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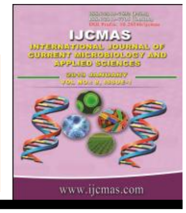

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Effect of Urea Briquettes in Combination of Organics on Root Growth and Nitrogen Losses in Rice Field

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A B S T R A C T

Nitrogenous fertilizers applied to soil undergo various physico-chemical and biological transformations due to influence of different enzymes and microbial activity and thereby become available to crops. The efficient use of nitrogen is recognized as an important production factor for rice production but it has always been a problem to raise its utilization rate by rice and to increase efficiency of absorbed nitrogen for grain production. Even with the best agronomic practices only 30-40 percent of applied nitrogen is actually utilized by the crop. A field experiment was conducted in kharif 2017 at the Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G). Rice variety Rajeshwari was taken as test crop under irrigated condition. The experiment was laid out in randomized complete block design comprising of total 11 treatments; out of which, four treatments involving application of urea briquettes, another four treatments involving application of urea and rest three treatments involving application of briquettes of urea + FYM, urea + vermicompost and urea + neem cake as source of nitrogen along with varying doses of phosphorus and potassium. Each treatment was replicated four times. The influence of the different levels and sources of Non root growth and nitrogen losses was studied under different treatments. The results revealed that Nitrogen losses in irrigated rice were significantly influenced by the treatments. The concentration of nitrates and ammonia found in leachates in treatments involving urea+organics briquettes were found significantly lower compared to rest treatments. There was a progressive increase in root dry weight and volume with the advancement of crop growth stage. The effect of different nitrogen levels and sources was found statistically significant on root growth. The highest value of root volume and dry weight were found in in treatments involving urea+FYM briquettes application. The addition of organics in urea briquettes and deep placement of briquettes exhibited better root development and lower nitrogen losses which might be attributed to slow release of nitrogen and thus reducing the losses and thereby higher nutrients uptake and ultimately higher root biomass.

Introduction

Chhattisgarh is popularly known as "Rice Bowl of India" with an area of around 3.68 million hectares and production of 8.20 million tons under rice cultivation during *kharif* season which contributes 8.65% and 6.30%respectively of total acreage and production in India with productivity being 2020 kg ha^{-1} in 2013-14 (Anonymous, 2015).

Nitrogen is the most important nutrient in irrigated rice production. Nitrogenous fertilizers applied to soil undergo various physico-chemical and biological transformations due to influence of different enzymes and microbial activity and thereby become available to crops.

The efficient use of nitrogen is recognized as an important production factor for rice production but it has always been a problem to raise its utilization rate by rice and to increase efficiency of absorbed nitrogen for rice grain production. Even with the best agronomic practices, only 30-40 percent of applied nitrogen is actually utilized by the crop. Availability of nitrogen is a determinant factor for the growth and yield of plants. Lowland rice is noted for the efficient utilization of applied nitrogenous fertilizer as compared to upland condition and this is especially true for top dressing of nitrogen.

The low utilization efficiency of N fertilizers is attributed to losses like volatilization, denitrification, leaching and surface run-off. These losses can be reduced by management practices like proper timing, rate and modified forms of urea and deep placement of N fertilizers. Several strategies have been tried to enhance nitrogen use efficiency (NUE) in rice including split N application, the use of slow release N fertilizers and nitrification inhibitors (NIs). Deep placement of N briquette at 8-10 cm depth of soil can save 30% N compared to Prilled Urea (PU), increases absorption rate, improves soil health and ultimately increases rice yield (Savant *et al.,* 1991). The present study was undertaken to evaluate the effect of PU, Urea briquette and Urea briquette in combination with organics on root growth and Nitrogen losses in rice field.

