Impact of integrated nitrogen management practices on nutrient content and their uptake by transplanted rice crop (*Oryza sativa* L.)

ABSTRACT

Aims: To evaluate the effect of integrated nitrogen management practices on nutrient content and their uptake by transplanted rice (*Oryza sativa* L.) crop in mid hill conditions of Himachal Pradesh.

Study design: The experiment was performed in randomized block design (RBD).

Place and Duration of Study: Department of Agronomy, School of Agriculture, Abhilashi University, Chail Chowk, Mandi, (H.P.), during the *kharif* season of 2023.

Methodology: The field trial was conducted with eight treatments and three replications. The different treatments combinations were T_1 (Absolute control), T_2 (100% RDN through Chemical Fertilizer), T_3 (75% RDN through CF + 25% N through FYM), T_4 (75% RDN through CF + 25% N through poultry manure), T_5 (75% RDN through CF + 25% N through vermicompost), T_6 (50% RDN through CF + 50% N through FYM), T_7 (50% RDN through CF + 50% N through poultry manure), T_8 (50% RDN through CF + 50% N through vermicompost).

Results: The study ~~of the data of~~ results revealed that the N, P and K content in grains and straw of rice crop showed no significant differences with the application of nitrogen through CF and organic manures, ~~while,~~while the maximum contents of these nutrients were higher in treatment T_2. However, the significantly highest uptake of N, P and K by grains and straw and total uptake of these nutrients by rice was noted in treatment T_2 which was statistically at par with treatment T_4 and T_5. Whereas, the minimum uptake of these nutrients by grains and straw along with their total uptake was found in treatment T_1 (Absolute control).

Conclusion: **This** s~~S~~tudy ~~results~~ ~~revealed~~ suggests that the use of integrated nitrogen management enhances the nutrient content and their uptake in rice crop.

Keyword: *Rice, chemical fertilizer, poultry manure, vermicompost, nutrient content and nutrient uptake.*

1. INTRODUCTION

Rice (*Oryza sativa* L.) is the most important crop in the developing world and is the staple food of over half the world's population. For 40% of the world's population, it is their primary source of calories **(Virdia and Mehta, 2009) [1].** Almost 90% of the total rice is produced and consumed in Asia. Half of the world's population depends primarily on rice, which is farmed in more than hundred countries **(Koumeleh et al. 2007) [2]**. Rice is an excellent food and ~~is~~ an excellent source of carbohydrates and energy. It is a high-calorie~~s~~ food which contains 75% starch, 6-7% protein, 2-2.5% fat, 0.8% cellulose and 5-9% ash. In Asia, more than two billion people are getting 60-70% of their energy requirement from rice and its derived products **Tomar et al. (2018) [3].** Rice is cultivated in approximately 120 countries; China grows 214 million tonnes, and India (about 173 million tons). China was the world leader in rice production in 2019-20, producing 146.73 million metric tons, followed by India with 115.00 million metric tons **(Anonymous, 2020) [4].** In India, rice occupies an area of 45.77 million hectares with production of 124.37 million tons with an average productivity of 2717 kg ha^{-1} **(Anonymous, 2021) [5]**.

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Nitrogen (N) is the most essential and limiting nutrient element required in large amounts for rice production and provision of adequate supply of N throughout the growing period is essential for realizing potential yields **Surekha et al. (2016) [6].** Nitrogen promotes rapid plant growth and improves grain yield and quality through higher tillering, leaf area development, grain formation, grain filling and protein synthesis **Reddy et al. (2019) [7]** and plays a crucial role in enhancing the yield. Nitrogen ~~play~~plays a vital role in ~~a living~~ plant tissues and is a constituent of protein, enzyme, hormone, vitamins, alkaloids and chlorophyll etc. Nitrogen is one of the primary nutrients critical for the survival of all living organisms. Amino acids are required by humans, and nitrogen is a vital supply of these amino acids, which aids in the production of animal proteins. Our genes are made up of nucleic acid DNA and RNA is involved in protein synthesis, which requires nitrogen. Nitrogen is abundant in the environment but humans ~~can't~~ cannot use it directly from air or soil. So, humans depend upon green plants and microbes to convert them into a usable form for using them.

