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Evaluation on Impact of Use of Urea Briquettes in Combination of Organics on Nutrient Use Efficiency in Irrigated Rice

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A B S T R A C T

Rice (*Oryza sativa L.*) is one of the most important staple food crops worldwide. Nitrogen (N) is the most important nutrient in irrigated rice cultivation. Current high yields of irrigated rice are often associated with applications of higher doses of fertilizer N, as nearly 30-40 percent of applied nitrogen is actually utilized by the crop; even with the best agronomic practices. It has always been a problem to raise the utilization rate of the rice plant and to increase efficiency of absorbed nitrogen for grain production. Hence, a field experiment was conducted during kharif 2017 at the Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G) to study the impact of use of urea briquettes in combination with organics in irrigated rice cultivation system with eleven treatments each replicated four times. Rice variety *Rajeshwari* was taken as test crop under irrigated condition. The experiment laidout in randomized complete block design comprised of 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. The influence of the different levels and sources of N on nitrogen, phosphorus and potash use efficiency under different treatments were studied. The results revealed that the addition of organics in urea briquettes and deep placement of briquettes exhibited higher nitrogen, phosphorus and potassium use efficiency which might be attributed to slow release of nitrogen, thus reducing the losses and thereby higher nutrients uptake and ultimately higher yield. 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. Application of urea briquettes significantly influenced the available N,P,K in soil at harvest. Overall, urea+FYM briquette application among different sources of fertilizer nitrogen was found most suitable for irrigated rice cultivation system and it also showed higher nitrogen use efficiency as compared to recommended dose of fertilizers.

Introduction

Rice (*Oryza sativa L.*) is one of the most important staple food crops in the world. In Asia, more than two billion people are dependent on rice for their livelihood. 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% acreage and 6.30%, production in India with productivity being 2020 kg ha^{-1} in 2013-14 (Anonymous 2015).

To meet the global rice demand, the production has to increase at the compound rate of 1.7% per year. However, the agricultural input sector has critical impact on the rice productivity of a nation as it influences farmers' success to and use of productivity enhancing input like agrochemicals, fertilizer, and seed. Low agricultural input use is often associated with declining soil fertility, declining yields, and low farmer income. Increased use of fertilizer and improved seeds as well as controlling pests and diseases using pesticides are partially credited with the large increases in agricultural productivity growth.

Nitrogen (N) is the most important nutrient in irrigated rice production (Cassman *et al*., 1998). Current high yields of irrigated rice are often associated with higher doses of fertilizer N. Nearly 30-40 percent of applied nitrogen is actually utilized by the crop; even with the best agronomic practices and strictly controlled conditions the recovery of nitrogen seldom exceeds 50-60 percent (De Datta *et al.*, 1968 and Aulakh *et al.,* 1992). The efficient use of nitrogenous fertilizer is a challenge due to various losses and increase in fertilizer cost. 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 dressed nitrogen.

Nitrogenous fertilizers applied to soil undergo physical, chemical and biological transformation by virtue of enzymes and microbial activity and ultimately become available to crops. Rice plants prefer ammonical form of nitrogen during the early stage irrespective of the source viz. ammonical, nitrate, amide or organic form (Yawalkar *et al.,* 1996). The efficient use of nitrogen is recognized as an important production factor for rice but it has always been a problem to raise the utilization rate of the rice plant and to increase efficiency of absorbed nitrogen for grain production.

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, N briquette and N briquette in combination with organics on N use efficiency and yield of rice crop.

Materials and Methods

Site description

The present investigation was carried out 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 (Indira Gandhi Agricultural University), Krishaknagar, Raipur. Major amount of 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. It is usually deep, clayey (49 %), dark brown to black in colour and neutral to alkaline in reaction due to presence of lime concentrations. The soil occurs on mid land position of landscape in Chhattisgarh, is deep and hence has good water holding capacity. The physico-chemical properties of the experimental soil are presented in Table 1.

Experiment design

The experimental details are as follows:-

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 block design**
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

It is given in Table 2.

Fertilizer application

The recommended dose of fertilizer phosphorus and potassium @ 60:40 kg/ha (P_2O_5:K_2O) was applied to the respective plots as per requirement (on dry weight basis) 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 stage and remaining one-third nitrogen was applied at panicle initiation stage.