Materials and Methods

Site description

An experiment was conducted under field conditions during kharif 2017 at the Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G) situated on National highway No. 6 in Eastern part of Raipur city and located between 20^{0} 4’ North latitude and 81^{0} 39’ East longitudes with an altitude of 293 m above mean sea level.The region comes under dry and **s**ub-humid climatic condition. The average annual rainfall of the area is 1400-1600 mm. The weather data during experimental period was collected from the meteorological observatory located at Labhandi (IGKV), Raipur. Major precipitation occurs between June and December (about 5-6 Months) which is the main rice growing season. The hottest and coolest months are May and December, respectively. Rice variety “*Rajeshwari*”was used as a test crop.

Experimental soil

The experimental soil (*Vertisol*) is fine montmorillonitic, hyperthermic, chromustert, locally called as Kanhar and is identified as Arang II series. The physico-chemical properties of the experimental soil are presented in Table 1.

Experiment design

The Experimental details are as follows:-

Treatment details

Fertilizer application

The recommended dose of Phosphorus and Potassium fertilizers @ 60:40 kg/ha (P_2O_5:K_2O) was applied to the respective plots in the form of SSP and MOP as basal dose at the time of planting. Considering recommended dose of nitrogen @ 100 kg/ha. using urea one-third nitrogen was applied as basal dose, another one-third applied at maximum tillering and rest one-third nitrogen was applied at panicle initiation stage.

Urea briquettes application

Formation of urea briquette

Urea briquettes were made by physical modification of normal urea fertilizer. Its nature and properties are similar to that of urea but it is manufactured in pillow shaped structure and condensed with some conditions for slow hydrolysis. Each briquette weighed around 2.5 g with 46% N content similar to that of PU.

Formation of urea briquette with organics (FYM, neem cake, vermicompost)

These briquettes were prepared similarly to that of plain urea briquettes preparation but with some modification that 25% volume were replaced by organics (FYM, neem cake, vermicompost). Weight of each urea+FYM briquettes was 2.2g, urea+neem cake briquettes was 2.3g and urea+vermicompost briquettes was 2.2g per briquette.

Deep placement of urea briquettes

Full dose of Urea briquettes on weight basis were applied after 10 days of transplanting. For N application through USG @ 100, 75 and 50 percent RDF, one USG of 2.4 g size was employed for every five to six (avg.5.5) hills, seven to eight (avg. 7.3) hills and 11 hills, respectively. In case of urea briquette with organics (FYM, neem cake, vermicompost) one briquette was employed for every five to six (avg. 5.5) hills (Figure 1–3). The granules were deep placed in the puddled soil by hand and leveled immediately after placement.

Statistical analyses

Observations taken

Root growth parameters

Theroot sampling was done with the help of core sampler. The various rooting parameters were analyzed in laboratory.

Root volume (ml plant^{-1})

Water displacement method - by dipping the properly washed roots in a 1000 ml measuring cylinder containing water up to a certain point, root volume was determined by water displacement. The root volume was measured at depth 0-20 cm at 30, 60 and 90 DAT. The plant sample was uprooted with root by cylindrical shaped root sampler without damaging the root. Before measuring the root volume, the root was washed with tap water and then with hydrogen peroxide for complete removal of soil from root.

Root weight (g)

The clean roots were oven dried at 60^{o}C and weight was measured.

Nitrogen losses

The nitrogen losses were studied by performing Ammonical nitrogen (NH_4^+-N) and Nitrate nitrogen (NO_3-N) analysis in soil water (leachates). Leachates were collected by installing piezometer. PVC pipes (2.5 cm in diameter and 50 cm in length) with sealed bottoms were installed in each field plot to collect drainage water from the saturated soil. pipes were perforated 66 times within 20 cm from the bottom of the pipe. The porous zone of the pipe was wrapped with nylon textile to prevent sand in-filling. Comparison was done for the inorganic N leaching in 20 cm depth. The pipes were installed at depth of 20 cm from the surface to the uppermost pore. The leachates accumulated in these pipes were collected at 3, 5 and 7 days after each dose of fertilizer application and the inorganic nitrogen in the form of NH_4-N and NO_3-N were analyzed.

