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Influence of Neem Coated urea on Different forms of Nitrogen and Yield in Rice

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ABSTRACT

A field experiment was conducted in Agricultural college farm, Bapatla, Andhra Pradesh to study the "Influence of neem coated urea on different forms of nitrogen and yield in rice" during *kharif* season of 2016 with 9 treatments comprising of application of 75 to 125% RDN through neem coated urea and 100% RDN through urea in 3 and 2 splits. Forms of nitrogen (ammoniacal, nitrate, total and mineralizable- N) and yield of rice were significantly influenced by application of neem coated urea. Application of recommended dose of nitrogen through neem coated urea @ 75 to 125% in three (T_3 to T_5) and two split doses (T_7 to T_9) maintained maximum amount of ammoniacal - N, total –N and mineralizable –N and lower levels of nitrate –N in soil. The significantly highest grain (5182 kg ha^{-1}) and straw yield (6515 kg ha^{-1}) were recorded in the treatment that received 125% RDN through neem coated urea in 3 splits (T_5) which was on par with 75% and 100% RDN through neem coated urea. Even though 100% N applied through urea in 3 splits recorded lower yield compared to 75% RDN through neem coated urea). The use of 75% RDN through neem coated urea applied in 3 or 2 splits appeared to be economically viable treatment which contributed towards improvement of soil health and crop productivity with reduced losses.

Key words*: Neem coated urea, Splits and nitrogen forms.*

Rice (*Oryza sativa L.*) is the principal food for Indian people, being grown in 43.86 million ha, with a production of 105.8 million tonnes and productivity of 2.7 t ha^{-1} (Ministry of Agriculture, Government of India, 2014-2015). Nitrogen is the key element limiting the yield of rice. Fertilizer N-use efficiency varies from 18 to 40% in the rice soils, because applied inorganic N is rapidly lost from the soil by ammonia volatilization and denitrification (Shivay *et al.*, 2005). Urea is one of the most widely used sources of fertiliser N in the world. When urea is applied to soil, it undergoes hydrolysis transformed into ammoniacal (NH_4^+) form and followed by nitrite (NO_2^-) and nitrate (NO_3^-) forms by the process of nitrification. Most of the crop plants use nitrate as a source of nitrogen except rice which prefers ammoniacal form over the nitrate. The rapid nitrification is one of the key processes that encourage nitrogen losses from the soil. This leads to reduced recovery of urea-N by crop plants. Large loss of N from urea necessitates an innovative application technique for increasing the N-use efficiency. Slow release materials are of paramount importance as they regulate the nitrogen supply in consonance with the demand of the crop at various stages of growth (Bana and Shivay, 2012). Keeping this in view experiment was conducted with neem coated urea on N forms of soil.