Urea briquettes application

Formation of urea briquette

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

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

These briquetteswere prepared in similar way like plain urea briquettes but with some modification that 25% volume were replaced by organics (FYM, neem cake, vermicompost). Weight of urea+FYM briquettes was 2.2g, urea+neem cake briquettes was 2.3g and urea+vermicompost briquettes was 2.2g per briquette (Figure 1).

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 2). The granules were deep placed in the puddled soil by hand and leveled immediately after placement.

Statistical analyses

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.

Observations taken

Yield: In the experiment various growth and yield attributing characters viz., number of panicles m^{-2},number of grains per panicle, test weight of 1000 grain andgrain and straw yieldswere recorded.

Plant analysis: The dried and powdered form of straw and grain samples were analyzed for total N, P and K contents.

Soil analysis: The initial soil sample and plot wise samples collected at harvest were collected and analyzed for chemical properties like pH, EC, OC, and contents of available N, P and K following standard procedures.

Nutrient uptake (kg ha^{-1}): N, P and K uptake by the rice crop were computed from their respective elemental concentration in seed and straw of the crops.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Yields (kg ha}^{-1}\text{) x content (\%)}}{100}$$

Nutrient use efficiency (%): The other parameters viz; NUE of N, P, K, and Nutrient Recovery Efficiency (NRE) were calculated according to Ciampitti and Vyn(2011) is given below:

$$\text{NUE (\%)} = \frac{\text{Uptake from treated plot – uptake from control plot}}{\text{Applied fertilizer}} \text{ X 100}$$

Results and Discussion

Effect of different Nitrogen levels and sources on yield in irrigated rice

In the experiment grain and straw yieldswere recorded, the results are presented in the following table 3 and figure 3. The results revealed that all recorded yield attributes of rice were significantly influenced by the different levels and sources of nitrogen. The grain yield was found significantly superior in treatment T9 [Urea+FYM briquettes (75:25 vol. basis) + 100% PK(RDF)] (54.64 q/ha) when compared to treatment T1, T2, T3, T5, T6, T7 and T8 whereas, it was statistically at par to T4, T10, and T11. The lowest grain yield (40.75 q/ha) was recorded in treatment T5. The highest straw yield 80.54 q./ha was found in treatment T9 and the lowest straw yield 65.79 q./ha was recorded in treatment T5. Broadcasting of prilled urea tends to increase various losses of nitrogen therefore recorded lower yield compared with deep placement of briquettes which induces slow release of nutrient reducing the losses and thereby higher nutrient uptake and produces higher yield. These findings collaborate well with the observations found by Islam *et al.*, (2011).Similarly,Kapoor *et al.*, (2008) also observed that significantly higher grain yield was observed with deep placement of NPK briquette compared to 43 broadcast applications.

Effect of different nitrogen levels and sources on nutrient uptake

Results in table 4 and figure 4 indicate that the total N, P and K uptake in grain and straw of paddy varied significantly due to application of different nitrogen levels and sources in the form of PU, USG, and urea + organics briquettes.

Nitrogen uptake

The total N uptake ranged from 69.77 to 102.10 kg/ha. The highest value of total N uptake102.10 kg/ha. was observed in T9[Urea+FYM briquettes(75:25 vol. basis)+ 100%PK(RDF)]followed by T4[100%N through USG+ 100%PK (RDF)] whereas minimum total N uptake was recorded as 69.77 kg/ha. inT5 [50% N (RDF) through urea+50%PK(RDF)]. The overall observations revealed that the N uptake value recorded in treatment T9 was at par to that of treatments T10, T11 and T4 and significantly superior to rest treatments T1, T2, T3, T5, T6, T7 and T8.

Phosphorus uptake

The total P uptake by grain and straw ranged from 23.64 to 35.50 kg/ha. The highest value of total P uptake 35.50 kg/ha. Was recorded in T9 [Urea+FYM briquettes (75:25 vol. basis) + 100% PK(RDF)] followed by T4[100%N through USG+ 100%PK (RDF)] whereas minimum P uptake was recorded as 23.64 kg/ha. In T5 [50% N (RDF) through urea + 50%PK(RDF)].

Observations revealed that P uptake value recorded in treatment T9 T10, T11 and T4 and significantly superior to rest treatmentsT1, T2, T3, T5, T6, T7 and T8.

Potassium uptake

The total K uptake by grain and straw ranged from 100.52 to 131.98 kg/ha. The highest value of total K uptake 131.98 kg/ha. was observed in T9 [Urea+FYM briquettes (75:25) + 100%PK(RDF)] followed by T4 [100%N through USG + 100%PK(RDF)] whereas minimum K uptake was recorded as 100.52 kg/ha. In T5 [50% N (RDF) through urea + 50% PK(RDF)].