The data collected from field observations and those recorded in laboratory were subjected to statistical analysis by standard analysis of variance technique. For significant treatment effects, standard error of means (SEm ±) and critical differences were calculated at 5 per cent level of significance.

Results and Discussion

Effect of different nitrogen levels and sources on nitrogen losses in irrigated rice field

Nitrogen losses in irrigated rice field were significantly influenced by the treatments. The observations found are presented in Table 2 and 3 as well as Figure 4 and 5. The results revealed that highest concentration of NH_4-Nand NO_3-Nin leachate was recorded in treatment T8 [100% N (RDF) through urea+100% PK (RDF)] whereas lowest value was recorded in T9 [Urea+FYM briquettes (75:25) + 100% PK(RDF)] followed by T10 and T11. Overall results suggests that the treatments involving application of urea+organics briquettes minimized the nitrogen losses in the form of NH_4-Nand NO_3-Nin leachate and among them urea+FYM briquette application resulted in minimum Nitrogen losses. The concentration of nitrates and ammonia found in leachates in treatments T9, T10 and T11 were found significantly lower compared to rest of the treatments. The results obtained collaborated well with the findings of Vyas *et al.,* (1991), Cameron *et al.,* (2013), Fanqiao Meng *et al.,* (2014) and Lihong Xue *et al.,* (2014). Similar findings were reported by Omar *et al.,* (2015) whereammonium and nitrate leaching losses during 30 days of the leaching experiment were highest in urea alone than in urea with clinoptilolite, zeolite and compost treatments.

Experiment design

Location	**Instructional cum Research Farm, I.G.K.V. Raipur**
Soil Type	*Vertisols*
Season	*Kharif* 2017
Crop	Rice
Variety	*Rajeshwari*
Treatment	11
Design	Randomized complete blockdesign
Replications	Four
Net Plot size	7m x 2m (14 m^2)
Spacing	20 cm x 10 cm
RDF	**100:60:40 kg/ha (N: P_2O_5: K_2O)**

Treatment details

Notations	Treatments
T1	50 % N through USG+ 50% PK (RDF)
T2	75% N through USG + 50% PK (RDF)
T3	100% N through USG + 50% PK (RDF)
T4	100 % N through USG+ 100% PK (RDF)
T5	50% NPK (RDF)
T6	75 % N (RDF) through urea + 50% PK (RDF)
T7	100 % N (RDF) through urea + 50% PK(RDF)
T8	100 % N (RDF) through urea + 100% PK (RDF)
T9	Urea + FYM USG (75:25 volume basis)+ 100% PK (RDF)
T10	Urea+Vermicompost USG (75:25 volume basis)+100% PK (RDF)
T11	**Urea +Neem cake USG (75:25 volume basis)+100% PK (RDF)**

*USG = Urea Super Granules (Briquettes)
RDF = Recommended dose of fertilizer @ 100:60:40 Kg $N:P_2O_5:K_2O$ ha^{-1}

Table.1 Physico-chemical properties of experimental soil

Particulars		Values	Method
I. Physical properties			
1	Sand (%)	19	International pipette method (Piper 1966).
2	Silt (%)	32	
3	Clay (%)	49	
4	Soil textural class	Clayey	
5	Bulk density (Mg m^{-3})	1.51	Williams and Steinbergs (1959). Turbidimetrically.
II. Chemical properties			
1	pH (1:2.5)	7.48	Glass electrode pH meter Jackson.(1973)
2	EC (dSm^{-1} at 25^0C)	0.16	Solubridge conductivity method (Black1965).
3	Organic carbon (%)	0.56	Rapid titration method (Walkley and Black's 1965).
4	Available N (kg ha^{-1})	199	Alkaline permanganate method (Subbiah and Asija,
5	Available P_2O_5(kg ha^{-1})	14.97	Sodium bicarbonate (Olsen *et al.*, 1954)
6	Available K_2O (kg ha^{-1})	386.2	Ammonium acetate method (Jackson 1967).
7	Available B (mg kg^{-1})	1.54	Berger and Truog (1939)
8	Available S (kg ha^{-1})	17.76	Williams and Steinbergs (1959). Turbidimetrically.