MATERIAL AND METHODS

A field experiment was conducted at Agricultural college farm, Bapatla, Andhra Pradesh during *kharif* season of 2016 with rice (BPT-5204) as the test crop. The experimental soil was clay in texture, slightly alkaline in reaction (7.64) and non-saline (0.57 dS m^{-1}). The soil was medium in organic carbon (1.91 kg ha^{-1}) and available nitrogen (263.0 kg ha^{-1}), high in available phosphorus 22.6 kg ha^{-1}) and potassium (348.2 kg ha^{-1}) and sufficient in sulphur (38 ppm). The treatments comprised of control (T_1), 100% RDN through urea in 3 split doses (T_2), 75% RDN through neem coated urea in 3 split doses (T_3), 100% RDN through neem coated urea in 3 split doses (T_4), 125% RDN through neem coated urea in 3 split doses (T_5), 100% RDN through urea in 2 split doses (T_6), 75% RDN through neem coated urea in 2 split doses (T_7), 100% RDN through neem coated urea in 2 split doses (T_8), 125% RDN through neem coated urea in 2 split doses (T_9) were replicated thrice in randomized block design (RBD). The inorganic nitrogen through urea and neem coated urea was applied in 3 splits (as basal, at tillering & panicle initiation stages) to four treatments *i.e* T_2, T_3, T_4, and T_5 applied in 2 splits (as basal, in between tillering & panicle initiation stages) to four treatments *i.e* T_6, T_7, T_8 and T_9. Entire quantity of P_2O_5 in the form of SSP and K_2O in the form of MOP were applied to all the treatments as basal dose at the time of transplanting. (Recommended dose of fertilizers was 120-60-40 kg NPK kg ha^{-1}). The soil samples collected at 3 days and 7 days after every application of fertilizers *i.e.* basal (at time of transplanting), tillering (30 DAT), in between tillering and panicle initiation (45 DAT) and at panicle initiation (60 DAT) were analysed for ammoniacal-N, nitrate-N, total nitrogen and mineralizable-N. The fertilizer applied in two splits were applied at basal and in between tillering and panicle initiation (45 DAT) whereas, in three splits were applied at basal (at time of transplanting), tillering (30 DAT) and at panicle initiation (60 DAT). The grain and straw yield was recorded after harvest of the rice. Ammoniacal form of nitrogen was determined by Kjeldahl distillation method (Jackson, 1958). The nitrate nitrogen content of the soils was determined by the procedure outlined by A.O.A.C. (1950). The total nitrogen content in the soils was determined by modified kjeldahl method (Jackson, 1973). Mineralizable nitrogen content in the soils was determined by alkaline potassium permanganate method (Subbiah and Asija, 1956).

RESULTS AND DISCUSSION

Forms of nitrogen

Ammoniacal form of nitrogen

The soil samples collected at three days and one week after every application of fertilizers at different growth stages was significantly influenced by the application of neem coated urea in 3 and 2 splits (Table 1). The significantly highest amount of ammoniacal form of nitrogen (41.2 and 50.8 kg ha^{-1}) at three days after every application of fertilizer was recorded in the treatment T_6 (100% RDN through urea in 2 split doses) which was on par with T_9 (125% RDN through neem coated urea in 2 split doses) (39.4 and 48.1 kg ha^{-1}) at basal and 45 DAT compared to the other treatments. At tillering and panicle initiation stage, T_2 recorded highest (38.4 kg ha^{-1} and 42.8 kg ha^{-1}, respectively) NH_4-N which was on par with T_5 (125% RDN through neem coated urea in 3 split doses). Lowest NH_4-N was observed in control (T_1-where no nitrogen was applied) in all stages of growth.

Whereas, at 7 days after every application of fertilizer, the highest amount of ammoniacal form of nitrogen was observed in T_5 (45.2, 48.0, 36.6 and 50.6 kg ha^{-1}) followed by T_4 (42.6, 44.0, 35.1 and 46.6 kg ha^{-1}), T_9 (42.1, 39.3, 55.0 and 32.9 kg ha^{-1}) at basal, 30, 45 and 60 DAT, respectively. The lowest values of 23.8, 20.5, 20.3 and 18.3 kg ha^{-1} at basal, 30, 45 and 60 DAT, respectively were observed in treatment with no nitrogen (T_1). The availability of ammoniacal form of nitrogen was decreased with application of N in 2 splits and control.

Highest amount of NH_4-N content at one week after every application in the treatments T_3 to T_5 and T_7 to T_9 (neem coated urea applied @ 75 to 125% in three and two split doses) than T_2 and T_6 (where urea applied @ 100% in three and two split doses) and control (T_1) at all growth stages could be due to their inhibitory effect on nitrification process which might have helped in conserving ammoniacal form of nitrogen in the soil by delaying the conversion of NH_4^+ to NO_3^-. More amount of ammoniacal form of nitrogen at three days after application of urea in T_2 and T_6 (100% RDN through urea applied in three and two splits) compared to other treatments due to rapid hydrolysis, where nitrogen gets transformed into ammoniacal (NH_4^+) form and followed by nitrite (NO_2^-) and nitrate (NO_3^-) forms by the process of nitrification. Maintenance of higher soil NH_4^+-N with the application of neem coated urea at all the stages of crop growth is due steady release of NH_4^+-N in the soil and inhibitory action of nimbidin of neem on the nitrifiers (*Nitrosomonas*).