Observations revealed that the K uptake value recorded in treatment T9 was at par to that of treatments T11 and T4 and significantly superior to rest treatments T1, T2, T3, T5, T6, T7 and T8.

The treatment T9 performed better due to slow and regular release effect asbriquettes with organics provide better nutrient use efficiency and minimum nutrient losses so that plant can easily uptake nutrient in their critical growth period.

Darade and Bankar (2009) found similar level of nitrogen uptake by the deep placement of fertilizer briquettes. Similar result was reported by Mishra *et al.*, (1999), Laxminarayana (2006), Gupta *et al.*, (2006).

Chesti *et al.*, (2015), where application of recommended dose of NPK and USG along with organic sources improved nutrient uptake by rice.

Effect of different nitrogen levels and sources on nutrient use efficiency

Nutrient use efficiencyrepresents the response of rice plant in terms of grain yield to applied nutrient i.e. N, P and K fertilizer. The data on nutrient use efficiency is presented in table 5 and figure 5.

Nitogen use efficiency

The highest value (68.8%) of Nitrogen use efficiency (NUE) was obtained in T9 [Urea + FYM briquettes (75:25 vol. basis) + 100%PK(RDF)] followed by T1 whereas minimum value (34.5%) of NUE was observed in T7 [100%N(RDF) + 50%PK(RDF)]. The urea + organics briquettes treated plots i.e. treatments T9, T10 and T11 revealed much higher NUE compared to the PU treated plot *i.e* treatments T6, T7 and T8. These results indicated that application of urea+organics briquettes and USG in rice field decrease the losses of N and save the fertilizer, leading to efficient uptake and utilization of applied N.

Phosphorus use efficiency

The highest value (27.6%) of Phosphorus use efficiency (PUE) was obtained in T3[100%USG + FYM(75:25 Vol. basis) +100%PK (RDF)] followed by T2 whereas minimum value (13.2%) of PUE was observed in T5 [50%N(RDF)+50%PK(RDF)]. The urea+FYM briquettes treated plots i.e. treatments T9, T10, T11 and the plots treated with USG i.e. T4 had much higher PUE compared to the PU treated plot i.e treatments T8.

Potassium use efficiency

The highest value (89.9%) of Potassium use efficiency (KUE) was obtained in T3[100%N through USG+ 100%PK(RDF) followed by T2 whereas minimum value (45.4%) of KUE was observed in T8 [100%N(RDF) through urea+100%PK(RDF)]. The urea+FYM briquettes treated plots i.e. treatments T9, T10, T11 and the plots treated with USG i.e. treatments T4 had much higher KUE compared to the PU treated plot i.e. treatments T8.

Similar findings were reported by Jena *et al.*, (2003). Mishra *et al.*, (1999) observed that the relative efficiency of USG was increased by 40% over PU. Savant and Stangel (1990) also reported that the agronomic performance and NUE of deep placed USG was found to be superior to that of two or three split applications of urea through RDF.

Phosphorus and Potassium uptake by the crop is a function of P and K content respectively and above ground biomass production *i.e.* yield, so significant variation in uptake was found. This may be due to the synergistic effect of applied different nitrogen sources with P and K uptake resulting in varied PUE and KUE with applied different nitrogen levels. These results are similar to the findings of Laxminarayana (2006), Singh *et al.*, (2006), Sunitha *et al.*, (2010) and Chesti *et al.*, (2015).

Effect of different nitrogen levels and sources on nutrient status in soil after harvest

Data presented in table 6 and 7 as well as depicted in figure 6 and 7 indicates the nutrient status in soil after harvest. The data illustrates that available N (Kg ha^{-1}) in soil at harvest was significantly affected by different N levels and sources of N fertilizers. The highest value of available N was recorded in treatment T4 [100%N through USG + 100%PK(RDF)] followed by rest treatments involving urea+organics briquettes application i.e. T9, T10 and T11 whereas, minimum was observed in T5 [50% NPK

(RDF)]. Similarly available P and K (Kg ha^{-1}) in soil at harvest were significantly influenced by different nitrogen levels and sources of N fertilizers. The highest value of available P and K were recorded in treatments involving urea+organics briquettes i.e. T9[Urea+FYM briquettes (75:25)+100%PK(RDF)]followed by T10 and T11 and lowest value was observed in T5[50% NPK (RDF)].

