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Balance sheet of Nitrogen in Soil as Influenced by Differential Substitution of Nutrients through Organics in Rice Based Cropping System

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ABSTRACT

Field experiment was conducted for two consecutive years from *kharif* 2015 and summer 2017at research farm of Division of Agronomy, Skuast Jammu to study the effect of differential substitution of nutrients through organics on yield, nitrogen uptake and balance sheet of nitrogen of four crops basmati rice (1st crop) - knolkhol (2nd crop) - knolkhol (3rd crop) - green gram (4th crop) in cropping sequence for two years in Irrigated subtropical conditions of Jammu and Kashmir. The result of two year studied showed that significantly highest yield of all the four crops in two crop cycles in the rice based cropping system viz., basmati rice, knolkhol-1, knolkhol-2 and green gram were recorded with 100 % recommended dose of fertilizer which was found statistically at par with yields recorded with treatments 75 % NPK+25 % N through vermicompost and Fym (1:1), 25% yearly replacement of RDF through vermicompost and Fym (1:1) on N basis, 75% NPK+25% N through vermicompost, 25 % yearly replacement of RDF through vermicompost on N basis, 75 % NPK+ 25 % N through Fym and 25% yearly replacement of RDF through Fym on N basis. Further, highest mean total nitrogen uptake (544.95 kg/ha) in rice based cropping system were recorded with treatment 25% yearly replacement of RDF through Fym on N basis followed by treatment 75 % NPK+ 25 % N through Fym (541.29 kg/ha) whereas highest build-up of available nitrogen in soil after two crop cycles (8.79 kg/ha) was recorded with treatment 100 % N through Farmyard manure followed by treatment 100% N through Vermicompost whereas lowest build-up of available nitrogen (4.53 kg/ha) in soil was recorded with treatment 100 % Recommended dose of fertilizer in rice based cropping system.

Key words : *Balance sheet, Cropping system, Nitrogen uptake, Organics, Yield*

Introduction

Rice based cropping system is the foremost food production system in the world with rice as the main crop. The cereal-cereal based cropping system is low-yielding and highly nutrient exhaustive resulting in declining of soil fertility (John *et al*., 2001) .Therefore, crops that can improve the fertility status should be included in the cropping system. Diversified agriculture is profitable and it helps in the economic development of Indian farmers, generation of employment and conservation of natural resources. Diversification of rice based cropping system with inclusion of pulses/legumes and a short duration vegetable is one of the best options for horizontal expansion. Furthermore, imbalanced and inappropriate use of inorganic nutrients devoid of requisite quantity of organics has not only worsened the soil resource base by reducing the population of beneficial micro-organisms and the factor productivity of most of the crop lands but also deteriorated the quality of the crops. Increased health consciousness among the masses has augmented the demand for safe and quality foods for which a comprehensive food production technology needs to be developed with emphasises on quality enhancement and yield stability in comparison to the yield and quality aspects realized under conventional practices of crop production. In fact, it is not affordable for an average Indian farmer to jump immediately from inorganic source of nutrients to organics in their crop production programme as it may lead to unbearable drastic reduction in crop yields in the initial years. This may become possible through the progressive substitution of organic sources of nutrients in place of in organics to meet crop nutrient requirement for attaining higher and stable crop yield of better quality with an improvement in soil health. Therefore, high diversified and intensified cereal-vegetable-vegetable-legumecropping system was studied for two years in irrigated condition in Union Territory of Jammu and Kashmir.

