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Response of rice (*Oryza sativa* L.) as influenced by different planting systems and graded levels of nitrogen on yield, quality and economics

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Abstract
The field experiment was conducted during kharif season of 2016 at Crop Research Farm (CRF) SHUATS, Allahabad. The experiment was carried out to find the performance of three planting methods, (P1: Conventional transplanting; P2: System of Rice Intensification; P3: Machine transplanting) and three different levels of Nitrogen (N_1: 60 kg Nitrogen ha^{-1}, N_2: 90 kg Nitrogen ha^{-1}, N_3: 120 kg Nitrogen ha^{-1}) which laid out in Randomized Block Design (RBD) & replicated thrice. The experiment finding revealed that the treatment T_9 (SRI + 120 kg Nitrogen ha^{-1}) significantly performed better than all other varieties viz; Number of effective tillers $hill^{-1}$ (18.59), Number of grains $panicle^{-1}$ (108.88), Length of panicle (27.90 cm), Test weight (24.82 g), Grain yield (5.34 t ha^{-1}), Straw yield (10.26 t ha^{-1}), Harvest index (34.23%) and Protein content (8.37%). While the same treatment T_9 (SRI + 120 kg Nitrogen ha^{-1}) recorded highest gross return (152600.00 Rs ha^{-1}), net return (92077.92 Rs ha^{-1}) and B: C ratio (2.52), however treatment T_6 (MTR + 120 kg Nitrogen ha^{-1}) and T_7 (SRI + 60 kg Nitrogen ha^{-1}), T_8 (SRI + 90 kg Nitrogen ha^{-1}) T_9 (SRI + 120 kg Nitrogen ha^{-1}) were statistically at par with treatment T_9.

Keywords: conventional, SRI, panicle initiation, days after transplanting (DAT), one quadrate

Introduction
Rice belongs to genus *Oryza* and the family Gramineae (Poaceae). The genus Oryza contains 25 recognized species, of which 23 are wild species and two cultivated (*O. sativa* and *O. glaberrima*). Rice is the staple food for more than 60% of the Indian population. It accounts for about 43% of total food grain production and 46% of total cereal production in the country Anonymous 2006 [1]. More than 90 per cent of the world's rice is produced and consumed in Asia, where it is an integral part of culture and tradition. Rice occupies a pivotal place in Indian agriculture and it is contributes to 15 per cent of annual GDP and provides 43 per cent calorie requirement for more than 70 per cent of Indians Anonymous 2005 [2]. India has 44.14 million hectare area under rice and production of 106.65 million tonnes with an average yield of 2416 kg ha^{-1} during 2013-14, Uttar Pradesh has an area of 5.98 m ha, production of 14.64 million tonnes and productivity of 2.447 t ha^{-1} of rice GOI 2016 [3]. It is estimated that 5000 liters of water is needed to produce 1 kg of Rice Bouman *et al*., 2009 [4]. Manual transplanting is the most common practice of rice cultivation in south and south-east Asia. In recent years, water table is running down at a very rapid rate throughout the globe, thus sending an alarming threat and limiting the scope for cultivation of high water requiring crops very seriously. Changes in crop establishment have important implications for farm operations, including primary tillage, seedbed preparation, planting, weeding, and water management that have a considerable impact on rice growth, especially seedling development and rice canopy structure establishment Saha and Bharti, 2010 [5]. Similarly Tiwari and Rai 2003 [6] reported that by using eight row self-propelled rice transplanter save 68 per cent of labour compared to manual transplanting. Recently a water-saving rice cultivation method known as the system of rice intensification (SRI) developed in Madagascar during the early 1980s has generated considerable debate globally. The components of SRI include the use of young seedlings, single seedlings per hill, wider spacing of transplanted seedlings plants leading to greater root growth and better tillering potential and limited irrigation. Though the individual agronomic factors of SRI may have their own effects, the synergistic effects of the components of SRI have a major role in the gains of SRI cultivation Uphoff, 2002 [7]. Nitrogen is a key component of many organic compounds, nitrogen application can improve the root system, so that water and nutrient absorption are facilitated & Rice production and productivity was significantly enhanced with the introduction and cultivation of semi-dwarf, fertilizer responsive and non-lodging high yielding varieties in the early seventies leading to the "Green Revolution".

