

Comparative Study of Rice Yield Production for Conventional Paddy Rice and Systems of Rice Intensification

Gideon Too^{1,*}, Julius Kipkemboi Kollongei¹, Japheth Ogalo Onyando², Emmanuel Chessum Kipkorir³

¹Department of Agricultural and Biosystems Engineering, Faculty of Engineering, University of Eldoret, Nairobi, Kenya

²Faculty of Engineering and Technology, Egerton University, Nairobi, Kenya

³Department of Civil and Structural Engineering, Moi University, Nairobi, Kenya

Email address:

toogideon@gmail.com (G. Too), ceaser_kollongei@yahoo.co.uk (J. K. Kollongei), jonyando@gmail.com (J. O. Onyando),

emmanuel_kipkorir@yahoo.co.uk (E. C. Kipkorir)

*Corresponding author

To cite this article:

Gideon Too, Julius Kipkemboi Kollongei, Japheth Ogalo Onyando, Emmanuel Chessum Kipkorir. Comparative Study of Rice Yield Production for Conventional Paddy Rice and Systems of Rice Intensification. *American Journal of Water Science and Engineering*. Vol. 6, No. 2, 2020, pp. 70-75. doi: 10.11648/j.ajwse.20200602.13

Received: April 20, 2020; **Accepted:** May 8, 2020; **Published:** May 29, 2020

Abstract: Food security in Kenya is at stake due to decline in farm productivity with a combination of an ever increasing population and worsened by global warming. Improvement of agricultural productivity may not be realized soon as rice farmers currently uses traditional method of flooding rice which has been reported to yield low rice. There is need for a deliberate use of new agricultural technologies that improves productivity of rice farming. System of Rice intensification (SRI) provides an opportunity of yield improvements in rice production. This study was undertaken in Ahero Irrigation Scheme to compare yield production of conventional and SRI rice production for IR 2793-80-1 cultivar. The experiment was laid out in a randomized complete block design with three replications. SRI experiments recorded higher number of effective tillers with experiment having a spacing of 20cm by 20cm and transplanted at 8-11 days gave 321 per m² as compared to 226 effective tillers/m². Seed yield/plant was highly significant in SRI (39.61 g) as compared to a traditional paddy system (17.32 g). Transplanting rice seedling at the age of 8 to 11 days and at 20cm by 20cm spacing recorded highest seed yield/ha of 4.7 t/ha as compared to traditional flooding which recorded 2.7 t/ha. These results imply that planting young rice seedlings improves grain yield because of increase in number of tillers per square meters, plant height and better plant rooting ability.

Keywords: Systems of Rice Intensification (SRI), Conventional Paddy Rice, Yield, Rice Production

1. Introduction

Access to adequate food for an increasing population has drew a number of strategies worldwide. One among the many strategies is a strategy of increasing agricultural productivity in smallholder managed irrigation schemes. If sustainable food production systems and resilient agricultural practices are implemented, increase productivity and production would be realized and this will as well as strengthen capacity for adaptation to climate change and extreme weather conditions [1].

Shortage of food in Kenya has been experienced due to

decline in farm productivity and this has been attributed to low fertility levels of agricultural farms, unreliable weather such that there is delayed rainfall, and high input costs such as the ever increasing prices of fertilizer. This situation has been worsened by global warming due to climate change, hence food security in Kenya is at stake. This explains an urgent need for a shift from normal food production systems to sustainable water management and at the same time expanding on irrigated agriculture [2].

A deliberate use of less water to obtain optimum yields by most irrigators has been triggered by a number of reasons including cost of irrigation going up, low prices of

commodities, less irrigation system capacity and limited and unreliable water supply [3]. Reddy and Reddy noted that when specific depth of water is applied only during water sensitive period of flowering and yield formation stages and allowing some water stress at some stages such as vegetative and maturity stages, optimum yields with less water consumed during a crop growth period is achieved [4].

Currently, rice farmers in Kenya still use traditional technique of flooding their fields [5]. The challenge with this technique is the decreasing trend in the water resources availability especially during dry season. On the other hand, the water demands for domestic and industrial water supply are increasing. As a result, the water availability for agriculture purposes is decreasing and conflicts among the water users and among farmers cannot be avoided. Moreover, conventional method has also been reported to yield low rice production or low water productivity [6]. This study therefore aimed at comparing rice yield production for traditional conventional system and system of rice intensification which involve deliberate use of less water for optimum yields.