Nitrate form of nitrogen (NO_3^--N)

Nitrate form of nitrogen (NO_3^--N) in soil samples collected at three days and 7 days after every application of fertilizers at different growth stages was significantly influenced by the treatments (Table 2). The soil samples collected after 3 days after fertilizer application recorded significantly highest amount of nitrate form of nitrogen in the treatment T_6 (100% RDN through urea in 2 split doses) (40.0 and 42.1 kg ha^{-1} at basal and in

Table 1. Effect of neem coated urea on ammoniacal form (kg ha^{-1}) of nitrogen at different growth stages of rice.

Treatment	Basal (at time of transplanting)		Tillering (30 DAT)		In b/w tillering & Panicle initiation (45 DAT)		Panicle initiation (60 DAT)	
	3 days	7 days	3 days	7 days	3 days	7 days	3 days	7 days
T• - Control	23.9	23.8	21.1	20.5	20.7	20.3	18.6	18.3
T‚ - 100% RDN through urea in 3 split doses	35.7	34.9	38.4	30.2	26.0	28.9	42.8	37.3
Tƒ - 75% RDN through neem coated urea in 3 split doses	29.3	40.6	30.0	41.3	32.3	33.7	31.9	43.6
T„ - 100% RDN through neem coated urea in 3 split doses	31.1	42.6	32.5	44.0	33.4	35.1	34.8	46.6
T… - 125% RDN through neem coated urea in 3 split doses	33.6	45.2	35.6	48.0	35.3	36.6	39.6	50.6
T† - 100% RDN through urea in 2 split doses	41.2	30.5	25.7	28.2	50.8	35.1	26.0	23.6
T‡ - 75% RDN through neem coated urea in 2 split doses	34.2	37.2	30.4	36.1	44.7	46.9	30.3	28.9
T_8 - 100% RDN through neem coated urea in 2 split doses	35.7	38.9	32.1	37.5	46.3	50.9	33.4	30.4
T_9 - 125% RDN through neem coated urea in 2 split doses	39.4	42.1	33.8	39.3	48.1	55.0	35.6	32.9
SEm±	1.6	2.0	1.2	1.8	1.6	1.6	1.5	1.6
CD (0.05)	4.8	6.1	3.6	5.5	4.9	4.7	4.6	4.9
CV (%)	8.1	9.4	6.7	8.7	7.5	7.1	8.1	8.0

between tillering and panicle initiation stage *i.e.* 45 DAT, respectively) followed by T_9 (100% RDN through urea in 2 split doses) (34.0 and 36.8 kg ha^{-1} at tillering and panicle initiation stage, respectively). Same trend was observed at 7 days after application, where highest nitrate nitrogen was observed with the treatment T_6 at basal and in between tillering and panicle initiation stage.

The significantly highest amount of nitrate form of nitrogen at 3 and 7 days after every application of fertilizers (34.0 and 34.9 kg ha^{-1}, respectively) at tillering and at panicle initiation stage (36.8 and 37.8 kg ha^{-1}, respectively) was observed with T_2- 100% RDN through urea in 2 split doses followed by T_5 (application of 125% RD of neem coated urea in 3 split doses) and T_9. At different growth stages, the lowest amount of nitrate form of nitrogen at 3 and 7 days after fertilizer application ranged from 16.1 to 16.3 kg ha^{-1} was obtained in control (T_1) where no nitrogen was applied. In general, the control plot (T_1) has recorded the lowest amount of NO_3-N when compared to nitrogen applied plots (T_2 to T_9), which could be attributed partly due to the crop removal and partly due to nitrogen losses. More amount of nitrate form of nitrogen was recorded at three and 7 days after application in the treatments of T_2 and T_6 where normal urea was applied. The release of nitrate nitrogen is more when applied through urea at initial stage of crop, in later stages (PI stage) the release is more from neem coated urea. This indicates that the inhibitory effect of neem lasted even beyond 30 days of application of the fertilizers which was responsible for increase in accumulation of NO_3-N in the soil with advancement of time even after meeting the crop requirements. Lower amount of nitrate- N in neem coated urea treatments attributed due to slow dissolution of fertilizer and mineralization of amide nitrogen and retarded nitrification due to the presence of tetranotriterpenoids viz., nimbin and nimbidin which inturn resulted in slow mineralization of soil nitrogen (Subbiah and Kothandaraman, 1980). Higher nitrate form of nitrogen with normal urea is due to quick conversion of ammoniacal form of nitrogen to nitrate form of nitrogen with in lesser period of application. These results are in line with findings of Sharadha (2004).