Table.2 Effect of different nitrogen levels and sources on losses of NH_4-N

Treatments	Concentration of NH_4-N in leachates (mg/L)								
	Fertilizer application at 10 DAT			Fertilizer application at 30 DAT			Fertilizer application at 50 DAT		
	After 3 Days	After 5 Days	After 7 Days	After 3 Days	After 5 Days	After 7 Days	After 3 Days	After 5 Days	After 7 Days
T1	0.48	0.73	0.69	0.68	0.65	0.61	0.59	0.58	0.45
T2	0.56	0.73	0.68	0.67	0.68	0.71	0.69	0.67	0.63
T3	0.98	0.73	0.70	0.69	0.70	0.73	0.70	0.68	0.65
T4	0.98	0.97	0.83	0.81	0.82	0.81	0.83	0.80	0.78
T5	1.12	1.02	0.90	1.72	1.52	1.22	1.62	1.42	1.13
T6	1.12	1.18	0.93	1.93	1.82	1.12	1.82	1.72	1.22
T7	1.12	1.20	0.98	2.13	2.03	1.32	2.03	1.88	1.23
T8	1.40	1.94	1.03	2.27	2.21	1.52	2.24	2.20	1.42
T9	0.56	0.56	0.42	0.42	0.46	0.47	0.40	0.40	0.38
T10	0.56	0.56	0.48	0.76	0.79	0.67	0.65	0.63	0.53
T11	0.56	0.70	0.56	0.78	0.82	0.70	0.67	0.66	0.56
CD (P= 0.05)	0.062	0.082	0.018	0.123	0.113	0.078	0.118	0.118	0.071

Table.3 Effect of different nitrogen levels and sources on losses of NO_3-N

Treatments	Concentration of NO_3-N in leachates (mg/L)								
	Fertilizer application at 10 DAT			Fertilizer application at 30 DAT			Fertilizer application at 50 DAT		
	After 3 Days	After 5 Days	After 7 Days	After 3 Days	After 5 Days	After 7 Days	After 3 Days	After 5 Days	After 7 Days
T1	0.56	0.98	0.94	0.98	0.98	0.95	0.97	0.96	0.94
T2	0.56	1.26	0.94	1.00	1.00	0.98	0.99	0.98	0.96
T3	1.12	2.80	1.96	1.96	1.96	1.82	1.80	1.80	1.78
T4	1.12	2.80	2.30	2.30	1.98	1.98	1.98	1.86	1.98
T5	1.12	3.78	3.22	4.20	4.06	2.38	3.92	2.50	1.98
T6	1.12	4.41	3.50	4.06	4.20	2.80	5.02	3.64	2.24
T7	1.12	4.95	3.86	5.08	4.88	4.00	5.06	4.00	2.46
T8	1.68	5.15	4.06	5.28	5.08	4.20	5.26	4.20	2.66
T9	0.56	0.88	0.78	0.75	0.77	0.75	0.77	0.74	0.70
T10	0.56	0.98	0.88	0.85	0.87	0.85	0.84	0.86	0.84
T11	0.56	0.98	0.93	0.90	0.92	0.90	0.89	0.91	0.89
CD (P= 0.05)	0.057	0.240	0.154	0.238	0.232	0.128	0.260	0.202	0.093

