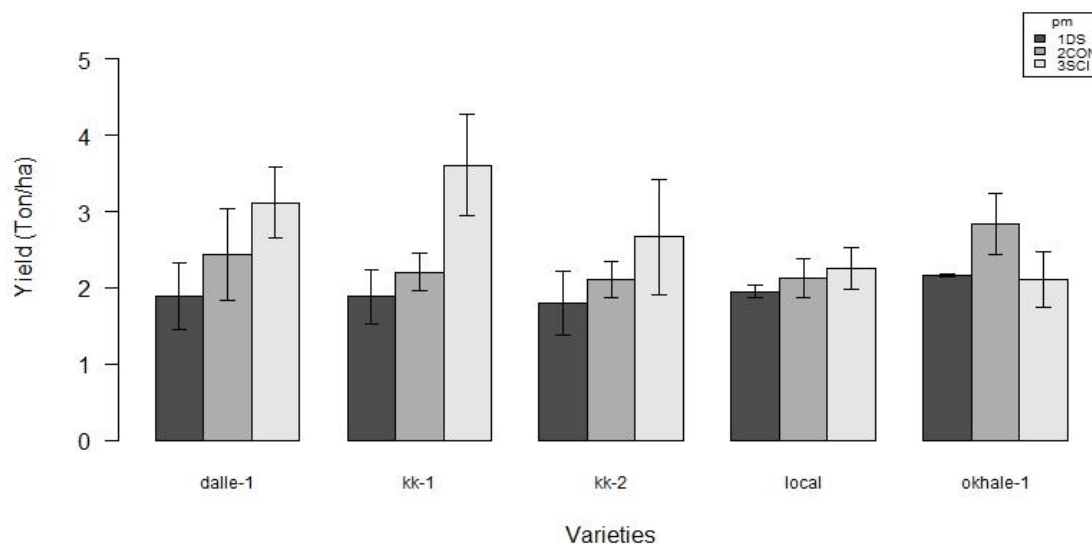


Figure 7: Grain yield as affected by planting methods and varieties

Different varieties did not show any significant impact on grain yield. However, significant difference in yield was observed among various planting methods. In kabrekodo-1 variety, grain yield was significantly affected by planting method being recorded as highest in SCI. The overall mean yield was higher in SCI in all the varieties except in case of Okhale-1. SCI produced highest grain yield of 2.75 tons/ha which was 17.49% and 42.40% higher than CT and DS respectively. Highest grain yield was obtained by growing Kabrekodo-1 by SCI method i.e. 3.62 tons/ha which was 49.22% and 39.05% more than same variety grown in direct sowing and conventional method of transplanting respectively. Highest grain yield in SCI was due to greater availability of nutrients owing to more space available per plant (Abraham et al., 2014). Higher yields with increased spacing in case of rice were also suggested by Uphoff (2003) and Uprety (2005). Use of young seedlings caused less trauma during initial phase of establishment and preserved the potential of giving high yield (Uphoff, 2002). Recent studies on System of Rice Intensification (SRI) showed that yield and components of yield can be increased by transplanting young seedlings preferably 14 days old instead of older seedlings of 21-23 days (Makarim et al., 2002). Young seedlings are easier to establish as they suffer from less root damage during uprooting, with minimum transplanting shock and mortality rate which increases all yield attributes in rice (Sarwar et al., 2011). Among variety, the mean yield of Kabrekodo-1 was found to be more than others. This was due to presence of a greater number of grains per finger in this variety.

4. CONCLUSION

The performance of various varieties of finger millet under different planting methods was observed during the research period. Among varieties, Kabrekodo-1 recorded maximum height, growth rate and yield. From the study, it was enlightened that finger millet cultivated with SCI practices produced better growth attributes and grain yield. Hence, it is better to transplant young seedling (15 days old seedling or at biological age of seedling i.e. at 2 leaf stage) at wider spacing (square planting) that leads to double advantages viz. lower seed and seedling requirement and higher productivity (due to efficient utilization of above ground and underground resources). Thus, the study revealed Kabrekodo-1 as potential variety of the area and SCI as a better option to increase the performance of finger millet.