Total nitrogen

Application of neem coated urea had significant influence on total nitrogen in soil samples collected at three days and one week after every application of fertilizers at different growth stages (Table 3). The amount of total nitrogen was higher with the treatments receiving normal urea at 3 days after application of fertilizers and was decreased with 7 days after application, whereas, the treatments received with neem coated urea recorded more total nitrogen at 7 days after application. The significantly highest amount of total nitrogen at one week after every application of fertilizers was recorded in T_5 - 125% RDN through neem coated urea in 3 split doses (0.070 and 0.073% at tillering and panicle initiation stage, respectively) and T_9 - 125% RDN through neem coated urea in 2 split doses (0.064 and 0.072% at basal and in between tillering and panicle initiation stage, respectively). While, three days after every application of fertilizers, significantly highest amount of total nitrogen was recorded in T_2 -100% RDN through urea in 3 split doses (0.069 and 0.073% at tillering and panicle initiation stage, respectively) and T_6 - 100% RDN through urea in 2 split doses (0.066 and 0.071% at basal and in between tillering and panicle initiation stage, respectively). At different growth stages, the lowest amount of total nitrogen at three days and one week after application of fertilizers was observed in control (T_1) where no nitrogen was applied and is more or less uniform throughout the crop growth period.

Higher amount of total nitrogen with neem coated urea treated plots applied in three (T_3 to T_5) and two (T_7 to T_9) splits was due to increase in organic and inorganic forms of nitrogen. Organic form of nitrogen is increased due to its organic and acidic behaviour of neem cake helps in growth of micro organisms and inorganic form of nitrogen is increased due to its nitrification inhibiting property helps in conserving the more amount of ammoniacal -N. Since all the N levels (75 to125%) used in the study, N concentration was not too high at a given time and not toxic to the bacterial population in the soil. The increase in total N might also be due to the mineralization of native N due to higher bacterial population (Suresh *et al.,* 1995).

Mineralizable form of nitrogen

Mineralizable form of nitrogen in soil samples collected at three days and 7 days after every application of fertilizers at different growth stages was significantly influenced by the treatments (Table 4). At basal and 45 DAT, significantly higher amount of mineralizable N was recorded with T_6 - 100% RDN through urea in 2 splits (312 and 346 kg ha^{-1}, respectively) at 3 days after urea application, whereas, at 7 days after application T_9 (125% RDN through neem coated urea in 2 splits) recorded higher mineralizable nitrogen content. At tillering stage, after 7 days application T_5 recorded significantly higher mineralizable N (331 kg ha^{-1}) which was on par with T_4, T_3, T_9, T_8 and T_7. At panicle initiation stage, T_2 (100% RDN through urea in 3 splits) recorded significantly higher mineralizable N content (362 kg ha^{-1}) which was on par with T_6 (100% RDN through urea in 2 splits) at 3 days after urea application, while T_5 (125% RDN through neem coated urea in 3 split doses) recorded higher mineralizable form of nitrogen (362 kg ha^{-1}) which is on par with T_9, T_4, T_8 and T_3 at 7 days after application of urea. At different growth stages, the lowest amount of mineralizable form of nitrogen at three days and 7 days after application of fertilizers was observed in control (T_1) where no nitrogen was applied.