Table.4 Effect of different nitrogen levels and sources on root growth

Treatment	Root dry weight (g/hill)			Root volume (cm^3/hill)		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
T1	0.68	4.80	5.10	7.85	31.92	33.11
T2	0.76	5.82	6.23	8.15	37.83	40.49
T3	1.10	6.99	7.59	11.30	38.93	44.74
T4	1.28	8.42	9.42	12.26	50.52	56.52
T5	0.69	4.78	4.98	8.90	30.83	32.89
T6	0.80	5.73	5.99	9.50	33.80	35.34
T7	1.12	5.99	6.32	12.20	38.10	41.08
T8	1.29	6.35	7.00	13.00	38.70	42.68
T9	1.30	8.62	9.74	13.30	51.84	56.52
T10	0.95	7.74	9.42	10.40	44.40	52.44
T11	1.10	7.59	8.29	11.15	44.38	45.11
CD (P= 0.05)	**0.05**	**0.31**	**0.33**	**0.53**	**1.92**	**2.04**

Fig.1 Layout for Briquette application (a) Urea briquette with organics and also for 100 % RDF-N through USG (b) 75% RDF-N through USG (c) 50% RDF-N through USG (d) Depth of application of USG

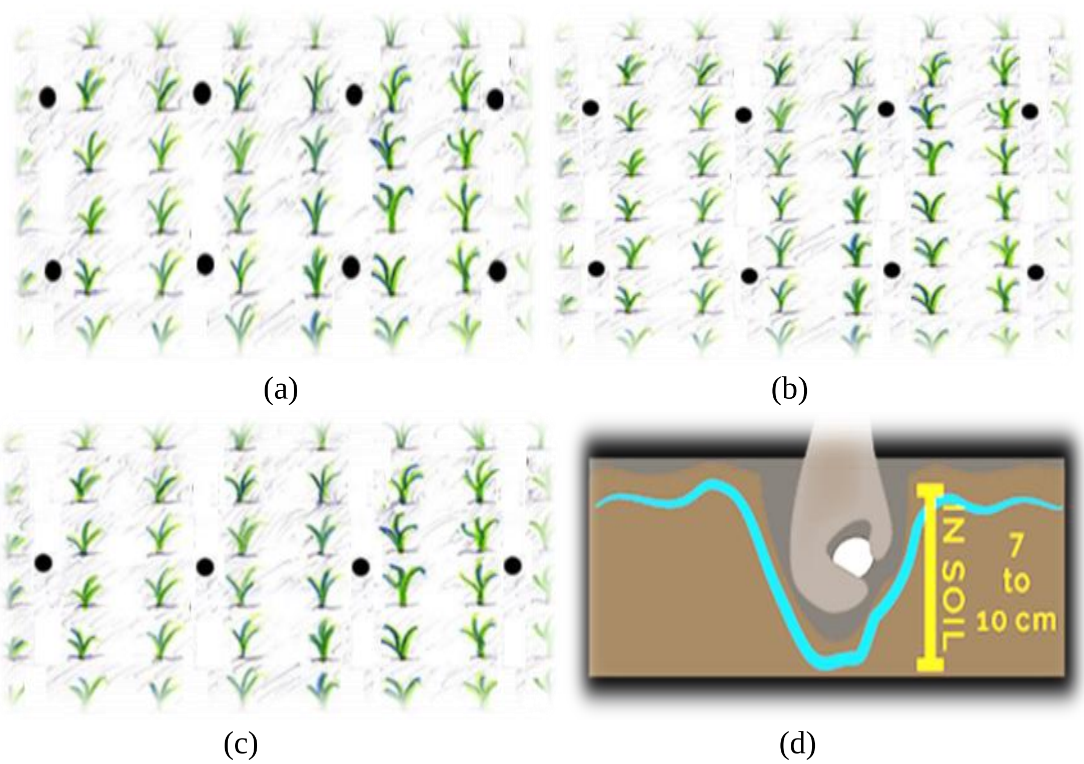


Fig.2 Piezometer installation (a) Making hole in plot to install piezometer (b) Installed piezometer (c) field photograph with piezometers installed

(a) (b) (c)

