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Optimization of Nitrogen Dose for Green Manure Incorporated Rice under Sodic Soil

T. Ramesh* and S. Rathika
Department of Agronomy, ADAC&RI, TNAU
Tiruchirappalli-620 009, Tamil Nadu, India

A field experiment was conducted at Anbil Dharmalingam Agricultural College and Research institute, Thiruchirappalli during *Samba* season 2015-16 to optimize the nitrogen dose for green manure incorporated paddy field under *sodic* soil. The experiment was laid out in Randomized block design (RBD), with three replications. The treatments consists of green manure (GM) alone, green manure + 100% recommended dose of nitrogen, green manure + 75% recommended dose of nitrogen, green manure + LCC based nitrogen management, green manure + skipping N during tillering stage, 100% recommended dose of nitrogen alone and control (No nitrogen). The results revealed that the green manure + 100% N recorded significantly higher growth, yield parameters and grain yield (5900 kg ha^{-1}), net returns and BCR over green manure alone. However, the grain yield was comparable with GM + 75% N, GM + skipping N during tillering stage, GM + LCC based nitrogen management. Since the grain yield recorded under GM + 100% N was statistically on par with GM + 75% N, 25% of nitrogen could be saved through green manuring. Hence the recommended dose of nitrogen could be reduced from 187.5 kg to 140.6 kg ha^{-1} (75%) for green manure incorporated rice under sodic soil.

Key words: Green manure, Nitrogen, Rice, LCC, Optimization, Grain yield, Economics

Rice is the most important human food crop in the world, directly feeding more people than any other crop. Rice is being cultivated globally around 161.72 million ha and produced 480.7 million tonnes (Nathan, 2016). In India, it is being cultivated under 44.14 million ha and produced 106.65 million tonnes (Annual Report, 2016-17). Nitrogen management is very critical management factor for getting higher grain yield of paddy particularly under *sodic* soil. In alkali soil, nitrogen availability is reduced mainly due to high soil pH. Nitrogen availability could be improved by green manuring in *sodic* soil. Green manuring is one of the important organic sources as it improves the soil fertility, crop productivity, reduces the application of inorganic fertilizers, and reduces *sodic*ity. It acts as soil acidifying agent to decrease the alkalinity / pH of alkali soils by generating humic acid and acetic acid. Incorporation of green manures into a cropping system can drastically reduce the need of external inputs like inorganic fertilizers. Green manuring of daincha supplies 10-15 tonnes of green biomass and 40-50 kg of nitrogen per hectare to succeeding crops. It is evident that the application of green manure along with nitrogen fertilizers ensured adequate supply of nutrients especially nitrogen to the transplanted rice over the entire growing season for better plant growth with higher grain production (Paramanik *et al.,* 2004). Keeping these in view, the present investigation has been undertaken to optimize the nitrogen dose for green manure incorporated rice under *sodic* soil condition.

Corresponding author's email: agronramesh@gmail.com

Material and Methods

A field experiment was conducted at Anbil Dharmalingam Agricultural College and Research Institute, Thiruchirappalli during *Samba* season 2015-16 to optimize the nitrogen dose for rice under green manure incorporated fields in *sodic* soil. The soil of the experimental field was sandy clay loam in texture belonging to series of *Vetric Ustropept*. It was alkaline pH, low in available nitrogen, high in available phosphorus and medium in available potassium. The experiment was laid out in Randomized block design (RBD), with three replications. The treatments consist of green manure (GM) alone, green manure + 100% recommended dose of nitrogen, green manure + 75% recommended dose of nitrogen, green manure + Leaf Colour Chart (LCC) based nitrogen management, green manure + skipping N during tillering stage, 100% recommended dose of nitrogen alone and control (No nitrogen). Medium duration variety TNAU Rice TRY 3 was used in this study.