Highest pH value 7.53 was observed in treatment T10 [Urea + vermicompost USG (75:25 vol. basis) + 100%PK(RDF)] followed by T8 and T7 whereas minimum (7.35) was recorded in T2[75%N through USG + 50%PK(RDF)]. However, there were no significant effect of treatments on pH of soil at harvest. Highest EC value 0.178 dSm^{-1} in soil was observed in treatment T8 [100%N(RDF) through urea + 100%PK(RDF)] followed by T6 and T4 whereas minimum EC value 0.153 dSm^{-1} was recorded in T9 and T1. Highest value of organic carbon (0.54%) was observed in T10 [Urea+vermi. USG (75:25 vol. basis) + 100%PK(RDF)] which was at par with the treatments involving urea+organics briquettes i.e. T9 and T11 whereas it was significantly higher to OC values found in rest treatments.

Overall it was observed that available N, P, K and OC in soil at harvest were significantly influenced by different nitrogen levels and sources. This may be because urea+organics briquettes application or USG slowly releases the nitrogen in soil resulting in minimum losses of N due to volatilization and leaching as well as it also increases the efficiency of nitrogen. Further, nutrient management practices had significant influence on yield, so significant variation in N, P, K uptake and use efficiency was found. These results go in line with the findings of Rodgers (1986), Savant and Stangel (1990) and Choudhury *et al.*, (1997).

Table.1 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+VermicompostUSG (75:25 volume basis)+100% PK (RDF)**
T11	**Urea +Neem cakeUSG (75:25 volume basis)+100% PK (RDF)**

Table.2 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).
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, 1956).
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 (Hanway and Heidel 1952).
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.
9	Available Fe (mg kg^{-1})	14.2	Lindsay and Norvell (1978) (DiethyleneTriaminePenta Acetic Acid Method)
10	Available Zn (mg kg^{-1})	1.53	
11	Available Cu (mg kg^{-1})	2.21	
12	Available Mn (mg kg^{-1})	6.89	

Table.3 Effect of different nitrogen levels and sources on yield in irrigated rice

Treatment	Grain Yield (q/ha)	Straw Yield (q/ha)
T1	48.28	73.07
T2	50.18	74.75
T3	50.40	75.23
T4	53.57	80.54
T5	40.75	65.79
T6	45.54	72.59
T7	46.61	72.62
T8	49.68	73.25
T9	54.64	80.71
T10	52.86	77.63
T11	52.69	79.04
CD (P= 0.05)	3.4576	4.3654

Table.4 Influence of different nitrogen levels and sources on Nutrient uptake in irrigated rice

Treatment	Nutrient Uptake (kg ha.$^{-1}$)		
	N	P	K
T1	82.50	28.41	113.32
T2	86.96	30.36	117.04
T3	92.57	30.84	118.20
T4	101.14	35.16	130.39
T5	69.77	23.64	100.52
T6	80.90	27.46	112.52
T7	84.95	28.93	113.73
T8	90.11	31.44	118.61
T9	102.10	35.50	131.98
T10	97.51	33.72	125.29
T11	98.05	33.24	126.97
CD (P= 0.05)	4.800	2.298	6.2847

Table.5 Influence of different nitrogen levels and sources on NPK use efficiency (%) in irrigated rice

Treatments	**NUE**	**PUE**	**KUE**
T1	64.0	22.8	80.1
T2	48.6	26.7	87.6
T3	42.1	27.6	89.9
T4	50.7	18.1	57.1
T5	38.6	13.2	54.5
T6	40.6	20.9	78.5
T7	34.5	23.8	80.9
T8	39.6	14.4	45.4
T9	68.8	18.5	58.7
T10	62.7	16.7	52.0
T11	63.4	16.2	53.7

* For calculating NUE, PUE and KUE, yield of control was 25 q/ha absolute

Table.6 Influence of different nitrogen levels and sources on pH, EC and Organic carbon in soil after harvest