Irrespective of treatments, maximum value of mineralizable form of nitrogen was noticed at panicle initiation stage (60 DAT) which could be due to high rate of mineralization encouraged by microbial activity during peak growth stage. Coating of urea with neem products reduces the losses of nitrogen by volatilization as well as leaching of nitrates through inhibitory effect on nitrification, which could be responsible for higher amount of mineralizable-N status. Lower amount of mineralizable-N with urea applied in three (T_2) and two (T_6) splits was due to quick hydrolysis and more urease activity. Higher amount of total nitrogen observed with neem coated urea applied in three splits than two splits but on par with each other at

Table 2. Effect of neem coated urea on nitrate form (kg ha^{-1}) of nitrogen at different growth stages of rice.

Treatment	Basal (at time of transplanting)		Tillering (30 DAT)		In b/w tillering & Panicle initiation (45 DAT)		Panicle initiation (60 DAT)	
	3 days	7 days	3 days	7 days	3 days	7 days	3 days	7 days
T_1 - Control	16.3	16.2	16.2	16.2	16.2	16.1	16.1	16.1
T_2 - 100% RDN through urea in 3 split doses	27.5	28.5	34.0	34.9	26.0	28.2	36.8	37.8
T_3 - 75% RDN through neem coated urea in 3 split doses	20.6	22.2	24.6	26.1	29.3	28.9	28.0	28.9
T_4 - 100% RDN through neem coated urea in 3 split doses	21.3	23.3	27.9	30.1	30.7	33.4	30.8	32.8
T_5 - 125% RDN through neem coated urea in 3 split doses	22.7	25.6	29.8	31.8	33.1	35.3	33.9	36.3
T_6 - 100% RDN through urea in 2 split doses	40.0	40.0	21.0	22.2	42.1	43.1	25.4	26.5
T_7 - 75% RDN through neem coated urea in 2 split doses	25.9	27.0	26.0	27.0	28.8	30.0	26.0	30.3
T_8 - 100% RDN through neem coated urea in 2 split doses	28.5	28.5	26.8	27.1	31.4	32.0	28.9	33.4
T_9 - 125% RDN through neem coated urea in 2 split doses	32.4	32.5	28.3	30.0	32.7	33.4	30.3	35.3
SEm$_{\pm}$	1.4	2.0	0.99	1.5	1.6	1.2	1.2	1.3
CD (0.05)	4.1	6.0	3.0	4.6	4.9	3.5	3.7	4.0
CV (%)	9.0	12.7	6.6	9.8	9.3	6.4	7.5	7.5

all growth stages. These results are in line with findings of Rajendra Prasad *et al*. (2002) who reported the availability of higher amount of mineralizable-N with neem coated urea.

Grain Yield

Grain yield of paddy was significantly influenced by the application of neem coated urea (Table 5 and Figure 1). The application of neem coated urea resulted in a significant increase in grain yield over the treatments, which received urea *i.e.* 100% RDN through urea applied in 3 split doses (T_2) and 100% RDN through urea applied in 2 split doses (T_6) and control (T_1). Grain yield ranged from 3167 to 5182 kg ha^{-1}. The highest grain yield of 5182 kg ha^{-1} was recorded with T_5 - 125% RDN through neem coated urea in 3 split doses. However, it was on par with those treatments which were supplied with neem coated urea *viz*., 75% RDN through neem coated urea applied in 3 split doses (T_3), 100% RDN through neem coated urea applied in 3 split doses (T_4), 75% RDN through neem coated urea applied in 2 split doses (T_7), 100% RDN through neem coated urea applied in 2 split doses (T_8) and 125% RDN through neem coated urea applied in 2 split doses (T_9). The lowest grain yield of 3167 kg ha^{-1} was obtained in control (T_1) where no nitrogen was applied. Fertilizer applied through urea or neem coated urea applied in 3 split doses (T_2 to T_5) recorded more grain yield (4101 to 5182 kg ha^{-1}) than applied in 2 split doses (T_6 to T_9) (3876 to 4955 kg ha^{-1}). There was no significant difference in the grain yield of rice due to increase in the dose of N from 75 to 125% through neem coated urea applied in three and two splits (T_3 to T_5 and T_7 to T_9).