Materials and Methods

The field experiments were conducted for two years at research farm of division of Agronomy, Skuast-Jammu from *kharif* 2015 to summer 2017. Initally, soil of the experimental field was sandy loam soil in texture, slightly alkaline in texture (pH 7.81), low in organic carbon (0.45 per cent) and available nitrogen (249.88 kg/ha) but medium in available phosphorus (13.79 kg/ha) and available potassium (148.45kg/ha). The experiment was laid out in randomized block design with sixteen treatments T_1-100 % NPK (Recommended dose of fertilizer), T_2-75% NPK+25% N through vermicompost,T_3-50% NPK+50 % N through vermicompost, T_4-25 % NPK+75% N through vermicompost, T_5-100 % N through vermicompost, T_6-25 % yearly replacement of RDF through vermicompost on N basis, T_7-75 % NPK+ 25 % N through Fym, T_8-50 %NPK+50% N through Fym, T_9-25% NPK+75% N through Fym, T_{10}-100% N through Fym, T_{11}-25% yearly replacement of RDF through Fym on N basis, T_{12}-75 % NPK+25 % N through vermicompost and Fym (1:1), T_{13}-50 % NPK+50 % N through Vermicompost and Fym (1:1), T_{14}-25% NPK+75% N through vermicompost and Fym (1:1), T_{15}-100% N through vermicompost and Fym (1:1) , T_{16}-25% yearly replacement of RDF through vermicompost and Fym (1:1) on N basis. The cropping system consists of four crops viz; rice (Basmati-370), knolkhol-1(G 40), knolkhol-2 (G 40) and green gram (SML-668). Basmati rice was transplanted into experimental field in *kharif* season during 13th June 2015 and 11th June 2016, knolkhol-1 was transplanted into *rabi* season on 21st November 2015 and 19th November 2016, knolkhol-2 was transplanted into main field on 12th February 2016 and 18th February 2017 whereas green gram was sown into experimental field on 13th April 2016 and on 13th April 2017. All the crops taken in the system were grown as per their respective recommended packages of cultivation except for the nutrient-N and its organic sources which were applied as per the treatments. The recommended dose of nutrients were presented in Table 1. The inorganic sources of nutrients were urea, ammonium phosphate and murate of potash whereas organic source of nutrients were farmyard manure, vermicompost alone and in combination of 1:1 ratio.

The technique adopted for soil sampling was two step procedure of random sampling given by (Peterson and Calvin, 1965). Similarly, treatment wise soil sampling was also done after the harvest from each treatment. The percent nitrogen content of Fym and vermicompost used in each crop during the both crops was worked out and mentioned in Table 2.

The grain yield of basmati rice (1st crop) was worked out from the thrashed grains of basmati rice obtained from each net plot were weighed separately and finally converted into quintal per hectare by multiplying with the conversion factor as given below:

Table 1. Crops and their recommended doses (kg/ha) in cropping sequence

	Crop	N	P_2O_5	K_2O	FYM
1st crop	Rice (Basmati -370)	30	20	10	-
2nd crop	Knol khol -1 (G 40)	100	50	50	30 t/ha
3rd crop	Knol khol-2 (G 40)	100	50	50	30 t/ha
4th crop	Green gram (SML-668)	16	40	-	-

$$\text{Grain yield (q/ha)} = \frac{\text{Yield obtained from net plot (kg)}}{\text{Area of net plot (m}^2\text{)} \times 100} \times 10{,}000$$

The straw yield of rice was worked out by subtracting the grain yield from the biological yield and expressed in q/ha by multiplying the same conversion factor employed for grain yield of basmati rice. The total plant weight of the knolkhol-1(2nd crop) and knolkhol-2 (3rd crop) was recorded from each net plot and converted in to quintal per hectare by multiplying with the below given conversion

$$\text{Knolkhol yield (q/ha)} = \frac{\text{Knolkhol yield obtained from net plot (kg)}}{\text{Area of net plot (m}^2\text{)} \times 100} \times 10{,}000$$

In green gram (4th crop), pods from each net plot were weighed separately and sundried for 3-4 days. After drying, pods were thrashed and seeds were cleaned. The final seed weight was recorded and expressed in q/ha as per the conversion given below:

$$\text{Seed yield (q/ha)} = \frac{\text{Yield obtained from net plot (kg)}}{\text{Area of net plot (m}^2\text{)} \times 100} \times 10{,}000$$

