Original Research Article

Effect of different kharif paddy straw management options on nitrogen requirement to *rabi* rice

Abstract

An experiment was conducted on "**Effect of different *kharif* paddy straw management options on nitrogen requirement to *rabi* rice"** during*rabi*, 2020-21 at Regional Agricultural Research Station, Polasa, Jagtial, Professor Jayashankar Telangnana State Agricultural University. The results of the investigation reported that incorporation of paddy straw whose C:N ratio was 71:1 resulted in immobilization of soil mineral nitrogen. About 7.2, 9.3 and 7.03 kg ha^{-1} of available nitrogen was immobilized during 7, 15 and 30 DAT, respectively in paddy straw incorporation without phosphorus, whereas in case of paddy straw incorporation with phosphorus treatment, about 10.94, 14.75 and 11.04 kg ha^{-1} of available nitrogen was immobilized during day 7, 15 and 30 DAT, respectively. Significantly higher soil available nitrogen of 169.7, 161.2 and 151.9 kg ha^{-1} was observed under paddy straw incorporation with phosphorus, incorporation without phosphorus and paddy straw burning respectively. Graded levels of nitrogen application influenced soil available nitrogen.

1. Introduction

Rice straw the byproduct of rice production requires some valuable disposal solution (Gaind and Nain, 2007). The intensification of the cropping system resulting in production of paddy straw in large volumes which need to be managed over shorter turnaround period between the crops. Globally, roughly 800 to 1000 Mt per annum of rice straw is produced, with about 600 to 800 Mt per annum produced in Asia (Bhuvaneshwari *et al*., 2019). And due to scarcity of labour and high labour cost involved in its removal from the field and also with little management options burning of paddy straw is adapted and it has been increased dramatically over the last decade. Currently, out of the total straw produced more than 80% is being burnt by farmers in the months of October-November (Singh *et al*., 2010).

One of the advantages of burning is that it is cost effective and the land will be cleared quickly from residues before the next crop is taken up, thus facilitating establishment of next succeeding crop. Though it has some positive effects in managing pests, it also leads to loss of essential soil nutrients – upto 80 % N, 25% P, 21% K and 4-60% S and 13 tonnes per ha of carbondioxide causing loss of soil organic matter (Mandal *et al*., 2004), reduces microbial diversity (Zhang *et al*., 2014). It also cause air pollution by releasing carbon dioxide, carbon monoxide, methane, sulphur and nitrous oxides and particulate matter into the atmosphere (Jain *et al*., 2014). On burning one ton of paddy straw about 1460 kg CO_2, 60 kg CO, 2 kg SO_2 and 199 kg ash are released into atmosphere which are associated with human respiratory problems Lohan *et al*. (2018). This has led to bans on open-field straw burning in most major rice-producing areas.

In addition to the present, straw management is one of the effective field management practice which will have a great influence on soil physical and biological properties, soil fertility and crop yields (Smitha *et al*., 2019). The common practice of straw burning reduces the soil organic carbon sequestration potential of straw incorporation. Straw incorporation in soil for fertilization in intensive agricultural systems is highly impossible with two to three crops in a year because the turnaround period is too short for decomposition to complete, resulting in poor crop establishment.

On analysis of the burnt residue, it had been found that burning resulted in 93 % loss of nitrogen (N) and 20 % loss of potassium (K) from the quantity originally present in the straw. Hence, to avoid the losses of soil nutrient by burning and atmospheric pollution, *in situ* incorporation of straw is the best option. Straw in its dry matter contains 0.5 to 0.8 % N, 0.16 to 0.27 % P, 1.4 to 2.0% K, 0.05 to 0.10% S and 4 to 7% silica (Dobermann and Fairhurst, 2002). On decomposition, this straw provides an abundant source of C and nutrients for microorganisms and enhancing their activity. At an equivalent time rice straw having higher C: N ratio compared to dhaincha and cow dung (Chowdhury *et al*., 2002) have lower decomposition. Under such condition, if planting is done immediately after incorporation of straw of preceding crop, growth and establishment of succeeding rice crop is adversely affected (Udayasoorian*et al*., 1997) due to immobilization of nutrients and poor nutrient availability. To overcome these problems, stubbles and mix harvested paddy straw is incorporated along side additional N source.

Residue recycling may be a key measure to reinforce the soil fertility and productivity in crop production systems. Incorporation of crop residues that are low in nitrogen into soil may enhance microbial activity and consequently lead to a significant immobilization of applied nitrogen, which can negatively affect crop yields. These negative effects can be corrected by applying extra nitrogen at the time of incorporation. Need of the hour is incorporation of paddy straw with suitable management practices for hastening the decomposition process and identifying the additional nitrogen required for healthy paddy cultivation by subsidizing the N immobilization during *rabi* season at Northern Telangana Zone of Telangana State.