2. Materials and Methods

2.1. Study Area

The study was conducted at Ahero Irrigation Scheme



Figure 1. Experiment Layout.

Square plot of size 5m × 5m was set up for SRI system but for traditional system, farmer's field was used as control and for comparing yields and water consumption. These plots

(AIS) located at 0°10'28.63" N 34°54'58.68"E, at Kano plain and is 25 km southeast of Kisumu town, Kisumu County. Black cotton is a type of soil in the study and is fertile. The rainfall pattern of the western Kenya region is characterized by bimodal rainy season, governed by the passage of the sun across the equator and the associated movement of the Inter-Tropical Convergence Zone. Also it is characterized by isolated rainfall due to the influence of Lake Victoria, located about 25 km away. The average annual rainfall is approximately 1175 mm, of which 39% is received during the long rain period (March to May), 29% is concentrated in the short rain period (August to November) and 32% is received during drier months. Amount of rainfall received in the area is important for it forms the basis of calculating irrigation water supplies with crop evapotranspiration (ET_c). The temperature at Ahero ranges from a monthly mean of 22.1°C in June to 23.5°C in March [2].

2.2. Experimental Design and Treatments

The experiment was laid out in a randomized complete block design with three replications. Experiment compared conventional (CS) system as a control and SRI (SS) systems. SRI system had four treatments (Table 1) with three replicates each. Spatial allocation of plots was done using random numbers (Figure 1).

were also surrounded by consolidated bunds and lined with plastic sheets installed to 0.3 m deep to prevent seepage from conventional system.

Table 1. Treatments.

	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5 (Control)
Rice Variety	IR 2793-80-1	IR 2793-80-1	IR 2793-80-1	IR 2793-80-1	IR 2793-80-1
Seedling transplanting	8 to 11 day-old 1 per hill	8 to 11 day-old 1 per hill	12 to 15 day-old 1 per hill	12 to 15 day-old 1 per hill	28 day-old
Spacing	30 x 30cm	20 x 20cm	30 x 30cm	20 x 20cm	Randomly
Irrigation	Intermittent	Intermittent	Intermittent	Intermittent	Continuous flooding
Weeding	Mechanical	Mechanical	Mechanical	Mechanical	Uprooting

2.3. Land Preparation, Nursery Establishment and Transplanting

Land preparation for both conventional and SRI was done one month before transplanting rice for both systems as suggested by [7] that sufficient time should be provided for puddling process such that hard lumps of soil can be softened and broken more easily. The field was flooded then ploughed after three days. Ploughing was done mechanically. Puddling followed where the soil was harrowed shallowly thereafter the field was flattened [8].

Nursery was also established in a section of the field and this was done so that transplanting could be done in a very short time hence injury to young seedlings was minimized [9-11]. Nursery was designed in a way that would enable it accommodate seedlings for both systems. The size of the nursery was approximately 1% of the field size and 3.16kg rice seed was used. Nursery beds were made 1m wide each and raised to 10-15cm high. This allowed easy access to the nursery bed from both sides. The height of the bed was made sufficient such that during transplanting, seedlings were uprooted without damaging young seedlings roots. The seeds to be planted were also sorted.

In SRI system, 8-day-old seedling was transplanted as treatment one and two under different spacing, thereafter 15-day-old seedling was transplanted after 7 days as treatment three and four. One seedling was done per hill. For conventional system, 28-day-old seedling was transplanted.

2.4. Water and Crop Management

The experiment adopted user-defined intervals for SRI technology [5]. The SRI experimental plots were kept moist for the first seven days after planting young seedlings, thereafter the plots were bonded until panicle initiation stage with water of 2 cm depth of water for two days and without ponding water for five days before irrigating again. The cracks at this stage were between 10-15 mm on the soil surface. For the remaining days, SRI plots were saturated with water.

Control treatment was flooded throughout with water up to a depth of 50 mm [12]. The depth was reduced to 30mm only at the end of the tillering stage, this was to enhance tillers to develop.

For all plots and in the last two weeks, rice fields were left dried before harvesting so that maximum transfer of nutrients to the grains is enhanced.