The weight of dried stover was recorded from each net plot and converted in to quintal per hectare by multiplying the same conversion factor employed for seed yield of green gram. The crop samples were collected for the estimation of nitrogen as per procedure given in Table 2 for vermicompost and farmyard manure. The per cent nitrogen content in grain and straw in basmati rice, knob and stem in knolkhol-1 and knolkhol-2 plants, seed and stover in green gram were calculated by multiplying the per cent nutrient content with their respective dry matter as per the formula given below:

$$\text{Total Nutrient uptake (kg/ha)} = \frac{\text{Nutrient content (\%)} \times \text{dry matter accumulation (kg/ha)}}{\times 100}$$

Attempt was made to workout balance sheet of available nitrogen in the soil as affected by differential substitution of nutrients in basmati rice based cropping system. The losses occurred due to leaching, volatilization etc. were not taken in to consideration while working out the balance sheet of the above stated nutrients. The build up or depletion over the initial soil status of particular nutrient was worked out by computing the difference between the actual balance and initial status.Expected and actual balance was worked out as follows

Expected balance of nutrient in soil = A + B – C

Where

A = Intial status of nutrient,

B = Nutrient added and

C = Uptake of nutrient by crop

All the nutrients were converted into same units while working balance sheet.

Results and Discussion

Yield

In rice based cropping system, the yield of basmati rice (grain and straw yield), knolkhol-1(yield), knolkhol-2 (yield) and green gram (seed and stover yield) were significantly influenced by differential substitution of nutrients through organics during both the crop growing years (Table 3). Significantly highest grain and straw yield of basmati-370 were recorded with treatment 100% recommended dose of fertilizer which was found statistically at par with treatment $T_{12,}$ $T_{16,}$ $T_{2,}$ $T_{6,}$ T_7 and T_{11}. This was might be due to their greater availability and uptake of macro and micronutrients and their active participation in carbon assimilation, photosynthesis starch formation translocation of proteins and sugar, entry of water into the plant roots and its development etc. Combination of organic and inorganic fertilizers also enhances the process of tissue differentiation *i.e* from somatic to reproductive phase leading to higher grain and straw yields. These results are also in conformity with findings of Hossaen *et al.* (2011) and Mohantey *et al.* (2013) where as in basmati-370

Table 2. Per cent N content in Vermicompost and Farm yard manure used in different crops during 1st and 2nd year

Crops	N (%)				Method employed
	Vermi compost		FYM		
	Ist Year	2nd Year	Ist Year	2nd Year	
Basmati rice	1.60	1.53	0.60	0.60	Modified Kjeldhal's method (Jackson, 1967)
Knol khol-1	1.54	1.56	0.53	0.64	
Knol khol-2	1.58	1.60	0.55	0.53	
Green gram	1.61	1.62	0.62	0.57	