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Nitrogenous fertilizers are one of the main factors responsible for contributing to increase in rice yield in India. In rice production, farmers apply large amounts of N fertilizer to maximize yield, but only 20-50% of N is taken up by the crop. The resulting loss of the applied N, which is a mobile nutrient leads to increased water and land pollution and greenhouse gas (GHG) emissions. Continuous use of chemical fertilizers alone causes soil organic matter degradation, soil acidity and environmental pollution **Shipra et al. (2019) [8].** The increasing fertility of soil and crop productivity through use of chemical or synthetic fertilizers has often ~~affected~~ negatively affected ~~on~~ biogeochemical cycles. Also, usage of fertilizer causes~~d~~ leaching and run-off of nutrients, especially nitrogen and phosphorus results in degradation of environment. Nitrogen (N) can be lost from the soil by leaching, de-nitrification and volatilization. Practices like deep placement of urea super granule (USG), soil incorporation, use of slow release N fertilizer etc., that minimize N concentration in flood water can reduce its loss through runoff.

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The use of inorganic fertilizer to sustain cropping was found to increase yield only for some few years but not long terms, it has not been effective and leads to soil degradation **Satynarayana et al. (2002) [9]**. The integration of organic manure with inorganic fertilizers is essential to achiev~~e~~inge sustained production of rice and maintain the soil fertility for a longer period **(Gill and Walia, 2014) [10]**. Numerous research findings suggest that using nitrogen fertilizer in combination with organic sources can accelerate the process of organic N mineralization and immobilization, hence, lowering nitrogen losses. Manures improve soil structure, water holding capacity of soil, organic matter contents as well as microbial populations. Integrated use of organics especially vermicompost, poultry manure, farmyard manure, green manure, neem cake and bio-fertilizers as sources of nitrogen application with inorganic fertilizers improve the growth, yield and yield attributing traits in rice. Poultry manure contains major, secondary and micro nutrients that can support crop production and enhance the physical and chemical properties of soil. It improves soil retention and uptake of plant nutrients. **(Mohammed et al. (2010) [11]**. Vermicompost is rich in plant nutrients like~~-~~ nitrogen, phosphorus, potassium, calcium, vitamins, natural phyto-regulators and micro flora in balanced form that helps in re-establishment of the natural fertility of the soil **(Arancon and Edwards, 2009) [12]**. Optimal crop yields and long term soil productivity may be maintained with the combined application of organic manures and inorganic fertilizers **Puli et al. (2016) [13].** So, there is a need to integrate organic manures with chemical fertilizers for sustainable crop production, maintenance of soil fertility and conservation of natural resources.

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2. MATERIAL AND METHODS

~~The experiment entitled "Effect of integrated nitrogen management on productivity of transplanted rice (*Oryza sativa* L.) in mid hill conditions of Himachal Pradesh"~~This research was carried out at the research farm of the School of Agriculture, Abhilashi University, Mandi (H.P.) during the *Kharif* season of 2023. The experimental farm is situated at 30^0 32' N latitude and 74^0 53' E longitudes, with an elevation of 1391 m above mean sea level. The soil of the experimental field was slightly acidic in reaction, medium in organic carbon, low in available nitrogen and medium in available phosphorus and potassium. The pH of the experimental soil was slightly acidic in reaction, which is 5.5 with an electrical conductivity of 0.011 dSm^{-1}), medium in organic carbon (0.70%), low in available nitrogen (218.37 kg ha^{-1}), medium in available phosphorus (17.89 kg ha^{-1}) and potassium (226.15 kg ha^{-1}). The spacing for the tested variety (Hybrid paddy super-120) was 20 × 10 cm row to row and plant to plant. The experiment was laid out in a randomized block design (RBD) with eight treatments and three replications. ~~There were eight treatments comprising~~The treatments include ~~of~~ T_1= Absolute control, T_2= 100% RDN (Recommended Dose of Nitrogen) through CF (c~~C~~hemical f~~F~~ertilizer), T_3= 75% RDN through CF + 25% N through FYM, T_4= 75% RDN through CF + 25% N through poultry manure, T_5= 75% RDN through CF + 25% N through vermicompost, T_6= 50% RDN through CF + 50% N through FYM, T_7= 50% RDN through CF + 50% N through poultry manure, T_8= 50% RDN through CF + 50% N through vermicompost. Recommended doses of N, P and K were applied in the form of urea, d~~D~~iammonium phosphate (DA~~S~~P) and muriate of potash (MOP). Well decomposed farm yard manure, poultry manure and vermicompost were used as organic sources for nitrogen. Urea was the source of nitrogen, and it was administered in three separate doses during the transplanting, tillering and panicle initiation stages. Equal doses of potassium and phosphorus (50 kg ha^{-1}) in the form of muriate of potash and diammonium phosphate (DAP), respectively. Half of the potash and the entire amount of phosphorus were administered as basal, while the other half was applied at the heading stage. Upon harvest, plant samples from each treatment were gathered, cleaned and then allowed to dry in the shade. A mixer grinder was used to finely powder the samples after they had been shade-dried and oven-dried for 24 to 48 hours at 60 ± 50 °C. N, P and K content as well as rice crop uptake were examined using the finely powdered plant samples. **Jackson (1973) [14]** described the modified Kjeldahl digestion and distillation method, which was used to estimate the amount of nitrogen in the plant sample. Using the vae~~e~~nadomolybdate phosphoric yellow color method, the phosphorus content of the plant was ascertained, and the phosphorus content of the plant sample was estimated as per Jackson (1973) instructions. A flame photometer was used to evaluate the potassium content of plants (Jackson, 1973). After multiplying the N, P and K content (%) by the grain and straw yields (q ha^{-1}) at harvest, the N, P and K absorption (kg ha^{-1}) in each treatment was determined. When the rice crop was harvested, the yields of grain and straw were noted.