Green manure crop daincha was raised and incorporated during flowering stage. The green biomass produced by daincha at the time of incorporation was 22.30 tonnes, which supplied 47.85 kg N/ha. Recommended dose of phosphorus was applied as basal. Inorganic nitrogen was applied as urea along with recommended dose of potassium at four split doses *viz*., basal, active tillering stage, panicle initiation and heading stages. Since the experimental soil was alkaline, 25% extra N was applied as recommended dose (187.5 kg/

ha). LCC readings were taken at weekly intervals from 14 days after transplanting in ten plants and average was made and 30 kg ha^{-1} N was applied as on when the reading goes below the critical value of 4 (Ravi and Ramesh, 2007). In green manuring + skipping N during tillering treatment, nitrogen was not applied during tillering stage and remaining three split doses were applied. Observations on growth parameters were recorded at tillering and flowering stages. Cost of cultivation and gross returns for all the treatments were worked out on the basis of prevailing input cost and market price of grain at the time of experimentation. Net return was calculated by deducting costs of cultivation from gross return. Data on various characters studied during the course of investigation was statistically analysed as suggested by Gomez and Gomez (1984).

Results and Discussion

Effect of green manuring on the growth parameters of rice at tillering stage

The effect of green manuring on the growth parameters of rice was recorded at tillering stage. The results revealed that the green manure incorporated rice recorded higher chlorophyll content (SPAD reading - 45.1), plant height (70 cm), tillers/hill (27), number of leaves per plant (112), leaf area index (3.2), shoot dry weight (6.07 g/plant), root length (30.6 cm), root volume (14.3 cc/plant) and root dry weight (1.89 g/plant) than the plots left without incorporation of green manure (Table 1). The lower growth parameters were recorded under without green manure incorporated plot. Incorporation of green manure under *sodic* soil would have altered the soil pH favourably and increased the nitrogen availability during early stages resulted in higher crop growth parameters. The positive response of green manuring on leaf area index (LAI), specific leaf area (SLA), crop growth rate (CGR), leaf relative growth rate (LRGR), leaf weight ratio (LWR) and net assimilation rate (NAR) of rice was reported by Md Safiqul Islam *et al*. (2015).

Table 1.Effect of green manuring on the growth parameters of rice at tillering stage

Parameters	With green manure	Without green manure
Chlorophyll content (SPAD reading)	45.10	30.60
Plant height (cm)	70.00	54.00
No. of tillers/hill	27.00	16.00
No. of leaves/plant	112.00	54.00
Leaf Area Index	3.20	2.80
Shoot dry weight (g/plant)	6.07	5.63
Root length (cm)	30.60	29.00
Root volume (cc/plant)	14.30	9.00
Root dry weight (g/ plant)	1.89	1.56

Effect of green manuring and nitrogen management on growth parameters of rice at flowering stage

Growth parameters of rice at flowering stage revealed that the green manure + 100% N produced significantly taller plants (128.2 cm), tillers per hill (23), leaves per plant (61), LAI (5.4), shoot dry weight (49 g $plant^{-1}$), root length (26 cm), root dry weight (21.3 g $plant^{-1}$) over green manure alone and control.

Table 2. Effect of green manuring and N management on growth parameters of rice at flowering stage

Treatments	Plant height (cm)	Tillers/ hill (No's)	Leaves / plant	LAI	Shoot dry weight (g/plant)	Root length (cm)	Root dry weight (g/plant)
GM alone	117.8	17	47	4.2	32	23	12.5
GM + 100% N	128.2	23	61	5.4	49	26	21.3
GM + 75% N	124.5	21	56	5.2	45	24	19.1
GM + LCC based N	117.7	20	55	5.1	43	25	18.3
GM + skipping N at tillering	116.5	20	56	5.2	42	25	16.7
100 % N alone	123.6	23	59	5.2	16	23	16.5
Control (No N)	91.4	14	44	4.0	26	22	10.7
CD (P=0.05)	9.4	1.6	4.1	0.2	2.2	1.5	1.0

GM – Green manure; LCC – Leaf colour chart

However, this was comparable with green manure + 75% N and 100% N without green manure (Table 2). Green manure incorporation followed by LCC based N management, skipping N during tillering stage in green manure incorporated plots and GM alone recorded significantly higher growth parameters

than control plot. Control plot (No N) recorded the lower growth parameters at flowering stage as compared to other treatments. Combined application of *Sesbania* green manure and nitrogen fertilizer increased the growth parameters of rice (Deshpande and Devasenapathy, 2011; Shrivastava *et al*., 2005).