the highest percent increase in grain and straw yield (34.41 per cent and 10.00 per cent) during *kharif* 2016 over *kharif* 2015 was recorded with treatment 100 % N through Fymfollowed by treatment 100 % N through vermicompost and Fym and100 % N through vermicompost whereas lowest per cent increase in grain and straw yield (13.79 per cent and 6.49 per cent) was recorded with treatment 100 % N through recommended dose of fertilizer. Similarly, significantly highest knolkhol-1 yield and knolkhol-2 yield was also recorded with 100% recommended dose of fertilizer which was found statistically at par with knolkhol yield recduring both the crop growing years for knolkhol crops. The higher yield in knolkhol-1 and knolkhol-2 with treatments $T_{12,}$ $T_{16,}$ $T_{2,}$ $T_{6,}$ T_7 and T_{11} was due to the reason that organic manures (Vermicompost and Fym) would have provided the micronutrients such as Zinc, Iron and Manganese etc. in the optimum level where Zinc is involved in the biochemical synthesis of the most important plant hormone Indole acetic acid (IAA) through conversion of tryptophan to IAA whereas iron is involved in the chlorophyll synthesis pathway. Vermicompost and FYM activate many species of living organism, which release phytoharmones and may stimulate the knolkhol growth and absorption of essential nutrients. Similar results were also reported by Ouda *et al*. (2008) where as highest per cent increase (15.04 per cent) in yield of knol khol-1 and (11.93 per cent) in knol khol-2 yield was recorded with treatment 100 % N was substituted through Fym whereas lowest percent increase in knolkhol yield (3.85 per cent) and (3.15 per cent) was recorded with treatment 100 % N through recommended dose of fertilizer in first year over 2nd year. This was might be due to the reason that organic manures not only releases essential nutrients but also prevents the losses of chemical fertilizers through denitrification, volatilization and leaching by binding the nutrients and release them with the passage of time. Thus, organic manures prevent nutrient losses. These results were in close proximity with the findings of (Chaudhary *et al.*, 2018) in cole crops. Similarly, seed and stover yield in green gram were significantly influenced by the differential substitution of the nutrients through organics. Significantly highest seed and stover yields of green gram was recorded with treatment T_1 which was found statistically at par with treatments $T_{12,}$ $T_{16,}$ $T_{2,}$ $T_{6,}$ T_7 and T_{11} during summer 2016 and 2017. Highest seed yield in T_1, T_{12}, $T_{16,}$ $T_{2,}$ $T_{6,}$ T_7 and T_{11} was might be due to higher yield attributes on account of increased growth in terms of biomass accumulation during vegetative phase leading to increased bearing capacity (no. of seeds/pod and 100-seed weight) which ultimately increased the seed yield of green gram whereas significantly highest stover yield was might be due to vigorous vegative growth and high-

Table 4. Total Nitrogen Uptake (kg/ha) in of different crops in basmati rice based cropping system (Data of 2 Years)

Treatments	1st crop (Basmati rice)		2nd crop (Knolkhol-1)		3rd crop (Knolkhol-2)		4th crop (Green gram)	
	I Year	II Year	I Year	II Year	I Year	II Year	I Year	II Year
T_1	63.02	71.77	167.49	182.58	138.20	148.43	89.80	99.84
T_2	69.53	78.34	183.06	196.79	145.40	159.39	107.72	121.33
T_3	61.76	69.11	168.69	186.25	138.90	155.07	95.19	107.31
T_4	51.94	60.50	146.42	169.10	124.59	141.60	79.67	92.73
T_5	46.01	55.90	148.11	171.96	125.20	143.85	76.85	90.61
T_6	69.76	77.81	186.84	201.52	148.80	162.05	107.29	120.88
T_7	70.32	78.70	186.12	200.76	148.42	161.32	106.78	130.16
T_8	61.06	68.84	170.16	188.76	140.68	156.67	93.94	107.45
T_9	50.05	58.67	146.41	170.28	124.75	142.87	78.93	92.61
T_{10}	45.61	55.88	148.81	173.51	125.44	144.37	73.34	88.73
T_{11}	71.64	79.09	189.23	204.81	151.39	166.90	106.58	120.26
T_{12}	68.14	77.54	180.66	192.90	144.33	157.54	108.80	121.88
T_{13}	62.60	69.92	169.09	186.89	139.46	155.03	95.24	108.37
T_{14}	53.39	62.20	145.58	168.78	123.01	140.48	80.52	94.07
T_{15}	46.57	56.79	147.18	170.42	124.92	143.22	78.00	92.13
T_{16}	67.95	77.99	181.42	193.53	144.82	157.90	108.55	121.40
CD (P=0.05)	8.03	9.45	24.35	25.08	17.41	17.45	12.71	14.68

*Details of treatments were given in material and methods

est dry matter accumulation in these treatments. These results were in agreement with the findings of Aslam *et al*.(2010) and Meena *et al*. (2015). The highest per cent increase (16.85 per cent) and (20.01 per cent) in seed yield and stover yield of green gram were recorded in treatment 100 % N through FYMwhereas lowest percent increase was recorded with recommended dose of fertilizer, respectively.