2. Material and Methods

The experiment was conducted at Regional agricultural research station, Polasa, Jagtial district. It is situated in the Northern Telangana Zone. The experimental site is located between 18º 51' 53" N latitude and 78º 56'21" E longitude at an altitude of 243.4 m above mean sea level (MSL). The soil of the experimental site was sandy clay loam, which is medium in organic carbon (0.54%), low in soil available nitrogen 157.6 kg ha^{-1}, high in soil available phosphorus (31.05kg ha^{-1}) and potassium (309.5kg ha^{-1}). The experiment was laid out in Factorial RBD, with 2 factors, factor 1 comprised of 3 levels and factor 2 comprised of 4 levels with a total of 12 treatments and replicated thrice. Paddy straw mulcher was run to chop it and is incorporated 10 days before transplanting. Paddy (variety- JGL-24423) was transplanted with a spacing of 15x15cm. The recommended dose of fertilizer was 150:60:40 kg N, P_2O_5, K_2O ha^{-1}. The entire recommended dose of phosphorus and potassium was applied as basal dose in the form of SSP and MOP respectively. Nitrogen was applied in 3 splits and the excess of RDN was applied at basal in the form of urea.

Available nitrogen present in soil sample was determined by alkaline permanganate method outlined by Subbiah and Asija (1956). To a 5 g of soil sample in a kjeldahl tube 30 ml of 0.32% potassium permanganate was added. A 250 ml conical flask containing 25 ml of 2.5% boric acid with mixed indicator is placed at the end of delivery tube, 30 ml of 2.5% sodium hydroxide was run into kjeldahl tube automatically after placing kjeldahl tube in position. After 6 minutes of distillation process contents in conical flask turned into light bluish green colourwhich were titrated against 0.01 N sulphuric acid till pink colour appeared. A blank was run without soil.

List 1 :Treatment details

T_1	100% RDN + Residue burning
T_2	10% excess N over RDN + Residue burning
T_3	15% excess N over RDN + Residue burning
T_4	20% excess N over RDN + Residue burning
T_5	100% RDN + Residue incorporation without phosphorus
T_6	10% excess N over RDN + Residue incorporation without phosphorus
T_7	15% excess N over RDN + Residue incorporation without phosphorus
T_8	20% excess N over RDN + Residue incorporation without phosphorus
T_9	100% RDN + Residue incorporation with P application through SSP
T_{10}	10% excess N over RDN + Residue incorporation with P application through SSP
T_{11}	15% excess N over RDN + Residue incorporation with P application through SSP
T_{12}	20% excess N over RDN + Residue incorporation with P application through SSP

3. Result and discussion

3.1.Available nitrogen content (kg ha^{-1}) of soil at different intervals

At 7 day after transplanting, the soil available nitrogen ranged from 165 to 176 kg ha^{-1} and was not significantly influenced by paddy straw management options. However, nitrogen levels significantly influenced the available nitrogen content in soil at 7 DAT. With the increase in the nitrogen dose from 100% RDN to 120% RDN soil available nitrogen content has increased. The nitrogen content values under 120 % RDN (184 kg ha^{-1}) where significantly higher than that of 110% RDN and 100% RDN but on par with 115% RDN (174 kg ha^{-1}). Similar observations were recorded by Sharma *et al.* (2021). who observed on an average of 9 % higher concentration of ammonical nitrogen and 10 % higher concentration of nitrate nitrogen under 120 and 150 kg N ha-1 as compared to control.

At 15 DAT, soil available nitrogen was significantly influenced by both paddy straw management options and nitrogen levels. Higher soil available nitrogen was recorded under burning practice (166 kg ha^{-1}). Though, it was significantly superior to was on par with paddy straw incorporation with P (151 kg ha^{-1}), but, at par with paddy straw incorporation without P

(158 kg ha^{-1}). Such lower soil N content in paddy straw incorporated treatments may be due to immobilization of nitrogen. Paddy straw used in the present investigation had wide C:N ratio i.e., 71:1, where huge amount of carbon in straw might have increased the microbial population in soil as carbon is food source of microorganisms. Besides carbon, microorganisms require nitrogen for their growth, but the straw contains low concentrations of nitrogen and microorganisms might utilize the N from soil (Naresh *et al*., 2021). Hence, soil available nitrogen might have been transformed to organic nitrogen (Hartmann *et al*., 2015). Similar observations were recorded by Garcia-Ruiz and Baggs. (2007) and Singh *et al*. (2004). The effect of different nitrogen levels on soil available nitrogen was significant and soil available nitrogen was increased with increase in nitrogen levels and significantly higher soil available nitrogen was observed in the treatment with 20% excess RDN.