Materials and Methods

A field experiment was conducted during kharif season of 2016 at the Crop Research Farm (CRF) Department of Agronomy, Allahabad School of Agricultural, Sam Higginbottom University of Agriculture Technology and Sciences, Allahabad. The experiment site lies between 25-27° N latitude, 8.5°E Longitude and 98 meters altitude. The climate is characterized by the alternate hot rainy season from late June to early September with mean temperature of 38°C. The soil was sandy loam in texture and having a pH (7.3), EC (0.26 dSm^{-1}), organic carbon (0.40%), available N (250 kg ha^{-1}), P (13.50 kg ha^{-1}), K (313 kg ha^{-1}) during the experimental year. The experiment was laid down in randomized block design (RBD) with three planting methods viz., conventional transplanting, machine transplanting and System of Rice Intensification (SRI) planting and three different levels of nitrogen (60, 90 and 120 kg ha^{-1}) with 9 treatments and 3 replications. Twenty one days old seedlings were transplanted conventionally at a spacing of 20 x 15 cm; while twelve days old seedlings of mat nursery were transplanted with a spacing of 25 x 25 cm in SRI. Similarly in machine planting, seedlings were raised in tray nursery, hence 18 days seedlings were used for transplanting with a self propelled paddy transplanter. The transplanting was done on 18 July 2016 for all the methods respectively & rice crop was fertilized with (100%) full dose phosphorus and potassium, whereas (50%) Nitrogen was applied at the time of planting as basal dose and the remaining Nitrogen was applied in two equal split doses as top dressing at (Active Tillering & Panicle Initiation stage) respectively. Irrigation was scheduled at 5-6 days interval during vegetative growth; in conventional and machine transplanting 5 cm standing water was maintained from tillering upto dough stage while in the case of SRI, intermittent wetting and drying was followed for the same period. For controlling of weeds in SRI, cono weeder was passed between lines at 10 and 20 days after transplanting (DAT) followed by two hand weedings at 30 and 40 DAT. However In case of traditional and machine transplanting, two normal hand weeding was done with the help of “Khurpi” after 30 days after transplanting and 50 days after transplanting. One quadrate (1 m^2) was harvested in every plot for the determination of results and data was subjected to statistical analysis separately by using analysis of variance technique. The difference among treatment means was compared by using least significant difference test at 5% probability levels. The treatment consisted of T_1: CTR + 60 kg Nitrogen ha^{-1}, T_2: CTR + 90 kg Nitrogen ha^{-1}, T_3: CTR + 120 kg Nitrogen ha^{-1}, T_4: MTR + 60 kg Nitrogen ha^{-1}, T_5: MTR + 90 kg Nitrogen ha^{-1}, T_6: MTR + 120 kg Nitrogen ha^{-1}, T_7: SRI + 60 kg Nitrogen ha^{-1}, T_8: SRI + 90 kg Nitrogen ha^{-1}, T_9: SRI + 120 kg Nitrogen ha^{-1}.