Total Nitrogen Uptake

Nutrient uptake is a function of content and yield. It is evident from the data depicted in Table 5 that total nitrogen uptake in basmati rice (1st crop), knolkhol-1 (2nd crop), knolkhol-2 (3rd crop) and green gram (4th crop) were significantly influenced by differential substitution of nutrients through organics in both the crop growing seasons . Significantly highest total nitrogen uptake in basmati rice (71.64 kg/ha and 79.09 kg/ha), total nitrogen uptake in knolkhol-1(189.23 kg/ha and 204.81 kg/ha) and total nitrogen uptake in knolkhol-2 (151.39 kg/ha and 166.90 kg/ha) were recorded with treatment $T_{11}$where as in green gram significantly highest total nitrogen uptake (108.80 kg/ha) during 1st crop growing year was recorded with treatment 75 % NPK +25% N through Vermicompost and FYM whereas during 2nd crop growing year significantly highest total nitrogen uptake (130.16 kg/ha) in green gram was recorded with treatment 75 % NPK +25% N through FYM.

During 1st crop and 2nd crop growing year in basmati rice based crop system highest mean total nitrogen uptake (518.84 kg/ha and 571.06 kg/ha) was recorded with treatment T_{11} as depicted in Figure 1. Lowest mean total nitrogen uptake (393.20

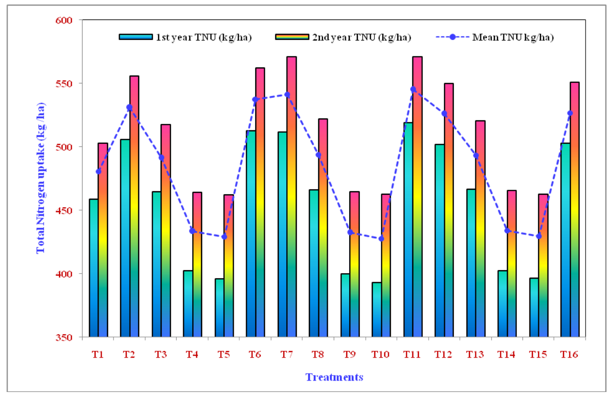

Fig. 1. Treatment wise total nitrogen uptake TNU (kg/ha) in basmati rice based cropping system after two crop cycles

Table 3. Yield of different crops as influenced by differential substitution of nutrients through organics in rice based cropping system (Data of 2 Years)

Treatments	1st crop (Basmati rice)				2nd crop (Knolkhol-1)		3rd crop (Knolkhol-2)		4th crop (Green gram)			
	Grain yield (q/ha)		Straw yield (q/ha)		Knolkhol-1 yield (q/ha)		Knolkhol-2 yield (q/ha)		Seed yield (q/ha)		Stover yield (q/ha)	
	I Year	II Year	I Year	II Year	I Year	II Year	I Year	II Year	I Year	II Year	I Year	II Year
T_1	28.42	32.34	70.15	74.70	833.26	865.31	712.35	734.79	9.56	10.44	39.16	43.03
T_2	26.10	31.35	68.93	74.17	810.00	855.62	682.63	714.77	9.34	10.34	38.33	42.61
T_3	21.89	25.52	57.96	62.21	651.32	708.17	569.25	610.52	7.69	8.61	31.98	35.33
T_4	17.14	21.16	46.40	50.26	517.38	585.16	463.15	511.18	6.20	7.22	25.00	28.33
T_5	14.60	19.39	41.31	45.12	505.48	579.00	447.15	499.47	6.13	7.15	23.58	27.23
T_6	25.86	30.03	68.81	73.57	805.34	853.91	679.47	713.89	9.29	10.20	38.14	42.47
T_7	25.73	29.86	68.76	73.30	792.00	840.00	668.55	701.41	9.28	10.17	37.88	42.15
T_8	21.58	25.49	57.15	61.51	647.00	706.96	562.73	607.24	7.68	8.60	31.16	35.12
T_9	17.10	21.15	43.26	46.99	513.73	585.11	458.65	510.25	6.17	7.19	24.66	28.27
T_{10}	14.30	19.22	41.00	45.10	502.74	578.36	443.24	496.12	6.10	7.13	21.79	26.15
T_{11}	25.67	29.80	68.50	73.27	788.46	839.38	666.92	701.26	9.22	10.15	37.80	42.12
T_{12}	26.76	31.97	69.43	74.52	821.17	861.14	700.65	732.74	9.40	10.40	38.91	42.95
T_{13}	22.00	25.79	59.50	63.92	660.51	718.81	573.92	617.65	7.71	8.63	32.15	36.00
T_{14}	17.58	21.73	48.12	52.19	521.81	592.22	467.73	516.47	6.22	7.27	25.42	28.91
T_{15}	14.80	19.77	42.09	46.05	509.26	583.62	455.92	509.67	6.15	7.17	24.21	28.00
T_{16}	26.40	31.40	69.10	74.11	817.22	856.31	696.23	727.65	9.38	10.36	38.73	42.66
CD (P=0.05)	3.37	3.73	8.83	9.57	113.78	111.76	90.70	82.86	1.36	1.28	5.00	6.08