Higher grain yield with neem coated urea application may be due to the presence of nitrification inhibitor in neem delayed conversion of ammoniacal form to nitrite form, thereby increasing and prolonging the availability of nitrogen, which contributed to increased dry matter production and well developed sink and source

Table 3. Effect of neem coated urea on total nitrogen content (%) of soil at different growth stages of rice.

Treatment	Basal (at time of transplanting)		Tillering (30 DAT)		In b/w tillering & Panicle initiation (45 DAT)		Panicle initiation (60 DAT)	
	3 days	7 days	3 days	7 days	3 days	7 days	3 days	7 days
T• - Control	0.052	0.052	0.050	0.049	0.048	0.047	0.047	0.046
T‚ - 100% RDN through urea in 3 split doses	0.065	0.063	0.069	0.059	0.070	0.060	0.073	0.063
Tƒ - 75% RDN through neem coated urea in 3 split doses	0.055	0.057	0.058	0.065	0.059	0.065	0.061	0.069
T„ - 100% RDN through neem coated urea in 3 split doses	0.057	0.059	0.061	0.068	0.061	0.068	0.063	0.071
T… - 125% RDN through neem coated urea in 3 split doses	0.059	0.061	0.063	0.070	0.063	0.071	0.065	0.073
T† - 100% RDN through urea in 2 split doses	0.066	0.063	0.068	0.058	0.071	0.062	0.072	0.061
T‡ - 75% RDN through neem coated urea in 2 split doses	0.056	0.058	0.057	0.063	0.060	0.068	0.059	0.065
T_8 - 100% RDN through neem coated urea in 2 split doses	0.059	0.061	0.059	0.065	0.063	0.070	0.061	0.068
T_9 - 125% RDN through neem coated urea in 2 split doses	0.061	0.064	0.061	0.067	0.065	0.072	0.063	0.071
SEm±	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002
CD (0.05)	0.003	0.005	0.005	0.005	0.005	0.005	0.005	0.005
CV (%)	6.1	6.5	7.1	10.4	7.4	7.3	6.6	6.6

capacity of the plant resulted in increase in yield attributing characters. The superiority of neem coated urea over urea was due to the restricted solubility of the fertilizer material due to presence of a thick coating of neem oil acting as a physical barrier as observed by suganya *et al.* (2007). Lower grain yield obtained with urea was due to rapid hydrolysis and loss of nitrogen through leaching. Further it was observed that higher grain yield was recorded with either through urea or neem coated urea applied in 3 split doses (T_2 to T_5) than 2 split doses (T_6 to T_9) was due to favourable influence on growth and yield attributes by increasing the nitrogen availability, reduced losses of N and better uptake throughout the crop growth. The result was in line with the findings of Raj *et al* (2014). Higher grain yield with the application of neem coated urea was in agreement with Kumar *et al*. (2015). Chaudhary *et al*. (2006) observed higher rice yield with the application of neem cake coated urea @ 100 kg ha^{-1} in two splits as compared to the application of urea.

Application of 75% RDN through neem coated urea in 3 and 2 splits recorded significantly more grain yield, which was on par with 100% and 125% RDN through neem coated urea over 100% RDN through urea applied in 3 and 2 splits due to increased nitrogen availability and higher nitrogen use efficiency and apparent nitrogen recovery in neem coated urea treatments in rice. T_3 (75% RDN through neem coated urea in 3 splits) is treated as best treatment when compared to the T_2 and T_6 where 100% N applied through urea. This is due to increase in grain yield, decrease in quantity of fertilizer N and increase in use efficiency. Maithra (2017) reported that application of 75% RDN as neem coated urea in 3 and 2 splits recorded maximum grain yield than 100% RDN as urea applied at basal, maximum tillering and panicle initiation stage. These results were in line with the findings of Wankhade (2007).