Results and Discussion

Yield attributes

The yield attributes of rice, viz., Number of effective tillers $hill^{-1}$, Number of grains $panicle^{-1}$, Length of panicle and Test weight were significantly influenced SRI method and attributed to the optimum plant population and geometry which led to availability of more resources to the plants, similarly higher nitrogen rates might be primarily due to increase in chlorophyll content of leaves which led to higher photosynthetic rate and ultimately plenty of photosynthesis available during grain development and also may be due to synchronized availability of essential plants nutrients to the crop especially NPK for a longer period during its growth & reproductive stages. Treatment T_9 (SRI + 120 kg Nitrogen ha^{-1}) recorded the highest Number of effective tillers $hill^{-1}$(18.59), Number of grains $panicle^{-1}$ (108.88), Length of panicle (27.90) & Test weight (24.82) where as lowest Number of effective tillers $hill^{-1}$(9.90), Number of grains $panicle^{-1}$(93.74), Length of panicle (26.27) and Test weight (21.85) was recorded in Treatment T_1 (CTR + 60 kg Nitrogen ha^{-1}). However treatment T_6 (MTR + 120 kg Nitrogen ha^{-1}) and T_7 (SRI + 60 kg Nitrogen ha^{-1}), T_8 (SRI + 90 kg Nitrogen ha^{-1}) T_9 (SRI + 120 kg Nitrogen ha^{-1}) were statistically at par with treatment T_9 (SRI + 120 kg Nitrogen ha^{-1}) respectively (Table 1) & (Fig 1). Increased number of effective tillers $hill^{-1}$, number of filled grains $panicle^{-1}$, length of panicle and test weight may have helped in increasing the photosynthetic area for photosynthesis in plant. In several rice cultivars, the effect on number of effective tillers production at all the growth stages was significant, the number increased till 77 DAT followed by a decline to harvest due to death of some undeveloped tillers, thus The increased yield attributes in SRI may be accounted due to concept of phyllochronic utilization that follows by young age seedling Shukla *et al.*, 2014 [8]. All the yield attributes were favorably influenced by wider spacing of 25 x 25 cm. This might be due to efficient utilization of resources and less inter and intra space competition among widely spaced plants which may be assigned as the reason for superiority in these yield attributes of rice and consequently increased yield Vijaykumar *et al.*, 2006 [9]. These results are in accordance with the findings of Padmavati *et al.*, 1998 [10] Increase in level of nitrogen fertilizer increased the number of grains in rice. Higher number of grains per panicle at higher nitrogen rate might be due to higher nitrogen absorption which favored formation of higher number of branches per panicle Rahman *et al.*, 2007 [11].

Yield

Rice as influenced by different methods of crop establishment and nitrogen levels had a significant effect on the yield parameters. Significant and highest grain yield (5.34 t ha^{-1}), straw yield (10.26 t ha^{-1}) and harvest index (34.23%) was recorded in treatment T_9 (SRI + 120 kg Nitrogen ha^{-1}) while lowest grain yield (3.83 t ha^{-1}), straw yield (8.95 t ha^{-1}) and harvest index (29.92%) was recorded in treatment T_1 (CTR + 60 kg Nitrogen ha^{-1}) however treatment T_6 (MTR + 120 kg Nitrogen ha^{-1}) and T_7 (SRI + 60 kg Nitrogen ha^{-1}), T_8 (SRI + 90 kg Nitrogen ha^{-1}) T_9 (SRI + 120 kg Nitrogen ha^{-1}) were statistically at par with treatment T_9 (SRI + 120 kg Nitrogen ha^{-1}) respectively (Table 2) and (Fig 2). The increased grain yield under SRI 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 and thereby leading to higher tillering and grain filling Thiyagarajan *et al.*, 2002 [12]. The same was also opined by Vijayakumar *et al.*, 2006 [9] with regard to nitrogen, Awan *et al.*, 2011 [13] and Rao *et al.*, 2013 [14] also reported higher yield with successive increase in nitrogen levels. The increment of grain yield at higher nitrogen levels might be due efficient absorption of nitrogen and other elements which raise the production and translocation of the dry matter from source to sink Morteza *et al*., 2011 [15].

Higher grain yield with higher nitrogen level might be due to higher values of growth parameters like dry matter accumulation etc. which result in higher capture of solar energy and hence lead to enhanced values of yield attributing characters that ultimately result in higher grain yield. These results are also in agreement with the findings of Sandhu 2011 [16], Mahajan *et al.* 2011 [17], Singh and Walia 2010 [18] and Singh *et al.* 2007 [19].

Quality attributes

Protein content (%)

Highest protein content (8.37%) has recorded in treatment T_9 (SRI + 120 kg Nitrogen ha^{-1}), while lowest protein content (7.07%) has recorded in treatment T_1 (CTR + 60 kg Nitrogen ha^{-1}). however treatment T_6 (MTR + 120 kg Nitrogen ha^{-1}) and T_7 (SRI + 60 kg Nitrogen ha^{-1}), T_8 (SRI + 90 kg Nitrogen ha^{-1}) T_9 (SRI + 120 kg Nitrogen ha^{-1}) were statistically at par with treatment T_9 (SRI + 120 kg Nitrogen ha^{-1}) respectively (Table 3) and (Fig 4). The increased protein content, probable this could be attributed due to; nitrogen an integral part of proteins and its increased application might have resulted in increased nitrogen content (%) in paddy grains, which ultimately increased protein content in milled basmati rice Gill and Walia 2013 [20].