*Details of treatments were given in material and methods

kg/ha) during 1st crop growing year was recorded with treatment T_{10} whereas during 2nd crop growing year lowest mean total nitrogen uptake (462.32 kg/ha) was recorded with treatment T_5. The increased N uptake in the vermicompost and Farmyard applied plots was due to its highest N content, mineralization of N from organic matter and mineralization effect upon native nitrogen. Similar findings were also given by Satish *et al.* (2011) and Mishra (2015). Another reason was might be that legume crop (green gram) add large amount of organic residues through leaf fall and produced intermediate acids during organic residue decomposition and also solubilise the fixed form of N in soil resulting in increased uptake of N by the crop. These results were in conformity with the findings of (Henri *et al*. 2008).

Balance Sheet of Nitrogen

The results of the nutrient estimation made to arrive at an appropriate balance sheet of nitrogen as affected by the differential substitution of nutrients through organics in basmati rice based cropping system over the two years period are presented in Table 5, revealed that differential substitution of nutrients through organics influenced the availability of nitrogen content in the soil.Balance sheet of available soil nitrogen based on initial and actual soil status after the two crop cycles was positive under all the treatments and irrespective of the treatment there was build-up of nitrogen in the soil. After the completion of two crop cycles, the treatment 100 % N through FYM recorded highest mean net build-up of nitrogen 8.79 kg/ha followed by treatment 100 % N through vermicompost and treatment 100% N was substituted through vermicompost and FYM (1:1) with mean net build-up of nitrogen 8.56 kg/ha and 7.87 kg/ha , respectively as depicted in Figure 2. On the other side lowest mean net build up in nitrogen (4.53 kg/ha) was recorded with treatment 100 % NPK (recommended dose of

Table 5. Balance sheet of Available Nitrogen (kg/ha) after two crop cycles in rice based cropping system