Weeds were controlled mechanically in SRI 4 times throughout the season by using mechanical weeder and manually in farmer's field by uprooting them. 125 kg per ha of DAP and 62 kg per ha of MoP was applied at the nursery. Additional 125 kg per ha of Sulphate of Ammonia (SA) was supplied to all experimental plots 10, 30 and 60 days after transplanting (DAT).

2.5. Sampling Procedure and Data Collection

Pre-harvest and post-harvest observations were undertaken

to capture information regarding rice growth and development in regard to water management and crop yields. Data were recorded on tiller number before harvest and panicle length, number of seeds per panicle and number of filled seeds per panicle were recorded after harvest. This enhanced the calculation of percent chaffy seeds per panicle using equation (1).

$$\% C = \frac{T_s - N_s}{T_s} \times 100 \quad (1)$$

Where % C – percentage chaffy, T_s -Total number of seeds/panicle, N_s - Number of filled seeds/panicle

The crop in all treatments was harvested in order to get plot yield, threshed and expressed in kilograms per hectare at 14% moisture content in grain using equation (2) [8]:

$$Y_{14} = \frac{(100 - MC)10000}{(100 - 14)A} \quad (2)$$

Where Y_{14} - Grain yield (kg/ha) at 14% moisture, A- Net plot area (m^2) and MC- Moisture content.

2.6. Data Analysis

Collected data was cleaned, arranged in a presentable manner then analysed using Analysis of Variance (ANOVA) technique. The significance of every treatment was determined using F-test and significant means separated using Least Significant Difference (LSD) test at 5% probability level [13, 14]. Two treatments were insignificantly different if the LSD was more than the difference in means between two treatments and vice versa.

3. Results and Discussion

3.1. Production Systems and Crop Growth

The tiller number counted/hill indicated continuous increase upto 90 DAT with the increase being rapid up to 60 DAT but slight decrease at harvest.

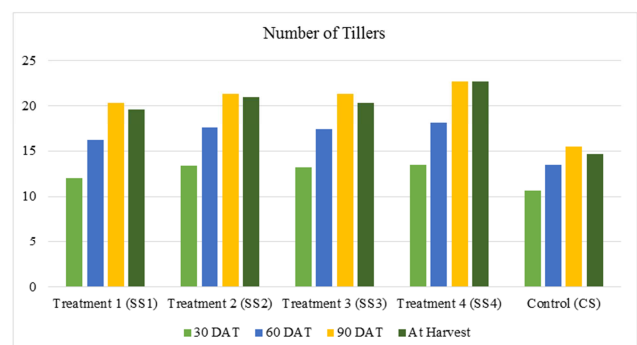


Figure 2. Number of Tillers in SRI and Conventional Irrigation System.

Significantly higher tiller number/hill was noticed in SRI system compared to CS method at all the growth stages. SRI treatment transplanted with 12 to 15 days seedling and more spacing of 20cm by 20 cm recorded 13.50, 18.17, 22.67 and 22.67 tillers per hill at respectively 30, 60, 90 DAT and at

harvest while CT method registered 10.67, 13.50, 15.50 and 14.67 tiller number per hill of each treatment at 30, 60, 90 days after transplanting and at harvest, respectively.

More tillers in SRI treatments could be explained by wetting and drying irrigation method recommended in SRI technology which allowed more tillers to develop as compared to conventional method. This advantage of SRI method of allowing the field to dry during tillering stage hence increased tiller numbers [15-23]. Ravi, Nobuhiko and Pabitra found similar results of increased number of reproductive tillers from 11.22 for non-SRI to 43.34 reproductive tillers for SRI system [15].

More tillers in SRI method could also be explained by transplanting younger seedlings. Reddy, K., Reddy, C., Abbas, Abel, and Muralidharan, opined that when seedlings are transplanted at less than 15 days, plant's potential for tillering and root growth is preserved and that careful transplanting promotes rapid resumption of growth [24].

3.2. Production System on Yield Components

The number of effective tillers in both production systems indicated that SRI system in all the treatments was highly significant with $p=0.005$ as compared to conventional paddy rice system. This was attributed to wide spacing of SRI method which results to reduced plant population hence less water requirement.

Table 2. Number of Tillers and Panicle Length.