ACKNOWLEDGEMENTS

We express our heartfelt gratitude to Institute of Agriculture and Animal Science, Lamjung Campus for providing the platform and immense support. We thank Laxmi Chaulagain and Santosh Joshi for their consistent help throughout the research period.

REFERENCES

Abraham, B., Araya, H., Berhe, T., Edwards, S., Gujja, B., Khadka, R., Koma, Y.S., Sen, D., Sharif, A., Styger, E., Uphoff, N and Verma, A., 2014. The system of crop intensification: Report from the field on improving agricultural production, food security and resilience to climate change for multiple crops.

Abraham, B., Adeoluwa, O.O., Araya, H., Berhe, T., Bhatta, Y., Edwards, S., Gujja, B., Khada, R.B., Koma, Y.S., Sen, D., Sharif, A., Styger, E., Uphoff, N., and Verma, A., 2014. The System of Crop Intensification: Agro-ecological innovation for improving agricultural production, food security and resilience to climate change.

Anitha, D., 2015. Finger millet, Eleusine coracana L. Gaertn. Productivity as Influenced by Crop geometry and Age of Seedlings. M.Sc. (Ag.) Thesis, ANGRAU, Hyderabad.

Avasthe, R.K., Verma, S., Kumar, A., and Rahman, H., 2012. Performance of rice, *Oryza sativa* varieties at different spacing under system of rice intensification (SRI) mid hill acid soils of Sikkim Himalaya, Indian Journal of Agriculture, 79(1): Pp. 32-37.

Bhandari, B., Gyawali, S., Baral, K.P., Chowin, K.R., and Rijal, D.K., 2005. Promoting the Utilization of Finger millet and its Products through Public Awareness Activities in Kaski, Nepal. Proceeding of Progress Review Workshop on Finger millet under IFAD-NUS Project: Nepal Component, NARC and LIBIRD.

Bhatta, L. R., Subedi, R., Joshi, P., and S.B. Gurung., 2017. Effect of crop establishment methods and varieties on tillering habit, growth rate and yield of finger millet. Agricultural research and technology, ISSN: 2471-6774.

Dahal, K.R., and Khadka, R.B., 2012. Performance of rice with varied age of seedlings and planting geometry under System of Rice Intensification (SRI) in farmer's field in western Terai, Nepal. Nepal Journal of Science and Technology 13(2): 1-6. doi:10.3126/njst.v13i2.7706.

Defeng Z., Shihua, C., Yiping, Z., and Xiaqing, L., 2002. Physiological effects of SRI methods on the rice plant. In: Assessments of the system of rice intensification, Proceedings of an International Conference, Sanya, April 1-4.

Dereje, G., Adisu, T., and Anbessa, B., 2016. Influence of row spacing and seed rate on yield and yield component of finger millet at Assosa zone in Benshaga Gumze region of Ethiopia. Journal of Biology, Agriculture and Horticulture. Vol. 6(5), Pp.42-45.

Dida, M.M., Devos, K.M., 2006. Finger Millet. In Genome Mapping and Molecular Breeding in Plants, Vol 1 Cereals and Millets, C.Kole, Springer-Verlag Berlin Heidelberg Pp. 333-343.

Ferry, L.S., 2014. Indigenous crop: Finger millet – high five for nutrition. Retrieved September 9, 2016. From: foodtank.com/news/2014/03/indigenous_crop_finger_millet_fivefor_nutrition.

Ganngaiah, B., 2016. Agronomy-kharif crops millet.

Hoshikawa, K., Sasaki, R. and Hasebe, K., 1995. Development and rooting capacity of rice nurseries seedlings grown under different raising conditions. Jpn. J. Crop Sci., 64, Pp. 328-332.