Table 4. Effect of neem coated urea on mineralizable nitrogen content (kg ha^{-1}) of soil at different growth stages of rice.

Treatment	Basal (at time of transplanting)		Tillering (30 DAT)		In b/w tillering & Panicle initiation (45 DAT)		Panicle initiation (60 DAT)	
	3 days	7 days	3 days	7 days	3 days	7 days	3 days	7 days
T• - Control	269	267	253	250	242	240	238	235
T‚ - 100% RDN through urea in 3 split doses	304	283	324	296	310	314	362	341
Tƒ - 75% RDN through neem coated urea in 3 split doses	283	294	308	324	322	334	339	356
T„ - 100% RDN through neem coated urea in 3 split doses	287	296	314	327	325	338	342	359
T… - 125% RDN through neem coated urea in 3 split doses	294	302	316	331	329	340	345	362
T† - 100% RDN through urea in 2 split doses	312	288	294	290	346	337	356	339
T‡ - 75% RDN through neem coated urea in 2 split doses	289	298	306	312	324	342	327	350
T_8 - 100% RDN through neem coated urea in 2 split doses	291	304	310	316	329	346	331	353
T_9 - 125% RDN through neem coated urea in 2 split doses	296	306	312	320	331	349	335	357
SEm$_{\pm}$	4.3	3.0	3.7	7.0	3.3	3.7	5.3	3.3
CD (0.05)	13.0	9.0	11.0	21.0	10.0	11.0	16.0	10.0
CV (%)	5.2	6.2	5.4	5.4	5.7	5.6	5.3	5.1

Straw yield

Straw yield was significantly influenced by different treatments in transplanted rice (Table 5 and Figure 1). The straw yield followed the same trend with that of grain yield. The results indicated that straw yield ranged from 4416 to 6515 kg ha^{-1}. The significantly highest straw yield (6515 kg ha^{-1}) was obtained with the application of 125% RDN through neem coated urea in 3 split doses (T_5) over the treatments, which received urea *i.e.* 100% RD of urea applied in 3 split doses (T_2) and 100% RD of urea applied in 2 split doses (T_6) and control (T_1). However, it was on par with the treatments those supplied with neem coated urea applied in 3 and 2 split doses. The lowest straw yield (4416 kg ha^{-1}) was recorded in T_1 (control), where no nitrogen was applied. Application of recommended dose of nitrogen @ 75 to 125% through neem coated urea in 3 split doses (T_3 to T_5) recorded more straw yield (6092 to 6515 kg ha^{-1}) than applied in 2 split doses (T_7 to T_9) (5802 to 6355 kg ha^{-1}).

Significantly higher straw yield recorded with neem coated urea in 2 or 3 splits over urea applied in 2 or 3 splits is due to prolonged availability of N from neem coated urea provides adequate supply of nutrients to the crop helps in the synthesis of carbohydrates, which are required for the formation of protoplasm, thus resulting in highest cell division and cell elongation which is account of overall improvement in the vegetative growth of the plant. The results are in line with the findings of Raj *et al* (2014). The increased growth and yield parameters have contributed for increasing the yield. This is due to improved and prolonged availability of N from this coated urea as observed by Kumar *et al*. (2015) and Murthy *et al*. (2003). Coating of urea with neem which obviously enhanced the efficiency of nitrogen through conserving ammoniacal nitrogen in the soil and also making more of nitrogen available to plants, resulting in significantly higher straw yield. These results of increased straw yield with neem coated urea are in accordance with the findings of Suresh *et al.* (1995).

Table 5. Effect of neem coated urea on yield (kg ha^{-1}) of rice.