Soil available nitrogen at 30 DAT was influenced by both paddy straw management options and nitrogen levels. Among residue management options, treatments showed non significant difference in soil available nitrogen. Different nitrogen levels have significantly influenced available nitrogen content in soil. With the increase in nitrogen dosed from 100 to 120 % RDF, soil available nitrogen increased linearly. Application of higher levels of nitrogen fertilizer (through neem coated urea) might released higher concentrations of mineral nitrogen to the soils by inhibiting nitrification and volatilization process there by increasing the N availability in the soil for plant consumption (Ghafoor *et al*., 2021).

At 45 DAT, effect of paddy straw management options on soil available nitrogen was non significant. However, the trend was contrast with that of 30 DAT. Paddy straw incorporation along with P application recorded higher available N (149.0 kg ha^{-1}) followed by paddy straw incorporation without P (145 kg ha^{-1}) and burning (141 kg ha^{-1}). This change could be due to mineralization of immobilized nitrogen (Yansheng*et al*., 2020) where indigenous organic nitrogen and immobilized nitrogen were re mineralized to inorganic forms. The effect of nitrogen levels was found to be significant. Soil available nitrogen increased with increasing nitrogen levels (Sharma *et al*., 2020), which might be due to increased decomposition rate with increased nitrogen levels and subsequent remineralization lead to increased N availability with increased N levels.Soil available nitrogen at 60 DAT was significantly influenced by both paddy straw management options and nitrogen levels.At 75DAT available soil nitrogen followed the similar trend set by treatment at 60 DAT with significantly higher values due to paddy straw incorporation with P addition (147.6 kg ha^{-1}) followed by paddy straw incorporation without phosphorus (138.4 kg ha^{-1}) and paddy straw burning practice (127 kg ha^{-1}). The effect of nitrogen levels was found to be significant. The soil available nitrogen increased with increasing nitrogen levels and recorded significantly higher values due to application of 120% RDN.

Soil available nitrogen at after harvest of rabi rice was significantly influenced by both paddy straw management and nitrogen levels. Higher soil available nitrogen (169.7 kg ha^{-1}) was observed when paddy straw incorporation combined with phosphorus. Though it was on par with that of paddy straw incorporation without phosphorus (161.2 kg ha^{-1}), but, significantly higher than that of and paddy straw burning (151.9 kg ha^{-1}). The effect of nitrogen levels was found to be significant and the trend is similar to that of other stages of crop growth. The initial soil available nitrogen of present study was 159 kg ha^{-1} , (before start of the experiment). Different levels of nitrogen in the form of urea were applied to respective plots during final puddling. This could be the probable reason for higher available nitrogen at 7 DAT in soil. Irrespective of treatments, with the time, soil available nitrogen content declined gradually upto 60 days, then increased in 75 DAT and post harvest samples. These finding may be due to - slow mineralization of organic matter at this stage where slowly decomposing material like lignin dominates the SOM and the easily decomposed part of SOM exhausts (Berg, 1986), resulting in the reduction of soil available N.

Further, at 60 DAT, rice crop growth is peak during which nutrient uptake or requirement is high ability of rice roots made them compete with microorganisms for inorganic nitrogen and small-molecule organic nitrogen during the vigorous rice growth stage (Ma *et al*., 2018), thus decreases in available soil was noticed. After 75 DAT crop turns into maturity phase, at this stage plant required N is limited. More over amino acids secreted by rice roots in the maturity phase will also add to the soil N (Yang *et al*., 2015), which in turn results in significantly higher soil available N. Furthermore, improvement in soil aeration at later crop growth stages due to removal of stagnated water might have increased soil protease activity (Yang *et al*., 2021). This inturn might have promoted the mineralization of organic matter to form N (Murphy *et al*., 2000), resulting in increased soil SON. Among the treatments, paddy straw burning treatment has recorded higher available nitrogen values upto 30 DAT than that of paddy straw incorporated treatments. This might be due to immobilization of nitrogen in the treatments where paddy straw was incorporated in situ. However, in later stages, paddy straw incorporation with phosphorus addition recorded higher soil available nitrogen. In contrast Pullicino *et al*. (2014) reported that nitrogen immobilization will be completed within 10 days after incorporation. In the present investigation, immobilization continued upto 30-32 DAT. After 30th day, mineralization of immobilized N occurred which improved the soil available N content (Fig 1). When initial and post harvest soil samples were compared for available N in soil, an increase under paddy straw incorporation with and without phosphorus and slight decline in burning treatment was observed. Similar findings were also observed by Mandal (2004), Thuan and Long (2010), Davari *et al*. (2012). Paddy straw incorporation with phosphorus showed higher availability of available nitrogen over without P addition as phosphorus application accelerated the process of decomposition and release of mineral nitrogen (Chen *et al*., 2016).