- ISD., 2009. Institute for Sustainable Development. Piloting a system of crop intensification. Retrived August 1, 2018, From: http://sri.ciifad.cornell.edu/aboutsri/othercrops/otherSCI/EthSCI_ISD09.pdf.
- Jyoti, B., and Kumar, P., 2017. Finger millet - A miracle crop of Uttarakhand, India. *Research in Environment and Life Sciences*.
- Kalaraju, K., Kumar, D., Nagaraja, N., and Ningappa, K.B., 2011. Effect of methods of planting on growth and yield of finger millet genotypes under organic farming. *Research on Crops*, 10(1): Pp. 20-24.
- Khadka, R.B., Shrestha, S.M., Manandhar, H.K., and K.C., G.B., 2013. Pathogenic Variability and Differential Interaction of Blast Fungus (*Pyricularia grisea* SACC.) Isolates with Finger Millet Lines in Nepal. *Nepal Journal of Science and Technology* Vol. 14, No. 2, Pp. 17-24.
- Kumar, C., 2018. Performance of finger millet, *Eleusine coracana* L. Gaertn. under different crop establishment methods. M.Sc. thesis (published) Birsa Agricultural University, India.
- Legesse, H., Zibelo, G.H., Assefa, T., Misgina, S., Asmelash, A., Araya, H., Edward, S., and Endris, M., 2013. *SCI: planting with space*.
- LI-BIRD., 2014. Constraints and opportunities for promotion of finger millet in Nepal. Pp. 1-4. Retrieved October 22, 2018. From: http://www.dhan.org/smallmillets/docs/report/Constraints_and_Opportunities_for_Promotion_of_Finger_Millet_in_Nepal.pdf.
- Makarim, A.K., Balasubramanian, V., Zaini, Z., Syamsiah, I., Diratmadja, I.G.P.A., Handoko, A., Wardana, I.P., and Gani, A., 2002. A Systems of rice intensification (SRI): Evaluation of seedling age and selected components in Indonesia, Pp. 129-139. In: Bouman, B.A.M., Hengsdijk, A., Hardy, B., Bindraban, P.S., Tuong, T.P. and Ladha, J. K. eds. *Water-Wise Rice Production*. Los Baños, Philippines: IRRI.
- Mans, D., Offenheiser, R.C., and Leape, J.P., 2016. More rice for people more water for planet. Pp: 6.
- Michaelraj, P.S.J., and Shahmugam, A., 2013. A study on millets based cultivation and consumption in India. *International Journal of Marketing, Financial Services and Management Research*. Vol. 2(4): Pp. 49-50.
- MoALD. 2022. Statistical information on Nepalese agriculture. Katmandu, Nepal: Planning & Development Cooperation Coordination Division, Statistic and Analysis Section, Ministry of Agricultural Development.
- Nayak, B.C., Dalei, B.B., and Choudhury, B.K., 2003. Response of hybrid rice, *Oryza sativa*, to date of planting, spacing and seedling rate during wet season. *Indian Journal of Agronomy* 48 (3): Pp. 172-174.
- Oh, Y.J., Kim, K.H., Suh, S.K., Kim, S.D., and Park, H.K., et al., 2007. Effects of stem lengths on seed yield and yield components of late planted soybeans. *World J. Agric. Sci.*, 3: Pp. 363-370.
- Pasuquin, E., Lafarge, T., and Tubana, B., 2008. Transplanting young seedlings in irrigated rice fields: Early and high tiller production enhanced grain yield. *Field Crops Research*, 105 (1-2): Pp. 141-155.
- Patwardhan, S.M., and Patel, S.M., 2008. Promotion of System of Rice Intensification (SRI) in rainfed rice cultivation amongst the farmers of Dangs district of Gujarat. 3rd Symposium on "System of Rice Intensification in India - Extended summaries" held at TNAU-Coimbatore from 1-3rd Dec., 1: Pp. 85-87.
- Paudel, M.N. 1995. Nutrient management for Sulphan buri- 90 rice variety in acid sulfate soil with green leaf manure. M.Sc. Thesis, Asian Institute of Technology, Bangkok, Thailand.
- Pederson, P., Lauer, J.G., 2003. Corn and soybean response to rotation sequence, row spacing, and tillage system. *Agronomy Journal*, 95: 965-971.
- Prakasha, G., Kalyana Murthy, K.N., Prathima A.S., and Meti. R.N., 2018. Effect of Spacing and Nutrient Levels on Growth Attributes and Yield of Finger Millet, *Eleusine coracana* L. Gaertn. Cultivated under Guni Planting Method in Red Sandy Loamy Soil of Karnataka, India. *International Journal of Current Microbiological Applied Science* 7(05): Pp. 1337-1343.