Table 3. Effect of green manuring and N management on yield parameters of rice

Treatments	Productive tillers/m^2	Panicle length(cm)	No. of grains/ panicle	No. of filled grains/ panicle	No. of ill filled grains/ panice	Test weight (g)
GM alone	360	26.5	132	112	20	19.7
GM + 100% N	504	30.7	212	196	16	22.3
GM + 75% N	484	27.9	210	192	18	21.9
GM + LCC based N	478	29.1	209	189	20	21.6
GM + skipping N at tillering	467	28.6	196	182	14	20.3
100% N alone	480	28.0	199	184	15	20.2
Control (No N)	288	25.3	132	106	26	18.6
CD (P=0.05)	22	2.2	15.3	14.9	1.2	0.9

GM – Green manure; LCC – Leaf colour chart

Effect of green manuring and nitrogen management on yield parameters of rice

Yield parameters of rice revealed that the green manure + 100% N recorded significantly higher productive tillers/m^2 (504), panicle length (30.7 cm), No. of grains/panicle (212), number of filled grains/ panicle (196), number of unfilled grains/ panicle (16), test weight (22.3 g) over control (Table 3). However, this was comparable with green manure + 75% N and 100% N without green manure. The treatments which received green manure incorporation with LCC based N management and green manure + skipping N at tillering stage were on par with each other and significantly lower than green manure +100% N application. Green manure + 100% N produced 75 per cent more productive tillers m^{-2}, 25 per cent lengthier panicle, 60 per cent more number of grains per panicle and 19% more test weight than control. The reason behind the increment was due to that nitrogen supplied through green manure and inorganic fertilizer increased the growth characters of rice resulted in more photosynthetic activity and ultimately improved the yield characters through better source - sink relationship. Similarly, Latt *et al.* (2009) reported that green manure incorporation increased the dry matter production and grain weight of rice significantly over no green manure. Minimum numbers of yield attributes were recorded under control.

Table 4. Effect of green manuring and nitrogen management on grain and straw yield, harvest index and soil available N at maximum tillering stage of rice

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest Index	Soil available N at tillering stage (kg/ha)
GM alone	4725	7040	0.40	176.8
GM + 100% N	5900	8260	0.42	329.2
GM + 75% N	5775	8085	0.42	254.0
GM + LCC based N management	5537	7752	0.42	172.4
GM + skipping N at tillering	5700	8265	0.41	203.8
100% N alone	5650	8362	0.40	244.6
Control (No N)	3825	6120	0.38	131.7
CD (P=0.05)	424	762	-	-

GM – Green manure LCC – Leaf colour chart

Effect of green manuring and nitrogen management on yield of rice

Grain and straw yields of rice was significantly influenced by green manuring and nitrogen management (Table 4). Combined application of green manuring with 100% inorganic nitrogen recorded significantly higher grain yield (5900 kg ha^{-1}) than green manure alone and no nitrogen application. The increment was 54 per cent over no nitrogen application. However, this was statically comparable with all the green manure applied plots irrespective of inorganic N management and 100% recommended N alone. Only 4 per cent of reduction in yield was noticed under green manuring + 75% N as compared to GM + 100% N. Incorporation of daincha before transplanting would have reduced the soil *sodic*ity, improved the organic matter content of the soil, microbial activity and soil available nitrogen which resulted in better crop growth and yield