3. RESULTS AND DISCUSSION

3.1 Nitrogen content (%) and uptake (kg ha^{-1})

The N content and their uptake by grains and straw of transplanted rice is displayed in ~~the (~~Table~~-~~ 1~~)~~ and predicted in the (Fig.~~-~~1). The study ~~of the data~~ showed no significant differences of nitrogen concentration present in the grains and straw of the transplanted rice crop by various nitrogen management treatments. However, the maximum nitrogen content in grains and straw of transplanted rice crop was noticed in treatment of T_2 (100% RDN through CF) and minimum in treatment T_1 (Absolute control).

The application N by organic manure and nitrogenous chemical fertilizer had a substantial impact on the uptake of N by grains and straw as well as the total N uptake. During the study, the highest nitrogen uptake by grains and straw of transplanted rice crop was recorded under treatment T_2 (100% RDN through CF), which was statistically at par with treatment T_4 (75% RDN through CF + 25% N through poultry manure) and T_5 (75% RDN through CF + 25% N through vermicompost). Though, treatment T_1 (a~~A~~bsolute control) showed the minimum amount of N uptake by grains and straw of transplanted rice crop. The treatment T_2 also recorded the total uptake of nitrogen and was it was on par with treatments T_4 and T_5 and the minimum total nitrogen uptake was found under treatment T_1.

As per the research the N uptake by rice grain and straw increased significantly with the combined application of organic manure and chemical fertilizers. The reason for the increased uptake of N with incremental dosages could be that the plant absorbed the nutrients proportionately as the amount of accessible nutrients in the soil solution increased. This could be because only larger fertilizer doses are

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able to fill the absorption sites in the soil and increase the nutrient status. Organic manure nutrient release rate is usually very slow and high depends on microbial activity. Whereas, chemical fertilizer are highly concentrated with less leaching and quick release of N compared to organic manure can be attributed for higher uptake of nitrogen in grains and straw of transplanted rice crop. Similar results also reported by **Baishya et al. (2015) [15]** and **Rao et al. (2014) [16]**.

Table 1. Effect of integrated nitrogen management on nitrogen content and their uptake by grain and straw of transplanted rice crop

S.N.	Treatments	Nitrogen content (%)		Nitrogen uptake (kg ha^{-1})		
		Grain	Straw	Grain	Straw	Total
T_1	Absolute control	1.31	0.40	37.74	15.87	53.61
T_2	100% RDN through CF (Chemical Fertilizer)	1.39	0.44	69.12	25.15	93.27
T_3	75% RDN through CF + 25% N through FYM	1.36	0.42	61.30	21.16	82.46
T_4	75% RDN through CF + 25% N through poultry manure	1.38	0.43	66.78	23.07	89.85
T_5	75% RDN through CF + 25% N through vermicompost	1.37	0.43	64.55	23.57	87.12
T_6	50% RDN through CF + 50% N through FYM	1.34	0.41	53.56	19.11	72.67
T_7	50% RDN through CF + 50% N through poultry manure	1.36	0.42	58.18	20.39	78.57
T_8	50% RDN through CF + 50% N through vermicompost	1.35	0.42	55.42	20.01	75.43
	S.Em.±	**0.04**	**0.01**	**1.89**	**0.61**	**2.51**
	C.D. (P= 0.05)	**NS**	**NS**	**5.78**	**1.88**	**7.70**