3.2.Immobilization and mineralization of nitrogen (kg ha^{-1}) in soil

Incorporation of crop residue increases the microbial population (Li *et al*., 2019). Paddy residues when incorporated into the soil needs addition of exogenous N for the decomposition to proceed. (Vijayprabhakar*et al*., 2017). As reported by many researchers, that immobilization of nitrogen occurs when residue high C:N ratio (>25- 30:1) is added to the soil (Van Kessel *et al*., 2000; Qian and Schoenau, 2002; Nicolardot *et al,* 2001, and Muhammad *et al*., 2011). In this study paddy straw had a C:N ratio of 71:1. Immobilization of mineral N might be due to the large demand for N by microorganisms proliferating rapidly in response to the availability of easily decomposable carbon compounds (Ali and Nabi, 2016). In the present study paddy straw incorporation without P treatment resulted in immobilization of 7.2, 9.3 and 7.03 kg ha^{-1} at 7, 15 and 30 DAT, respectively. While in case of paddy straw incorporation with P treatment, about 10.94, 14.75 and 11.04 kg ha^{-1} of nitrogen was immobilized during at 7, 15 and 30 DAT, respectively. Our results are in line with the reports of Sirinavas*et al*. (2006), Corbeels*et al*. (2000) Kachroo*et al*. (2006) who recorded 12 days as 15 days as immobilization period for residue incorporated in the soil. Net mineralization started on 30th day under paddy straw incorporation with P and 33 DAT under incorporation without P. These results are in contrast with that of Ali and Nabi. (2016) who observed net mineralization after 75 days after incorporation of crop residue- in an incubation study with surface application of crop residues.

Rate and time of immobilization and mineralization of nitrogen strongly depends on high contact of residue with soil, more moisture and nutrient availability (Brown and Dickey, 1970; Douglas *et al*., 1980). Hence, straw management should be done by incorporation rather surface application. After 45 DAT, some net mineralization was observed and paddy residue started to contribute to mineral nitrogen and the nitrogen contribution was greater from paddy straw incorporation with phosphorus compared with incorporation without phosphorus which is due P addition accelerated the process of nitrogen mineralization and N release (Chen *et al*. 2016). At maturity stage, rice roots secrete a large number of small organic molecules, which are conducive to the rapid growth of Bacteroidetes and Proteobacteria (nutrient-rich bacteria) (Goldfarb *et al*. 2011), which promote the mineralization of organic matter and increase the content of N (Fierer *et al*., 2007).

4. Conclusion

Soil available nitrogen was 7.68 % and 2.28% higher than initial in paddy straw incorporation with and without phosphorus respectively. Nitrogen immobilization of 7.2 kg ha^{-1}, 9.3 kg ha^{-1} and 7.03 kg ha^{-1} was occurred at 7, 15, 30 DAT by paddy straw incorporation without phosphorus. 10.94 kg ha^{-1}, 14.75 kg ha^{-1}, 5.88 kg ha^{-1} of available nitrogen was immobilized by paddy straw incorporation with phosphorus. It was observed that 14.75 kg ha^{-1} of available nitrogen was immobilized at 15 DAT, which can be compensated by adding 15% excess of RDN.

Table:1 Available soil nitrogen (kg N ha^{-1}) content at different intervals of *rabi* rice as influenced by different *kharif* paddy straw management options and fertilizer N levels

Treatments	7 DAT	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	AH
Paddy straw management							
RB	175.6	166.0	158.9	141	120.3	127.0	151.9
I-P	168.4	156.7	151.8	145	132.0	138.4	161.2
I+P	164.7	151.2	153.0	149	137.0	147.6	169.7
SEm±	3.99	3.76	3.63	3.4	3.2	3.23	4.13
CD@ 5%	NS	11.02	NS	NS	9.39	9.49	12.1
Nitrogen levels							

100% RDN	154.8	145.5	141.94	129.2	113.5	122.2	135.8
110% RDN	165.9	152.1	150.52	142.2	124.5	130.8	154.8
115% RDN	173.7	159.3	157.18	149.3	135.1	142.1	171.8
120% RDN	183.8	175.1	168.75	160.0	145.9	155.4	181.2
SEm±	4.6	4.34	4.19	3.95	3.699	3.73	4.78
CD@ 5%	13.5	12.7	12.29	11.59	10.85	10.9	14.01
Interactions							
SEm±	7.98	7.63	7.26	6.84	6.40	6.47	8.28
CD @ 5%	NS	NS	NS	NS	NS	NS	NS
CV	8.15	8.3	8.13	8.17	8.55	8.37	8.91