Fig.3 Root sampling using core sampler

Fig.4 Effect of different nitrogen levels and sources on losses of NH_4-N

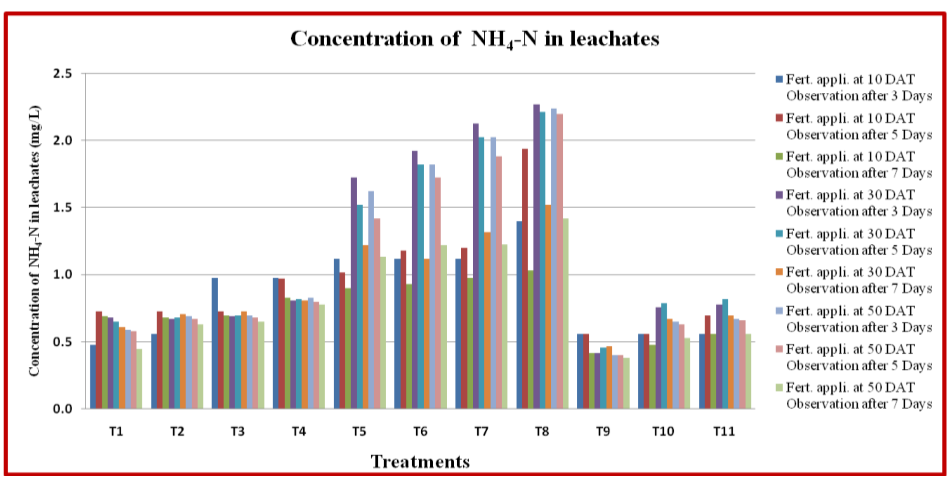


Fig.5 Effect of different nitrogen levels and sources on losses of NO_3-N

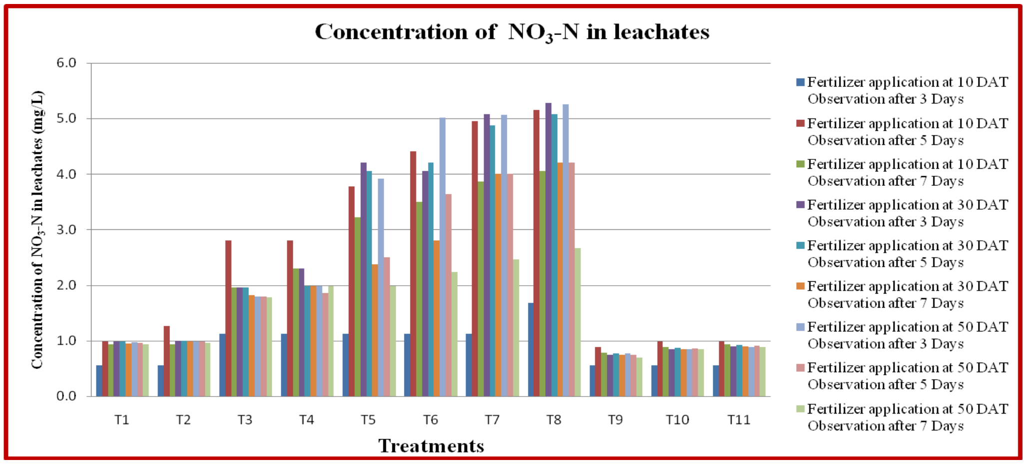
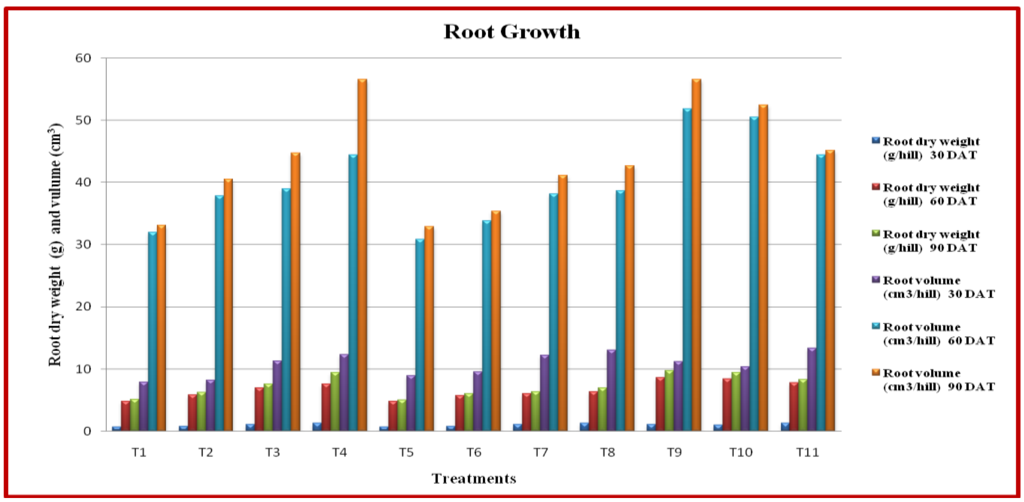