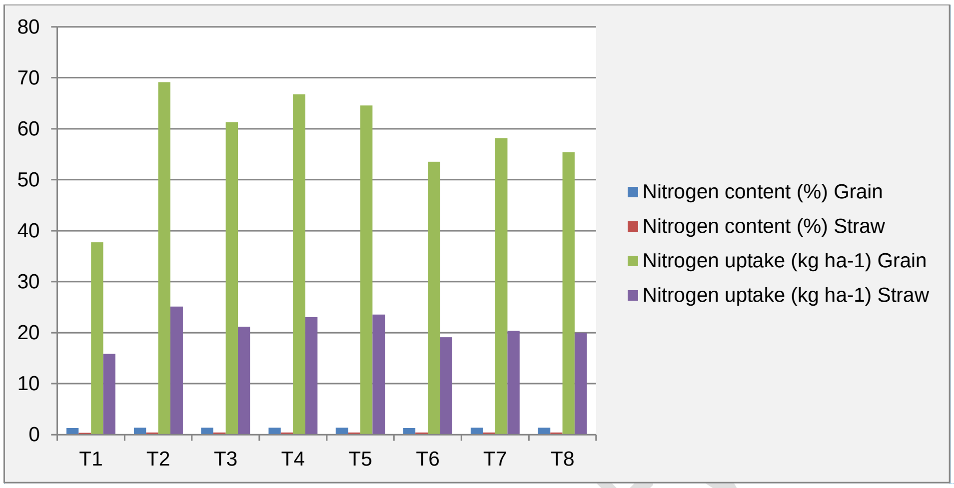

Fig.1. Effect of integrated nitrogen management on nitrogen content and their uptake by grain and straw of transplanted rice crop

3.2 P content (%) and uptake (kg ha^{-1})

Along with their uptake by grains, straw and total uptake, the P content in grains and straw of the transplanted rice crop is provided in Table~~-~~ 2 and illustrated in Fig.~~-~~ 2. The ~~perusal of the~~ data ~~of the study~~ shows~~ed~~ that the amount of P in the grains and straw of the transplanted rice crop did not ~~varied~~ vary significantly by the application of the various nitrogen management treatments. While, the treatment T_2= 100% RDN through CF had the highest P content in grains and straw of transplanted rice crop, however, the minimum P content in grain and straw of transplanted rice crop was reported under treatment T_1 (Absolute control).

Table 2: Effect of integrated nitrogen management on phosphorus content and their uptake by grain and straw of transplanted rice crop

S.N.	Treatments	Phosphorus content (%)		Phosphorus uptake (kg ha^{-1})		
		Grain	Straw	Grain	Straw	Total
T_1	Absolute control	0.21	0.100	6.05	3.97	10.02
T_2	100% RDN through CF (Chemical Fertilizer)	0.24	0.108	11.94	5.93	17.87
T_3	75% RDN through CF + 25% N through FYM	0.23	0.105	10.37	5.29	15.66
T_4	75% RDN through CF + 25% N through poultry manure	0.24	0.106	11.61	5.69	17.30
T_5	75% RDN through CF + 25% N through vermicompost	0.23	0.106	11.31	5.56	16.87
T_6	50% RDN through CF + 50% N through FYM	0.21	0.102	8.39	4.76	13.15
T_7	50% RDN through CF + 50% N through poultry manure	0.22	0.104	9.41	5.05	14.46
T_8	50% RDN through CF + 50% N through vermicompost	0.22	0.103	9.03	4.91	13.94
	S.Em.±	**0.01**	**0.003**	**0.28**	**0.16**	**0.49**
	C.D. (P= 0.05)	**NS**	**NS**	**0.86**	**0.50**	**1.51**