Post-harvest nutrients status of soil

The observations regarding total available nutrients (kg ha^{-1}) and (ppm) after harvest of rice is presented in (Table 3) and (Fig 5). According to data pertaining to available nutrients in soil was influenced by different methods of crop establishment and nitrogen levels had significantly influence over available soil nutrients after harvest of the crop. Data indicated that significantly higher available Nitrogen (235 kg ha^{-1}), Phosphorus (13.30 kg ha^{-1}), Potassium (309 kg ha^{-1}), Sulphur (13.39 ppm), has recorded in treatment T_9 (SRI + 120 kg Nitrogen ha^{-1}), whereas highest available Zinc (0.51 ppm), Iron (10.03 ppm), Manganese (6.02 ppm) and Copper (0.84 ppm) was recorded in treatment T_1 (CTR + 60 kg Nitrogen ha^{-1}).

Economics

The highest gross return (152600 Rs ha^{-1}), net return (92077.92 Rs ha^{-1}) and B:C ratio (2.52) was observed in treatment T_9 (SRI + 120 kg Nitrogen ha^{-1}), while lowest gross return (120270 Rs ha^{-1}), net return (57741.36 Rs ha^{-1}) and B:C ratio (1.92) was observed in treatment T_1 (CTR + 60 kg Nitrogen ha^{-1}) however treatment T_6 (MTR + 120 kg Nitrogen ha^{-1}) and T_7 (SRI + 60 kg Nitrogen ha^{-1}), T_8 (SRI + 90 kg Nitrogen ha^{-1}) T_9 (SRI + 120 kg Nitrogen ha^{-1}) were statistically at par with treatment T_9 (SRI + 120 kg Nitrogen ha^{-1}) respectively (Table 2) & (Fig 3).

Table 1: Response of rice as influenced by different methods of crop establishment & nitrogen levels on yield attributes viz., number of effective tillers $hill^{-1}$, Number of grains $panicle^{-1}$, Panicle length (cm) and Test weight (g)

	Treatments	No. of effective tillers $hill^{-1}$	No. of grains $panicle^{-1}$	Panicle length (cm)	Test weight (g)
T_1	CTR + 60 kg Nitrogen ha^{-1}	9.90	93.74	26.27	21.85
T_2	CTR + 90 kg Nitrogen ha^{-1}	11.73	94.96	26.47	22.97
T_3	CTR + 120 kg Nitrogen ha^{-1}	12.13	96.07	26.54	23.48
T_4	MTR + 60 kg Nitrogen ha^{-1}	13.99	99.58	26.59	23.56
T_5	MTR + 90 kg Nitrogen ha^{-1}	14.99	101.89	27.07	23.64
T_6	MTR + 120 kg Nitrogen ha^{-1}	16.80	105.98	27.43	24.11
T_7	SRI + 60 kg Nitrogen ha^{-1}	16.73	105.75	26.50	23.99
T_8	SRI + 90 kg Nitrogen ha^{-1}	17.97	107.00	27.46	24.17
T_9	SRI + 120 kg Nitrogen ha^{-1}	18.59	108.88	27.90	24.82
F-test		S	S	S	S
SEd(±)		0.54	1.39	0.33	0.55
CD (P=0.05)		1.15	2.94	0.71	1.17

Table 2: Response of Rice as Influenced by Different Methods of Crop Establishment & Nitrogen Levels on Yield & Economics viz., Grain yield, Straw yield, Harvest Index, Gross return, Net return and B: C ratio

	Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest Index (%)	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C ratio
T_1	CTR + 60 kg Nitrogen ha^{-1}	3.83	8.95	29.92	120270.00	57741.36	1.92
T_2	CTR + 90 kg Nitrogen ha^{-1}	3.98	8.98	30.87	123590.00	60539.60	1.96
T_3	CTR + 120 kg Nitrogen ha^{-1}	4.13	9.23	30.93	127420.00	63847.92	2.00
T_4	MTR + 60 kg Nitrogen ha^{-1}	4.24	9.46	30.95	130010.00	70441.36	2.18
T_5	MTR + 90 kg Nitrogen ha^{-1}	4.43	9.76	31.23	135050.00	74959.60	2.24
T_6	MTR + 120 kg Nitrogen ha^{-1}	5.20	10.06	34.08	148730.00	88117.92	2.45
T_7	SRI + 60 kg Nitrogen ha^{-1}	4.84	9.66	33.38	147280.00	87801.36	2.47
T_8	SRI + 90 kg Nitrogen ha^{-1}	5.25	10.13	34.14	150040.00	90039.60	2.50
T_9	SRI + 120 kg Nitrogen ha^{-1}	5.34	10.26	34.23	152600.00	92077.92	2.52
F-test		S	S	S	--	--	--
SEd(±)		0.10	0.24	0.97	--	--	--
CD (P=0.05)		0.22	0.71	2.06	--	--	--

Table 3: Response of Rice as Influenced By Different Methods of Crop Establishment & Nitrogen Levels on Quality Attributes (Protein Content %) and Post-Harvest Nutrients Status of Soil.

	Treatments	Protein Content (%)	N Kg ha^{-1}	P Kg ha^{-1}	K Kg ha^{-1}	S ppm	Zn ppm	Fe ppm	Mn ppm	Cu Ppm
T_1	CTR + 60 kg Nitrogen ha^{-1}	7.07	218	13.00	302	13.11	0.48	10.01	6.01	0.81
T_2	CTR + 90 kg Nitrogen ha^{-1}	7.26	220	13.00	305	13.10	0.49	10.02	6.00	0.81
T_3	CTR + 120 kg Nitrogen ha^{-1}	8.28	221	13.10	305	13.19	0.51	10.01	6.02	0.83
T_4	MTR + 60 kg Nitrogen ha^{-1}	7.14	219	12.80	301	13.08	0.49	10.01	6.04	0.82
T_5	MTR + 90 kg Nitrogen ha^{-1}	8.15	217	12.90	301	13.08	0.49	10.01	6.04	0.82
T_6	MTR + 120 kg Nitrogen ha^{-1}	8.32	225	13.05	305	13.27	0.49	10.02	6.01	0.83
T_7	SRI + 60 kg Nitrogen ha^{-1}	7.15	229	13.20	307	13.28	0.51	10.02	6.04	0.84
T_8	SRI + 90 kg Nitrogen ha^{-1}	8.22	231	12.95	305	13.27	0.50	10.01	6.00	0.83
T_9	SRI + 120 kg Nitrogen ha^{-1}	8.37	235	13.30	309	13.39	0.51	10.03	6.02	0.84

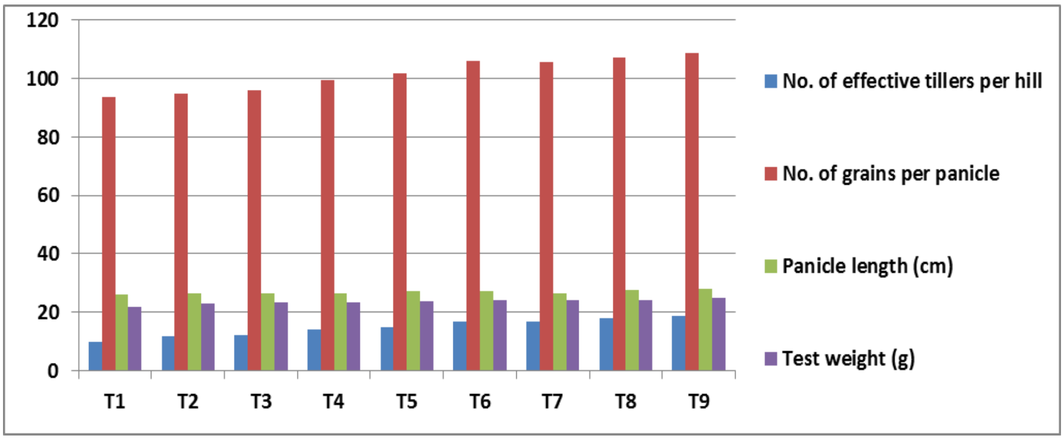

Fig 1: Response of rice as influenced by different methods of crop establishment & nitrogen levels on yield attributes viz., number of effective tillers hill^{-1}, number of grains panicle^{-1}, panicle length (cm) and test weight (g)