Fig.6 Effect of different nitrogen levels and sources on root growth



Effect of different nitrogen levels and sources on root dry weight (g hill^{-1})

There was a progressive increase in root dry weight with the advancement of crop growth stage up to 90 DAT. The data of dry weight of root in g hill^{-1} at 30 DAT, 60 DAT and 90 DAT is presented in Table 4 and Figure 6. The highest dry weight (1.30 at 30 DAT, 8.62 at 60 DAT and 9.74 at 90 DAT)g hill^{-1} was recorded under treatment T9[Urea+FYM briquettes(75:25)+100%PK(RDF)]followed by T4[100%N through USG+100% PK(RDF)] whereas, lowest value was observed inT5 [50% N (RDF) through urea+50%PK(RDF)]. The observations at flowering stage suggests that application of RDF, USG and urea briquettes in combination with organics produced significantly higher dry-matter and dry weight of root than the control.Similar findings have been reported by Islam *et al.,* (2011) and Ahmed *et al.,* (2005).

Effect of different nitrogen levels and sources on root volume (cm^{3}hill^{-1})

The data of root volume (cm^{3}hill^{-1}) at 30 DAT, 60 DAT and 90 DAT is presented in Table 4 and Figure 6. The highest root volume ($cm^3 hill^{-1}$) (13.30 at 30 DAT, 51.84 at 60 DAT and 56.52 at 90 DAT) was recorded under treatment T9[Urea+FYM briquettes (75:25)+100% PK(RDF)] followed by T4[100%N through USG+100% PK(RDF)] whereas, lowest value was observed in T5 [50% N (RDF) through urea+50% PK(RDF)]. Over all the effect of different nitrogen levels and sourceswas found statistically significant on root volume. Similar findings were reported by Singh *et al.*, (1997) and Sharma *et al.*, (2016).

The combination of organics like FYM, vermicompost and neem cake in urea briquettes in treatments T9, T10 and T11 respectively provided better physic-chemical and biological soil condition to plant and briquette formation reduced the surface area of applied N- fertilizer, also deep placement of briquettes induced slow release of nitrogen, thusreducing the nitrogen losses in the form of ammonia and nitrates in soil water leachate, thereby higher nitrogen uptake and ultimtely produced higher root biomass. The treatment T9 performed better due to slow and regular release of nitrogen as briquettes with organics provide better nutrient use efficiency and minimum nutrient losses so that plant can easily uptake nutrient in their critical growth period. Similar result was reported by Mishra *et al.*, (1999), Laxminarayana (2006), Yadav *et al.*, (2014) and Sunitha *et al.*, (2010) and Chesti *et al.*, (2015). Overall findings indicate that, Urea+FYM briquette application among different sources of fertilizer nitrogen was found most suitable for irrigated ricein terms of better root growth and minimum nitrogen losses.

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