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Nitrogen application through organic and inorganic sources had an adequate effect on the uptake of phosphorus by grains and straw. The study ~~of the~~ data ~~found~~ shows that treatment T_2= (100% RDN through CF) recorded the maximum nitrogen uptake by grains and straw of transplanted rice crop and it was statistically on par with treatment T_4 (75% RDN through CF + 25% N through poultry manure) and T_5 (75% RDN through CF + 25% N through vermicompost). However, the minimum uptake of P by grains and straw of transplanted rice crop was recorded under treatment T_1 (Absolute control). Likewise, uptake of P by grains and straw, the total P uptake by transplanted rice crop was highest under treatment T_2, which was statistically comparable with treatment T_4 and T_5. While, the lowest P uptake by transplanted rice crop were found in treatment T_1.

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In rice, phosphorus is necessary for root development, ripening, early blooming and tolerance to certain biotic and abiotic challenges. Data analysis reveals that treatment T_2= 100% RDN through CF (Chemical Fertilizer), in general, may be more effective than other treatments in promoting phosphorus uptake in rice crop. Phosphorus moves to the root surface through diffusion. However, the presence of the organic matters in the different organic manures increases the activity and population of the microbes into the soil, which might increases the absorption and uptake of phosphorus in grains and straw of transplanted rice crop. Similar results were also found by **Sathish et al. (2011) [17]** and **Tiwari et al. (2020) [18]**.

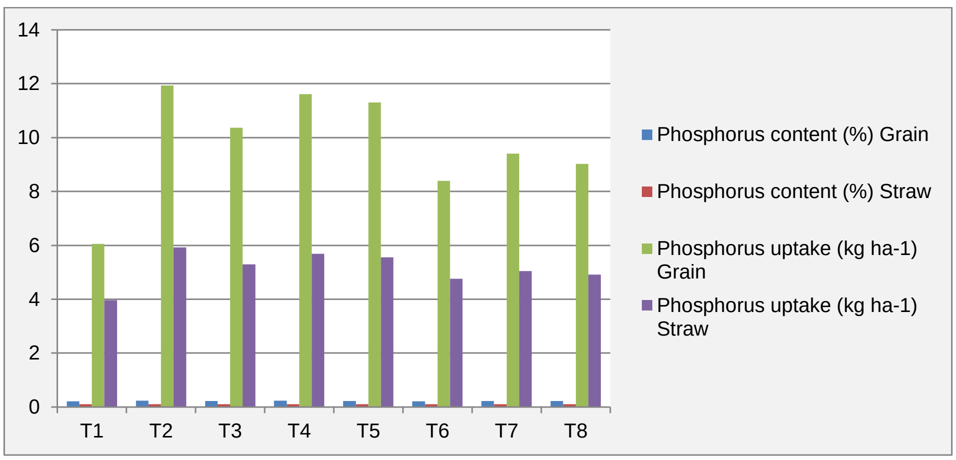

Fig.2. Effect of integrated nitrogen management on phosphorus content and their uptake by grain and straw of transplanted rice crop

3.3 ~~K~~ Potassium content (%) and uptake (kg ha^{-1})

The K content and their uptake by grains and straw of transplanted rice are presented in Table 4 and depicted in Fig. 4. The analysis of the data of the research trial showed that there are no significant differences of the K content in the grains and straw of the transplanted rice crop. However, the highest K content in grains and straw of the transplanted rice crop was recorded under treatment T_2= 100% RDN through CF (c~~C~~hemical f~~F~~ertilizer), whereas, the lowest was observed to be in treatment T_1 (a~~A~~bsolute control).

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The uptake of potassium (K) by transplanted rice crop grains and straw was found to be significantly impacted by integrated nitrogen management. In this study,~~During the research~~, T_2 (100% RDN through CF) recorded the maximum K uptake by grains and straw of transplanted rice crop, which was statistically at par with treatment T_4 (75% RDN through CF + 25% N through poultry manure) and T_5 (75% RDN through CF + 25% N through vermicompost). While, the treatment T_1 (a~~A~~bsolute control) noticed the lowest K uptake by grains and straw. The total uptake of K by transplanted rice crop was also recorded under treatment T_2, which was statistically on par with treatment T_4 and T_5. Even so, treatment T_1 (Absolute control) had the minimum uptake of K by transplanted rice crop during the research.