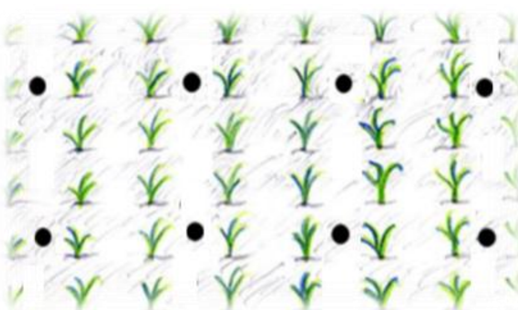
Treatments	**pH**	**EC(ds/m)**	**OC (%)**
T1	7.38	0.153	0.37
T2	7.35	0.165	0.48
T3	7.41	0.165	0.49
T4	7.39	0.173	0.47
T5	7.46	0.165	0.40
T6	7.49	0.173	0.43
T7	7.50	0.165	0.49
T8	7.52	0.178	0.48
T9	7.46	0.153	0.52
T10	7.53	0.155	0.54
T11	7.48	0.155	0.51
CD (P= 0.05)	0.291	0.028	0.085

Table.7 Influence of different nitrogen levels and sources on available NPK in soil after harvest

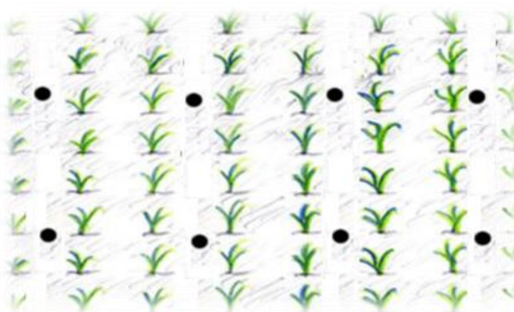
Treatment	**N (kg ha^{-1})**	**P (kg ha^{-1})**	**K (kg ha^{-1})**
T1	179.55	10.15	318.78
T2	183.11	11.23	321.84
T3	205.32	12.19	340.10
T4	227.21	16.15	351.85
T5	170.14	9.54	302.35
T6	173.95	10.31	320.59
T7	195.41	11.33	328.20
T8	202.52	15.05	341.30
T9	220.15	18.45	385.98
T10	218.33	16.98	376.80
T11	222.52	16.52	366.40
CD (P= 0.05)	4.80	0.73	21.75

Fig.1 Urea briquette formation using machine

Fig.2 Application layout for (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) Slot of application of USG



(a)



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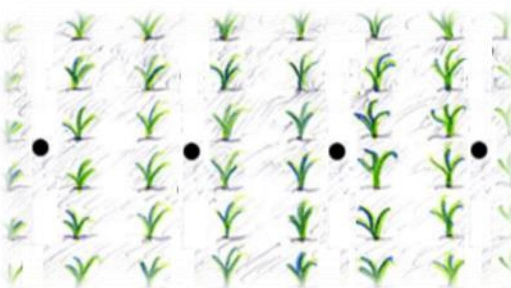

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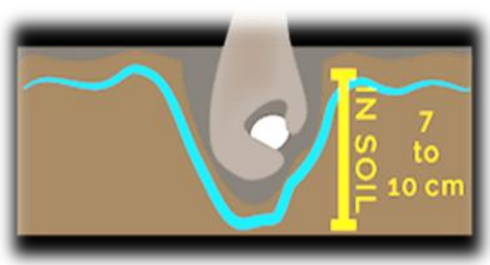


(d)

Fig.3 Effect of different nitrogen levels and sources on Yield attributes in irrigated rice