	Number of Effective Tillers/m ²	Panicle Length (cm)
Treatment 1 (SS1)	297	19.93
Treatment 2 (SS2)	321	22.83
Treatment 3 (SS3)	293	22.80
Treatment 4 (SS4)	312	22.23
Control (CS)	226	21.03

This was in conformity with the results by [25] that effective tillers m⁻² can be attributed to proper plant spacing which ensures good water management and photosynthetic activities and assimilate partitioning thereby resulting in good yield in well-spaced rice fields. This implies that plant spacing linearly affects performance of individual plants because of the area around to draw nutrients and have more water solar radiation to absorb for better photosynthetic activity [25]. Wider plant range resulting to more tillers per hill could be attributed to sunlight energy being used optimally by rice [26].

Regarding panicle length, SRI system recorded longer panicle lengths than in CS. The panicle length in widely spaced hills was longer than in closely spaced hills [27]. [30] recorded similar results.

3.3. Seed Yield

Seed yield/plant was highly significant in SRI (39.61 g) as compared to a traditional paddy system (17.32 g). Significance difference was also observed among all the treatments. Treatment 4 (SS4) recorded the highest seed yield per plant (42.19 g) while treatment 2 (SS2) recorded the lowest (37.32 g).

On seed yield per plot (kg), SRI again recorded higher yields of 10.95 kg while CS recorded lower yields of 6.87 kg. This could be explained that a number of spikelet and filled grain in System of Rice Intensification are more as compared to conventional system. Wider spacing and younger seedlings in SRI could be attributed to more tillers due to AWD irrigation method hence more spikelet and filled grained [26].

As indicated in figure 2 higher seed yield for SRI technology (4380Kg Ha⁻¹) as compared to conventional system (2746.7Kg Ha⁻¹). This could mean that SRI method provides better aeration and more spacing hence better root activity and plant water uptake.

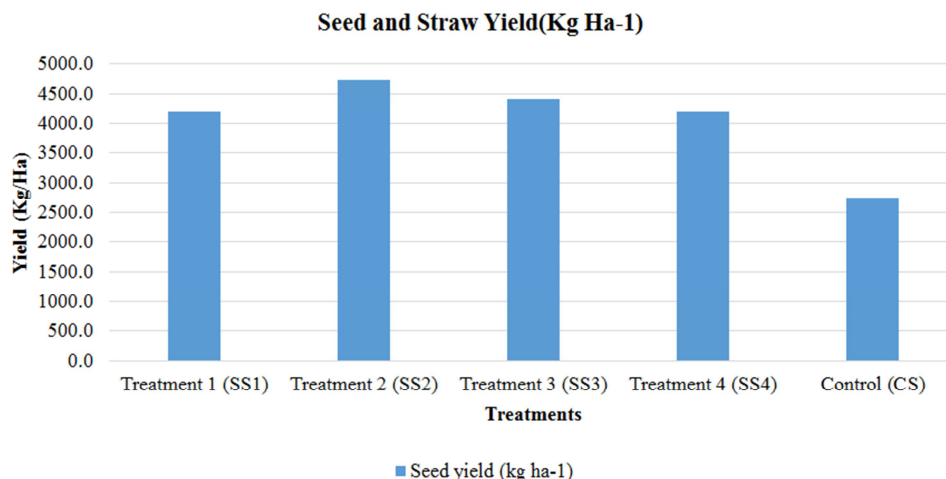


Figure 3. Seed Yield per Hectare.

Among all the treatments, transplanting rice seedling at the age of 8 to 11 days and at 20cm by 20cm spacing recorded highest seed yield/ha of 4733.3 kg/ha. The increased seed yield when rice is transplanted at young age and more spacing could

be attributed to the higher root growth which enabled them to access to nutrients from much greater volume of soils. It helped to capture all the essential nutrient elements important for plant growth. Increased seed yield also could be due to

more number of tillers which were experience during tillering stage when there was no application of water. At this stage the plant developed more tillers linked to more number of primary and secondary panicles. Similar findings have been highlighted earlier by [29, 30].

Young seedlings lead to improve in straw and grain yield as compared to old seedlings. This might be because of increase in number of tillers per square meters, plant height, better plant rooting ability, Leaf Area Index, and the highest matter accumulation (DMA) [31, 32].