Treatment	Grain yield	Straw Yield
T• - Control	3167	4416
T, - 100% RDN through urea in 3 split doses	4101	5290
Tƒ - 75% RDN through neem coated urea in 3 split doses	4830	6092
T„ - 100% RDN through neem coated urea in 3 split doses	4985	6370
T… - 125% RDN through neem coated urea in 3 split doses	5182	6515
T† - 100% RDN through urea in 2 split doses	3876	5090
T‡ - 75% RDN through neem coated urea in 2 split doses	4596	5802
T_8 - 100% RDN through neem coated urea in 2 split doses	4765	6160
T_9 - 125% RDN through neem coated urea in 2 split doses	4955	6355
SEm$_{\pm}$	235	222
CD (0.05)	708	669
CV (%)	9.1	6.7

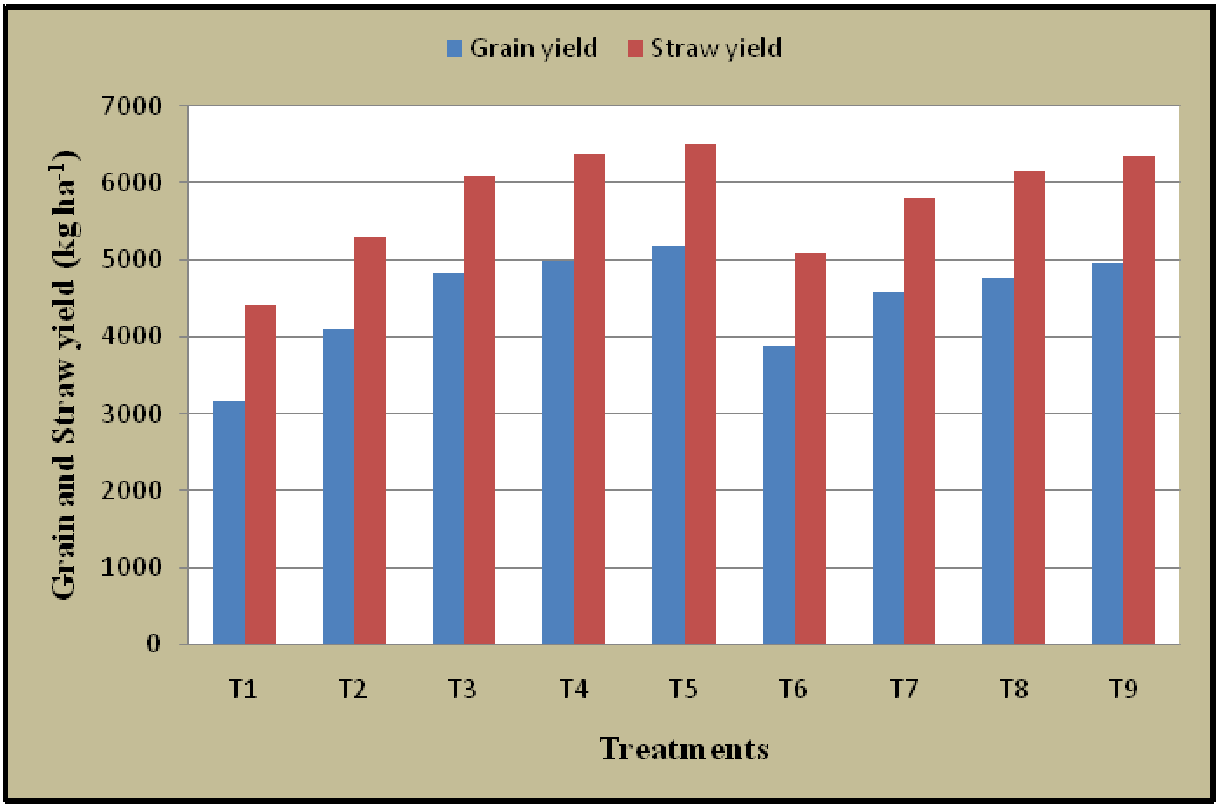

Fig 1. Effect of neem coated urea on yield (kg ha^{-1}) of rice.

Conclusion

Based on the above results and discussion, it can be concluded that the use of 75% RDN through neem coated urea applied in 3 or 2 splits appeared to be economically viable treatment which contributed towards improvement of soil health and crop productivity with reduced losses.

LITERATURE CITED

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