Potassium is an essential factor in optimizing root development, enhancing plant vigor, reducing lodging, encouraging cell division, supplying osmotic pull, helps in maintain metabolism. Treatment T_1 (a~~A~~bsolute control) where no fertilizer ~~were~~was applied, recorded the significantly lowest uptake of potassium nutrient. Higher uptake of potassium in grain and straw of transplanted rice crop due to increase with increasing levels of chemicals fertilizer. This might be due to increased supply of nutrients accruing directly through organic and inorganic sources to the crop. K application promoted the growth of the rice roots and overall plant growth because of increasing contact between the ions and roots with increasing K availability in the soil contributing to a high K uptake. The application of organic and inorganic sources of nutrient in combination remarkably increased K uptake in grains and straw of transplanted rice crop. Similar results were also reported by **Narwal and Chaudhary (2006) [19], Mondal et al. (2015) [20]** and **Shrivastava and Singh (2017) [21]**.

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Table 3: Effect of integrated potassium management on potassium content and their uptake by grain and straw of transplanted rice crop

S.N.	Treatments	Potassium content (%)		Potassium uptake (kg ha^{-1})		
		Grain	**Straw**	**Grain**	**Straw**	**Total**
T_1	Absolute control	0.27	1.30	7.78	51.58	59.36
T_2	100% RDN through CF (Chemical Fertilizer)	0.31	1.36	15.42	74.64	90.06
T_3	75% RDN through CF + 25% N through FYM	0.29	1.34	13.07	67.50	80.57
T_4	75% RDN through CF + 25% N through poultry manure	0.31	1.35	15.00	72.41	87.57
T_5	75% RDN through CF + 25% N through vermicompost	0.30	1.34	14.14	70.32	87.41
T_6	50% RDN through CF + 50% N through FYM	0.28	1.31	11.19	61.07	84.46
T_7	50% RDN through CF + 50% N through poultry manure	0.29	1.33	12.41	64.56	72.26
T_8	50% RDN through CF + 50% N through vermicompost	0.28	1.32	11.49	62.90	74.39
	S.Em.±	**0.01**	**0.04**	**0.43**	**2.12**	**2.40**
	C.D. (P= 0.05)	**NS**	**NS**	**1.32**	**6.51**	**7.36**

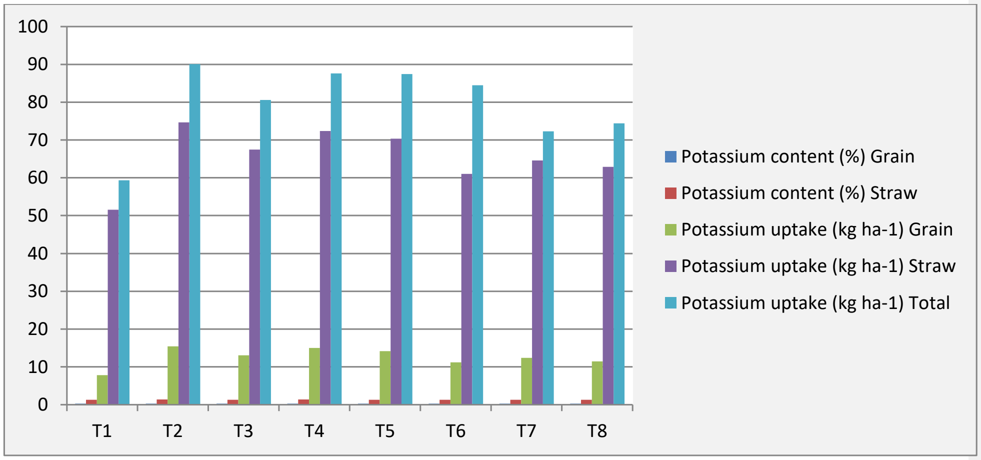

Fig.3. Effect of integrated nitrogen management on potassium content and their uptake by grain and straw of transplanted rice crop

4. CONCLUSION

In conclusion, the application of nitrogen through chemical fertilizers with alteration of organic manure can be good practice for achieving the higher N, P and K content in grains and straw of transplanted rice crop as well as their uptake in grains, straw and total uptake by transplanted rice crop. The results of this study suggest that applying 100% RDN through chemical fertilizer increased the nutrient content and their uptake by transplanted rice.

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