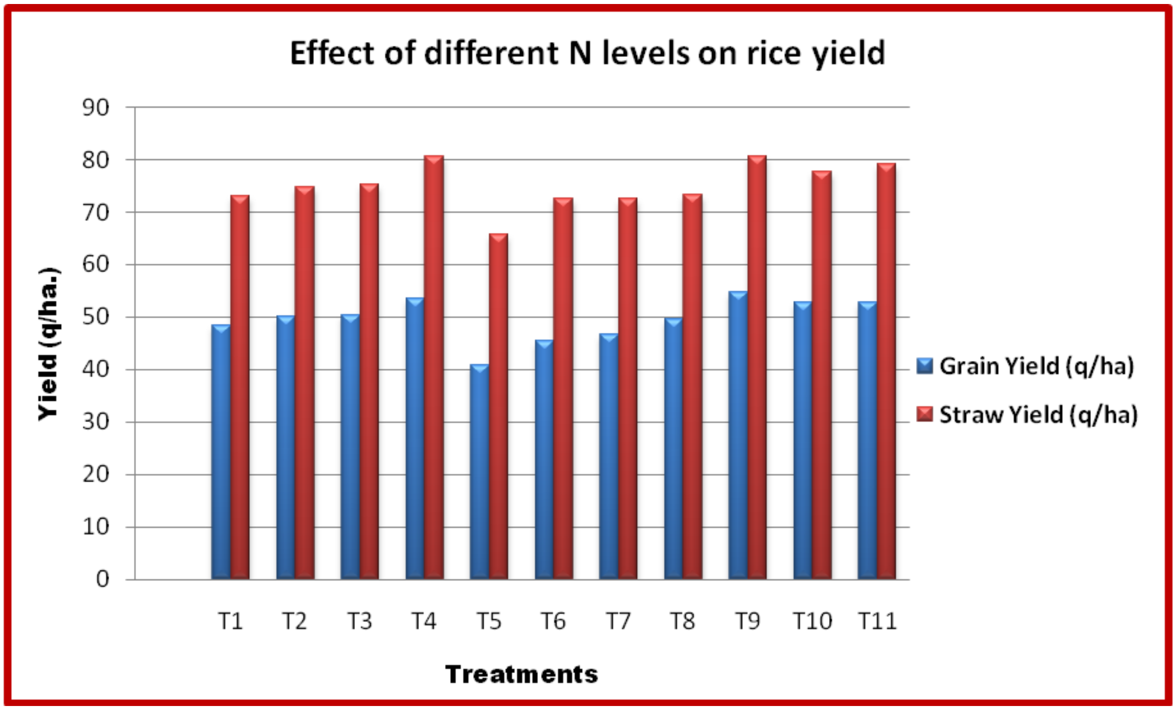


Fig.4 Influence of different nitrogen levels and sources on Nutrient uptake in irrigated rice

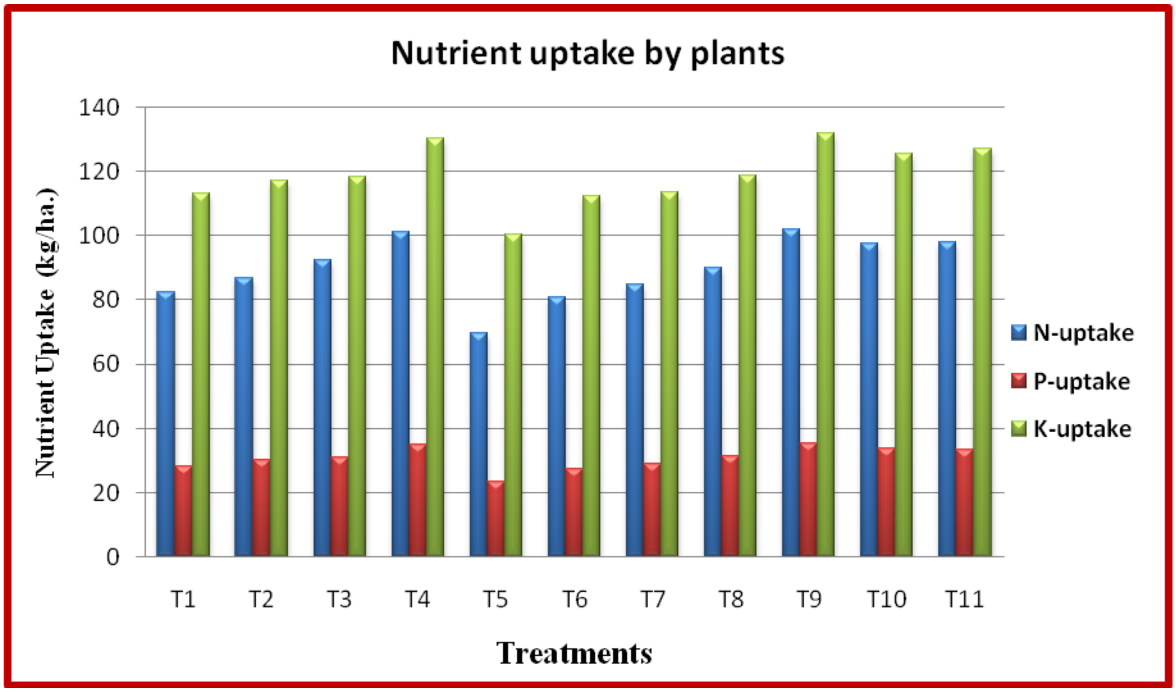


Fig.5 Influence of different nitrogen levels and sources on NPK use efficiency (%) in irrigated rice