- Priyanka. G., Sharma, G.D., Rachana, R., Lal, B., and Joshi, E., 2013. Evaluation of integrated nutrient management and plant density on productivity and profitability of rice *Oryza sativa*, under system of rice intensification in mid hills of Himachal Pradesh. *Indian Journal of Agronomy*. 58(13): Pp. 421-423.
- Rajbhandari, R., 2007. System of rice intensification under different plant population and levels of nitrogen. M.Sc. thesis (published), Tribhuvan University, Nepal.
- Shamshiri, R.R., Brahim, B., Ahmad, D., Che Man, H., and Wayayok, A., 2018. An Overview of the System of Rice Intensification for Paddy Fields of Malaysia. *Indian Journal of Science and Technology*, Vol 11(18).
- Sarwar, N., M., Maqsood, M., Wajid, S.A., and Anwar-ul Haq. M., 2011. Impact of nursery seeding density, nitrogen, and seedling age on yield and yield attributes of fine rice. *Chilean Journal of Agricultural Research* 71:Pp. 343.
- Shinggu, C.P., Dadari, S.A., Shebayan, J.A.Y., Adekpe, D.I., Mahadi, M.A., Mukhtar, A., and Asala, S.W., 2009. Influence of spacing and seed rate on weed suppression in finger millet, *Eleusine coracana* (L.) Gaertn. *Middle-East Journal of Scientific Research*. 4 (4): Pp. 267-270.
- Singh, S.K., and Bhatta, R.K., 2008. Comparative performance of System of Rice Intensification (SRI) under different planting geometries and water regimes. 3rd Symposium on "System of Rice Intensification in India - Extended summaries" held at TNAU-Coimbatore from 1-3rd Dec., 9: Pp. 25-26.
- Stoop, W.A., 2011. The scientific case for system of rice intensification and its relevance for sustainable crop intensification. *International Journal of Agricultural Sustainability*. Pp: 443-455.
- Stoop, W.A., Uphoff, N., and Kassam, A., 2002. A Review of Agricultural Research Issue Raised by System of Rice Intensification (SRI) from Madagascar: Opportunity for improving farming system for resource poor farmers.
- Thavaprakash, N., Sangeetha, S.P., Devasenapathy, P., and Natarajan, S., 2008. Performance evaluation of SRI in comparison with methods of planting under organic farming in rice. 3rd Symposium on "System of Rice Intensification in India - Extended summaries" held at TNAU-Coimbatore from 1-3rd Dec., 46: Pp. 200-202.
- Uphoff, N., 2001. Scientific issues raised by the SRI: A less water rice cultivations system. *Water Savings Rice Production Systems*. Pp. 69-82.
- Uphoff, N., Fernadez, E., Long-Pin, Y., Jiming, P., Sebastien, R., and Rabenanadrasana, J. (Eds.). 2002. Assessment of the system of rice intensification (SRI): Proceedings of an International Conference, Sanya, China. CIIFAD, Ithaca, New York.
- Uphoff, N., 2003. Higher yield with fewer external inputs, the system of rice intensification and potential contributions to agricultural sustainability. *International Journal of Agricultural Sustainability*. Vol. 1. Pp: 38-50.
- Uphoff, N., Marguerite, T., Devi, J., Behera, D., Verma, A.K., and Pandian, B.J., 2011. National Colloquium on System of Crop Intensification (SCI). In: <http://sri.ciifad.cornell.edu/aboutsri/othercrops/index.html>.
- Upreti, R., 2005. System of Rice Intensification (SRI) performance in Morang District during 2005 main season. System of Rice Intensification website. (10p., pdf), Report for District Agriculture Development Office, Biratnagar, Morang, Nepal.
- Vijaykumar, M., Ramesh, S., Chandrashekar, B., and Thiyagrajan, M., 2006. Effect of system of Rice intensification (SRI) practices on yield attributes, yield and water productivity of rice (*Oryza sativa* L.). *Research Journal of Agriculture and Biological Science*, 2 (6): Pp. 236-242.