character and yield of rice. Similarly, higher yield contributing characters and relatively higher grain and straw yields were recorded in combination of green manure and higher N level treatments were reported by Chaudhary *et al.* (2011). Control (No N) recorded lower yield of 3825 kg/ha because of low soil nitrogen status. With respect to straw yield, 100% N alone recorded the higher straw yield of 8362 kg/ha and this was comparable with green manure + 100% N and green manure + skipping N during tillering stage. Lower straw yield was recorded in no nitrogen application (6120 kg/ha) as the plants produces lesser tillers because of low nitrogen availability to the crop. Green manure + 100% N, green manure + 75% N and green manure + LCC based N management registered similar values of harvest index (0.42). Green manure alone registered harvest index of 0.40 and the control registered the lower value of 0.38.

Table 5. Effect of green manuring and nitrogen management on economics of rice

Treatment	Cost of cultivation (Rs./ha)	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	BCR
GM alone	40485	87317	46832	2.1
GM +100%N	47646	107970	60324	2.3
GM + 75%N	47031	105682	58651	2.2
GM + LCC based N management	46361	101327	54966	2.2
GM + skipping N at tillering	46801	104886	58085	2.2
100% N alone	45161	104299	59138	2.3
Control(No N)	38100	71527	28787	1.7

GM – Green manure; LCC – Leaf colour chart ; Data not statistically analysed

Effect of green manuring and nitrogen management on soil available nitrogen at maximum tillering stage

Soil available nitrogen at maximum tillering stage revealed that green manure + 100%N recorded higher available nitrogen (329.2 kg ha^{-1}) than other treatments (Table 4). This was mainly due to that incorporation of green manure as well as external application of N fertilizer. In general, all the green manure applied and inorganic nitrogen added plots recorded higher soil available N. Control plot recorded lesser soil available nitrogen of 131.7 kg ha^{-1} as compared to other treatments as well as initial soil nitrogen. In green manure + LCC based N management, fertilizer nitrogen was not applied at tillering stage due to dark green colour of leaves resulted in low soil available nitrogen at tillering stage. Green manuring increased the nitrogen supply and improved the soil health. This is in agreement with the findings of Shahzad Tahir and Muhammad Ifran (2013).

Effect of green manuring and nitrogen management on economics of rice

The economics of green manuring and nitrogen management revealed that green manure + 100% N gave higher gross returns (Rs.1,07,970 ha^{-1}), net returns (Rs.60,324 ha^{-1}) and benefit cost ratio (2.3) followed by green manure + 75% N which gave gross returns of Rs.1,05,682 ha^{-1}, net returns of Rs.58,651 $ha^{-1}$and benefit cost ratio (2.2) (Table 5). Green manure + 100% N gave 109.5 and 28.8 per cent higher net returns over no nitrogen application and green manure alone respectively. This was mainly because of higher grain and straw yield obtained under green manure + 100% N treatment over other treatments. The treatments which received green manure + 75% N, green manure + LCC based N management and green manure + skipping N at tillering stage gave similar BCR value of 2.2. Lower gross returns (Rs.71,527 ha^{-1}), net returns (Rs. 28,787 ha^{-1}) and benefit cost ratio (1.7) was obtained with no nitrogen application mainly due to lower grain yield. Green manure incorporation with 100% N and 100% N alone registered similar BCR value of 2.3 mainly due to lesser yield increment due to green manuring and cost of green manuring. However, considering the soil available nitrogen status and *sodic* soil reclamation and sustaining the rice production, green manuring could be recommended for *sodic* soil. Green manuring of daincha enhanced the rice yield as well as net returns, implying the potential of integrated nutrient management systems to augment crop productivity and profitability was reported by Anita and Jose Mathew (2010).

From this experiment, it could be concluded that 25% of nitrogen could be saved through green manuring as the grain yield obtained under green manure + 100% N was statistically on par with green manure + 75% N as well as GM + skipping N during tillering. Hence the recommended dose of nitrogen could be reduced from 187.5 kg to 140.6 kg/ha for green manure incorporated rice for sodic soil.

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