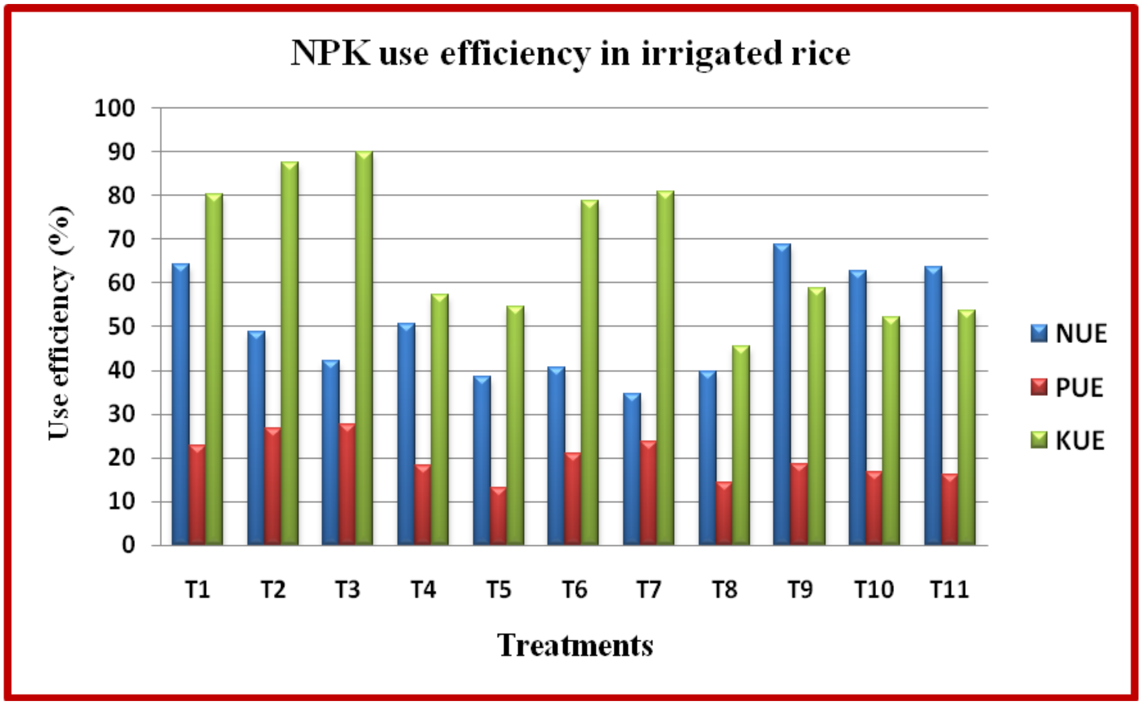


Fig.6 Influence of different nitrogen levels and sources on pH, EC and Organic carbon in soil after harvest