3.4. Conclusion

Basing on the findings of this study, SRI technology produces higher rice yields as compared to traditional farming method of flooding system. Results indicated that improvements in crop yield in SRI system was due to vigorous plant growth and increased number of tillers attributed to AWD form of irrigation. Allowing the field to dry until cracks of 1 to 1.5cm during tillering stage enhances profusion of more tillers. On the contrary, there is ineffective use of water in conventional system since flooding is done continuously and this affects negatively the growth of tillers and as the results indicated this system has less effective tiller number as compared to SRI technology which uses less water for more effective tillers.

Acknowledgements

This research was supported by National Council of Science and Technology (NCST), Ahero Irrigation scheme and Rice farmer in Ahero Scheme. We are very grateful for helping us realize this study.

References

- [1] FAO of the United Nations, (2009). Crop prospects and food situation. February (No. 1). Rome: FAO.
- [2] Nyang'au, W. O., Mati, B. M., Kalamwa, K., Wanjogu, R. K., and Kiplagat, L. K., (2014). Estimating Rice Yield under Changing Weather Conditions in Kenya Using CERES Rice Model. *International Journal of Agronomy*.
- [3] Craciun, I., Craciun, M. (1999). Water and nitrogen use efficiency under limited water supply for maize to increase land productivity. In: Kirda, C., Moutonnet, P., Hera, C., Nielsen, D. R. (Eds.), *Crop Yield Response to Deficit Irrigation*. Kluwer Academic Publishers, The Netherlands, 87–94.
- [4] Reddy, C. R., Reddy, S. R., (1993). Scheduling irrigation for peanuts with variable amounts of available water. *Agricultural Water Management* 23, 1–9.
- [5] Mati, M. and Nyamai, M. (2009). System of rice intensification. An information brochure used for Training on SRI in Mwea, Kenya.
- [6] Sujono, J., Matsuo, N., Kazuak, M., and Mochizuki, T. (2011). Improving the water productivity of paddy rice (*Oryza sativa* L.) cultivation through water saving irrigation treatments. *Agricultural Sciences*, 2 (2011) 511-517.
- [7] Nwite J. C., B. A. Essien, C. Keke I., Igwe C. A. and Wakatsuki T. (2016). Effect of Different Land Preparation Methods for Sawah System Development on Soil Productivity improvement and Rice Grain Yield in Inland Valleys of Southeastern Nigeria. *Advances in Research* 6 (2): 1-17.
- [8] Welch, R., Vincent, R., Auffhammer, M., Moya, F., Dobermann, A. and Dawe, D. (2010). Rice yields in tropical/subtropical Asia exhibit large but opposing sensitivities to minimum and maximum temperatures. *Sustainability Science, PNAS Early Edition*, Pp 6.
- [9] Yoshida, S. (1981). *Fundamentals of Rice Crop Science*. International Rice Research Institute, Manila, Philippines.
- [10] World Bank Institute, (2008). *System of Rice Intensification (SRI): Achieving more with less - A new way of rice cultivation. Overview of SRI - Improving Rice Productivity and Achieving Water Savings*. WBI Multimedia Team. Washington, D. C. The Institute.
- [11] Surajit, K. (1981). *Principles and Practices of Rice Production*. Technology and Engineering. Wiley, New York.
- [12] Nyirenda, M. E., Tarimo, A. K. P. R. and Kihupi, N. I. (2010). Yield response of different local and hybrid rice varieties to different ponding depths of water. *Comprehensive Assessment of Water Management in Agriculture*. Second RUFORUM Biennial Meeting 20–24 September 2010, Entebbe, Uganda.
- [13] Gomez A. K, Gomez AA (1984). *Statistical Procedures of Agricultural Research*, New York P: 704.
- [14] Singh C. B, Aujla T. S., Sandhu B. S., Khera K. L. (1996). Effect of transplanting date and irrigation regime on growth, yield and water use in rice (*Oryza sativa*) in northern India. *Indian Journal Agricultural Science* 66: 137-141.
- [15] Ravi C. S., Nobuhiko F. and Pabitra B. (2019). System of Rice Intensification Verses Conventional Rice System: Off-farm Field Studies. *NASS Journal of Agricultural Sciences*; 1 (1): 1-11.
- [16] Gani, A., Kadir, T. S., Jatiharti, A., Wardhana, I. P. and Lal, I. (2002). "The System of Rice Intensification in Indonesia," in N. Uphoff et al. (eds.), *Assessments of the System of Rice Intensification*, 58-63.
- [17] Satyanarayana, A., Thiyagarajan, T. M. and Uphoff, N. (2007). Opportunities for water saving with higher yield from the system of rice intensification. *Irrigation Science* 25: 99–15.
- [18] Uphoff, N. (2001). Scientific issues raised by the System of Rice Intensification: a less water rice cultivation system, In: Hengsdijk H, Bindraban P, editors. *Water savings rice production systems*. Proceedings of an international workshop on Water saving rice production, Nanjing University China, 2 – 4 April 2001. PRI report No. 33p 69-82.
- [19] Mulu D. (2004). Effect of seedling age, spacing and season on phyllochrons, yield and components of yield with SRI. M. Sc. Thesis. (In:) Report on SRI- visit to Philippines, March 19-28, 2004 (Ed.) Uphoff, N. pp. 5–8.
- [20] Udayakumar, (2005). Studies on System of Rice Intensification (SRI) for seed yield and seed quality. M. Sc. (Agri) Thesis, Acharya N. G. Ranga Agricultural University, Hyderabad.