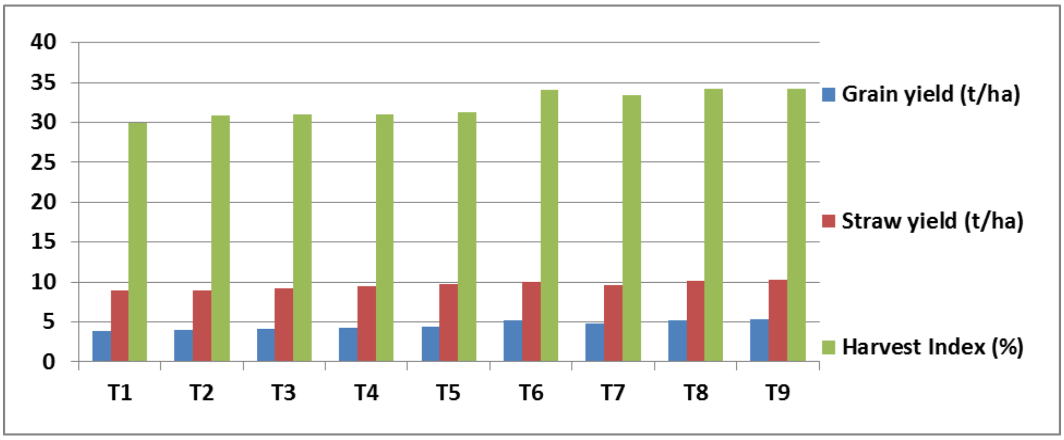

Fig 2: Response of rice as influenced by different methods of crop establishment & nitrogen levels on yield viz., grain yield, straw yield, harvest index.

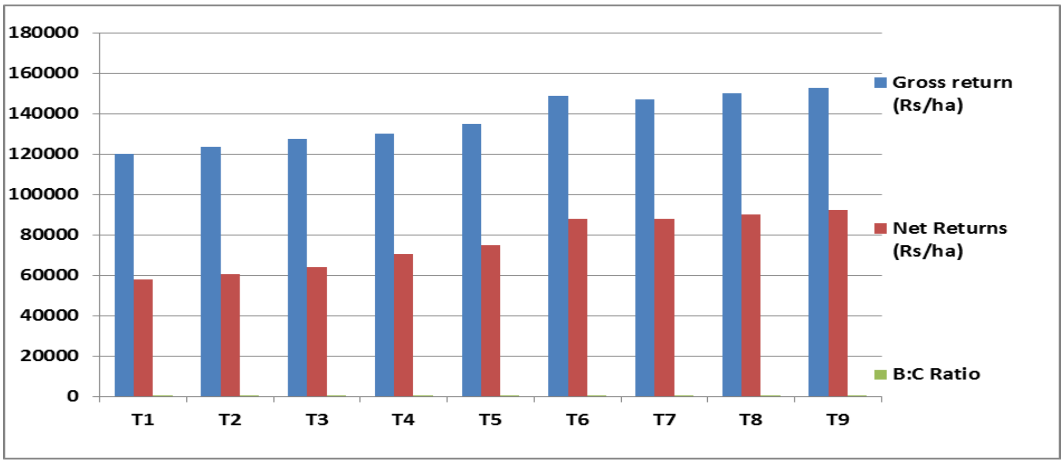

Fig 3: Response of rice as influenced by different methods of crop establishment & nitrogen levels on economics viz., gross return, net return and B: C ratio.