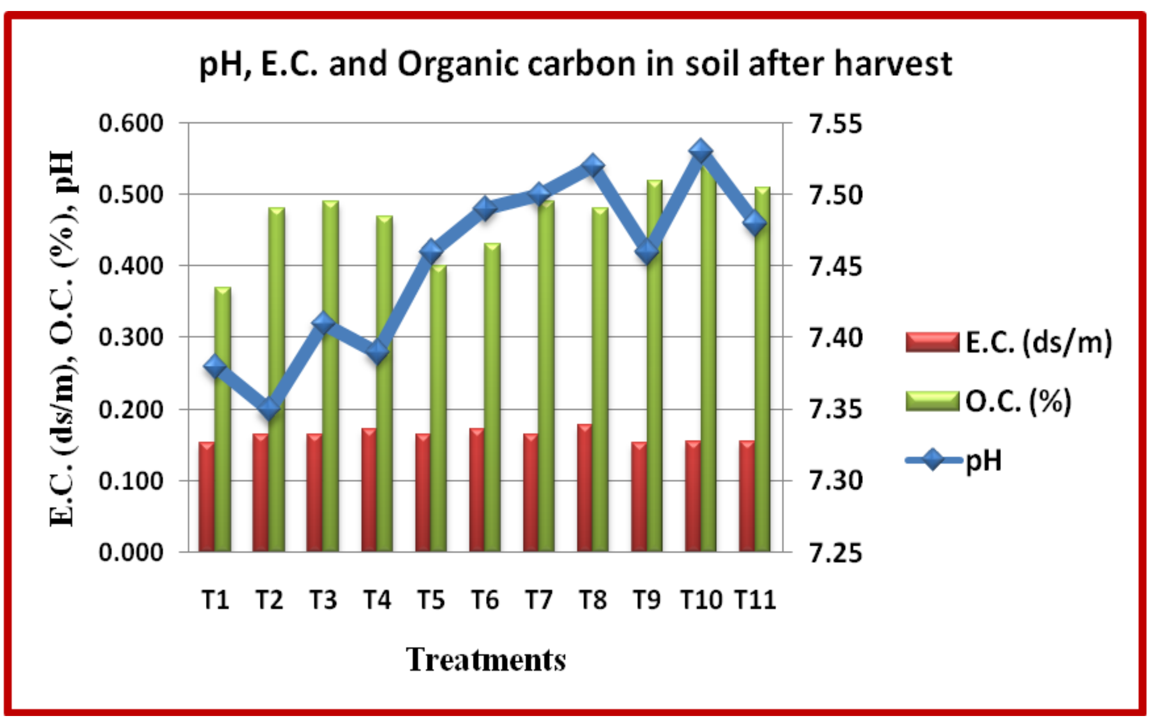
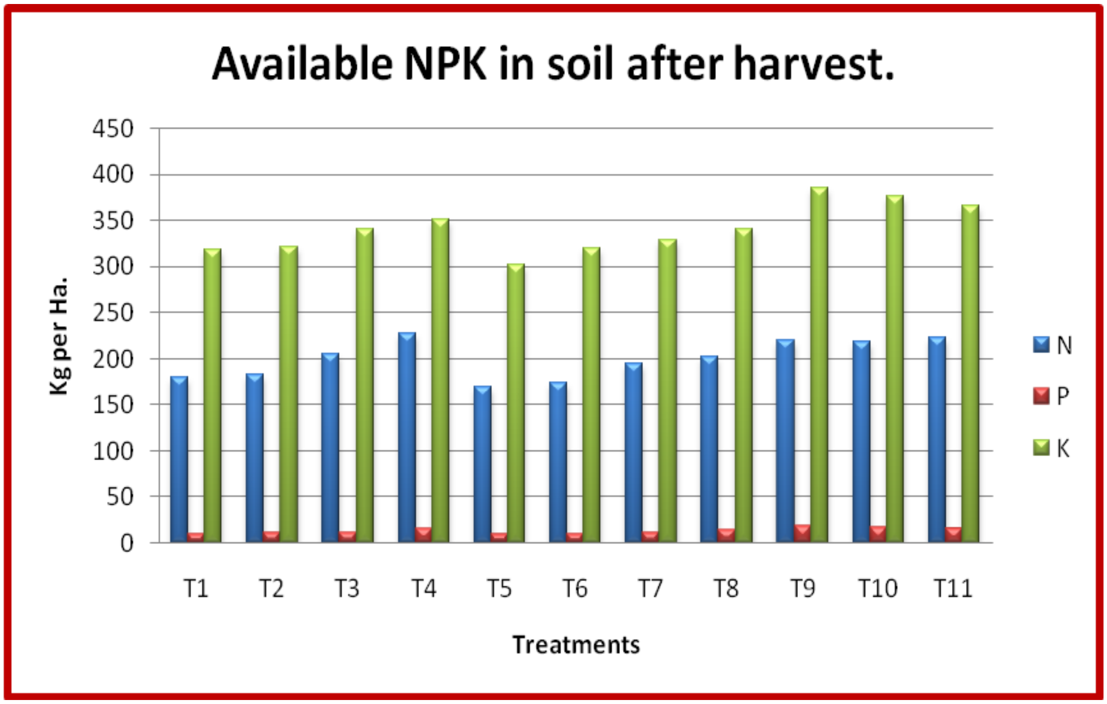


Fig.7 Influence of different nitrogen levels and sources on on available NPK in soil after harvest



Application of urea+organics briquettes increased crop growth and yield as evidenced by grain and straw yield data. Under irrigated rice, application of urea + FYM briquettes provided better physical, chemical and biological soil condition to plant and improved soil fertility as evidenced by increased soil OC status, available N, P and K; deep placement of briquettes induced slow release of nutrient reducing the losses and improved use efficiency of applied nutrients and thereby higher nutrient uptake as evidenced by better NUE, PUE and KUE.As per the above findings, among different sources of fertilizer nitrogen, Urea + FYM briquette application was found most suitable for irrigated rice cultivation system. More elaborate studies can be carried out to identify other possible natural organic additives and to improve the technology of briquette formation and application in order to reduce the manpower input in the same.

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