- [21] San-oh, Y., Sugiyama, T., Yoshita, D., Ookawa, T., Hirasawa, T. (2006). The effect of planting pattern on the rate of photosynthesis and related processes during ripening in rice plants. *Field Crops Res.*, 96: 113–124.
- [22] Krishna, A. and N. K. Biradarpatil, (2009). Influence of seedling age and spacing on seed yield and quality of short duration rice under system of rice intensification cultivation. *Karnataka J. Agric. Sci.*, 22 (1), 53-55.
- [23] Singh, P., Khan, I. M., Singh, S., Tiwari, R. K., Shukla, U. N. and Philip, P. (2014). Performance of physiological basis of rice hybrids under system of rice cultivation. *Bangladesh J. Bot.*, 43 (3): 359-361.
- [24] Reddy, K. R. N., Reddy, C. S., Abbas, H. K., Abel, C. A. and Muralidharan, K. (2008). Mycotoxigenic Fungi, Mycotoxins, and Management of Rice Grains, *Toxin Reviews*, 27: 3, 287—317.
- [25] Sarath P. Nissanka and Thilak B. (2004). Comparison of Productivity of System of Rice Intensification and Conventional Rice Farming Systems in the Dry-Zone Region of Sri Lanka. 4th International Crop Science Congress.
- [26] Arman E. A. R, Aswaldi A., and Reni M., (2018). The Effects of Planting Range and Weed Management on Growth and Yield of Rice (*Oryza sativa* L.) Using Modified SRI (The System of Rice Intensification). *International Journal on Advance Science Engineering Information Technology*, Vol 8 No. 1.
- [27] 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) in mid hill acid soils of Sikkim Himalayas. *Indian Journal of Agronomy* 57 (1): 32–37.
- [28] Singh, R. K., Singh, A. N., Ram, H., Rajendra Prasad, S and Chauhan, R. K. 2013. Response of basmati (*Oryza sativa* L.) rice varieties to System of Rice Intensification (SRI) and conventional methods of rice cultivation. *Ann. Agric. Res.*, 34 (1): 50-56.
- [29] Krupakar Reddy, G. 2004. Varietal performance and spatial requirement of rice under System of Rice Intensification during Kharif season. M. Sc. (Agri) Thesis, Acharya N. G. Ranga Agricultural University, Hyderabad.
- [30] Saravana P. M., Sivakumar G., Srinivaspermal A. P., S Kalaisudarson and Parimala G., (2019). Effect of system of rice intensification on yield attributes towards enhancement of grain yield in rice. *Journal of Pharmacognosy and Phytochemistry* 2019; 8 (2): 1541-1543.
- [31] Kavitha M. P., Ganesaraja V., Paulpandi V. K., Subramanian R. B. (2010). Effect of Age of Seedlings, Weed Management Practices and Humic Acid Application on System of Rice Intensification. *Indian Journal of Agricultural Research* 44 (4): 294-299.
- [32] Sawant S., Ritesh K., Kartikeya C., Anoop K. and Sandeep K. (2019). Performance of aromatic varieties and age of seedlings on yield and nutrient uptake of rice under irrigated ecosystem. *International Journal of Chemical Studies*; 7 (3): 166-169.