Treatments	Available Nitrogen													
	Initial soil available nitrogen (kg/ha)		Addition of nitrogen through fertilizers and manures (kg/ha)		Total nitrogen (kg/ha)		Crop uptake of nitrogen (kg/ha)		Expected nitrogen balance (kg/ha)		Actual nitrogen balance (kg/ha)		Build up (+)/ Depletion (-) (kg/ha)	
	I Year	II Year	I Year	II Year	I Year	II Year	I Year	II Year	I Year	II Year	I Year	II Year	I Year	II Year
T_1	249.88	253.65	570.00	597.00	819.88	850.65	458.51	502.62	361.37	348.03	253.65	258.94	3.77	5.29
T_2	249.88	254.99	570.00	597.00	819.88	851.99	505.71	555.85	314.17	296.14	254.99	261.65	5.11	6.66
T_3	249.88	255.85	570.00	597.00	819.88	852.85	464.54	517.74	355.34	335.11	255.85	263.00	5.97	7.15
T_4	249.88	256.32	570.00	597.00	819.88	853.32	402.62	463.93	417.26	389.39	256.32	264.84	6.44	8.52
T_5	249.88	257.00	570.00	597.00	819.88	854.00	396.17	462.32	423.71	391.68	257.00	266.99	7.12	9.99
T_6	249.88	255.33	570.00	597.00	819.88	852.33	512.69	562.26	307.19	290.07	255.33	261.74	5.45	6.41
T_7	249.88	255.65	570.00	597.00	819.88	852.65	511.64	570.94	308.24	281.71	255.65	262.00	5.77	6.35
T_8	249.88	255.95	570.00	597.00	819.88	852.95	465.84	521.72	354.04	331.23	255.95	264.21	6.07	8.26
T_9	249.88	256.44	570.00	597.00	819.88	853.44	400.14	464.43	419.74	389.01	256.44	265.36	6.56	8.92
T_{10}	249.88	257.20	570.00	597.00	819.88	854.20	393.20	462.49	426.68	391.71	257.20	267.45	7.32	10.25
T_{11}	249.88	255.74	570.00	597.00	819.88	852.74	518.84	571.06	301.04	281.68	255.74	262.74	5.86	7.00
T_{12}	249.88	254.94	570.00	597.00	819.88	851.94	501.93	549.86	317.95	302.08	254.94	258.99	5.06	4.05
T_{13}	249.88	255.79	570.00	597.00	819.88	852.79	466.39	520.21	353.49	332.58	255.79	262.98	5.91	7.19
T_{14}	249.88	256.00	570.00	597.00	819.88	853.00	402.55	465.53	417.33	387.47	256.00	264.54	6.12	8.54
T_{15}	249.88	256.98	570.00	597.00	819.88	853.98	396.67	462.56	423.21	391.42	256.98	265.61	7.10	8.63
T_{16}	249.88	254.94	570.00	597.00	819.88	851.94	502.74	550.82	317.14	301.12	254.94	260.21	5.06	5.27

*Details of treatments were given in material and methods

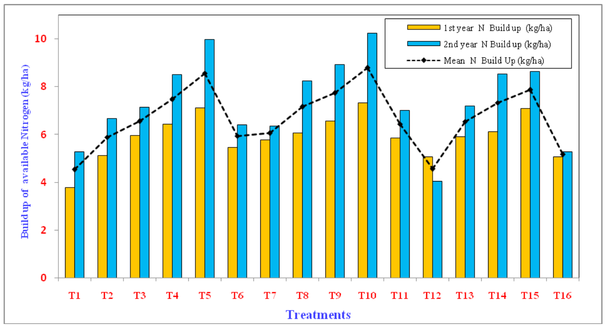

Fig. 2. Build-up of available nitrogen (kg/ha) in soil after two crop cycles in basmati rice based cropping system

fertilizers). The treatments next to T_{15} in mean net build-up of nitrogen were T_9(7.74 kg/ha) > T_4 (7.48 kg/ha) T_{14}(7.33 kg/ha) > T_8 (7.16 kg/ha) > T_3 (6.56 kg/ha) > T_{13} (6.55 kg/ha) >T_{11} (6.43 kg/ha) >T_7 (6.06kg/ha) > T_6 (5.93 kg/ha) >T_2 (5.88 kg/ha) > T_{16} (5.16 kg/ha) > T_{12} (4.56 kg/ha) and T_1. It is evident that after completion of two crop cycle maximum recovery of available nitrogen was recorded in treatment T_{10} - 100 % N through FYM followed by treatment T_5 and T_{15}. This was might be due to reason that organic manures release nitrogen after mineralization and partly due to releasing from the native soil. It might also be due to direct addition of N from the decomposition of organic matter which leads to mineralization of organically bound nitrogen. The result were in conformity with the findings of Chesti *et al.* (2013) and Baishya *et al.* (2015). Another reason for net build up available nitrogen in all the treatments after two crop cycles was inclusion of legume in the cropping system which increases the soil N concentration with the help of nitrogen fixation and reduced the decline of N in soil after continuous cultivation of crops in the cropping system.

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