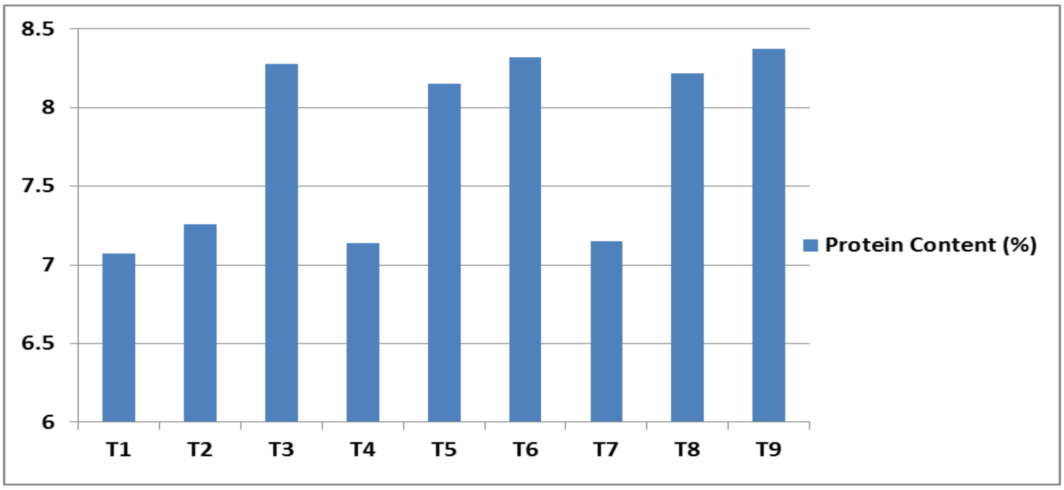

Fig 4: Response of rice as influenced by different methods of crop establishment & nitrogen levels on quality attributes (Protein Content %)

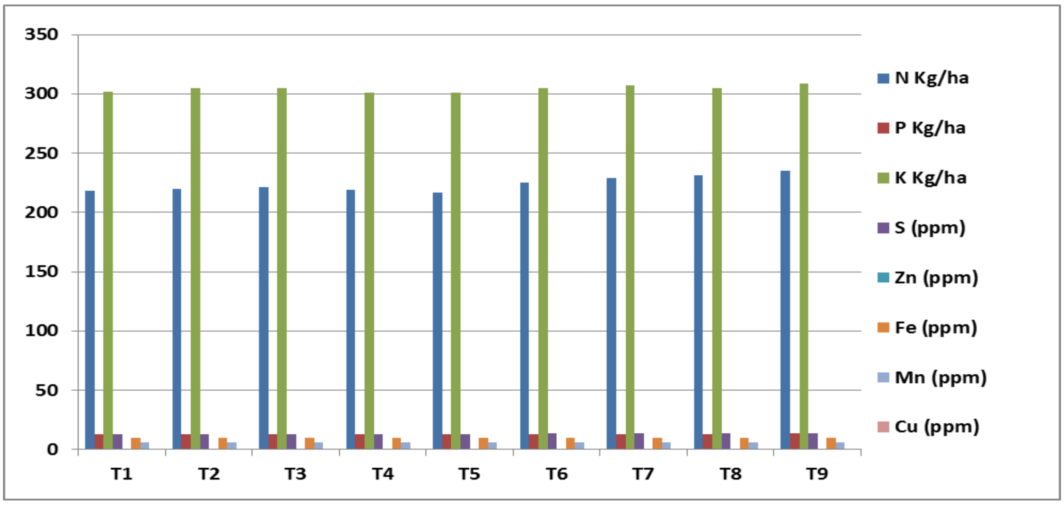

Fig 5: Response of rice as influenced by different methods of crop establishment & nitrogen levels on post-harvest nutrients status of soil

Conclusion

In conclusion, from the data pertaining to the different treatments, it may be indicated that by using (SRI + 120 kg Nitrogen ha^{-1}) higher grain yield and monetary benefits can be realized over control (Conventional method) and it was found to be the best for obtaining highest Seed yield, Stover yield and benefit cost ratio. Since the findings are based on the research done in one season it may be repeated for conformation.

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