RB-residue burning, I-P- incorporation with phosphorus, I+P- incorporation with phosphorus, RDN- recommended dose of nitrogen, AH- at harvest

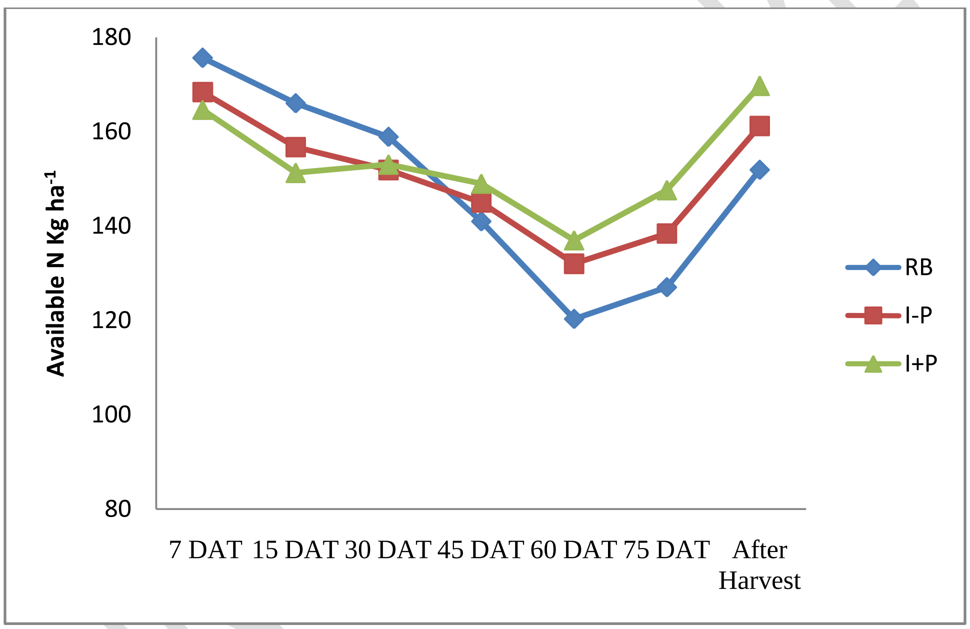

Fig. 1 Effect of different *kharif* paddy straw management options on soil available N (kg N ha^{-1})

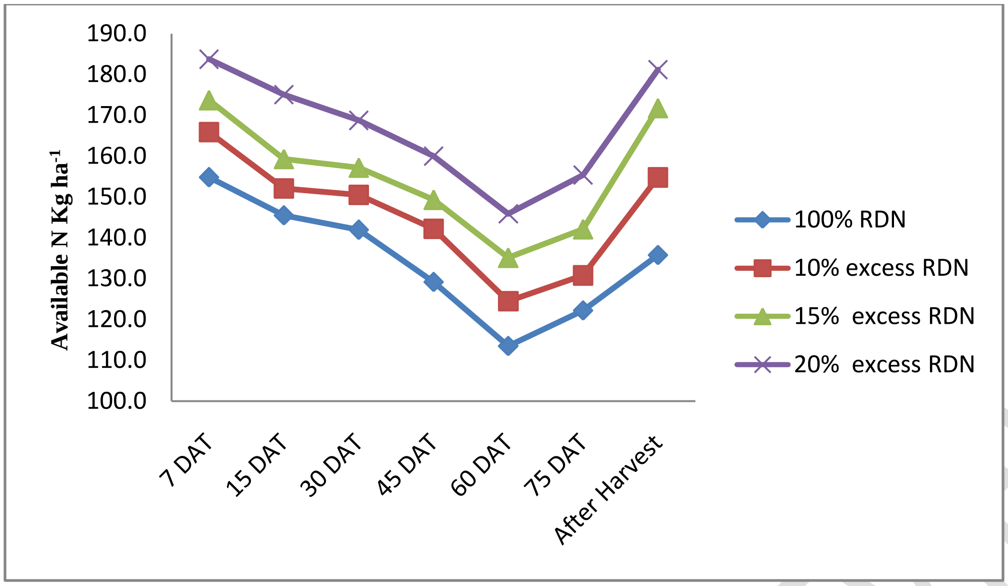

Fig. 2Effect of differentlevels on nitrogen application on soil available N (kg N ha^{-1})

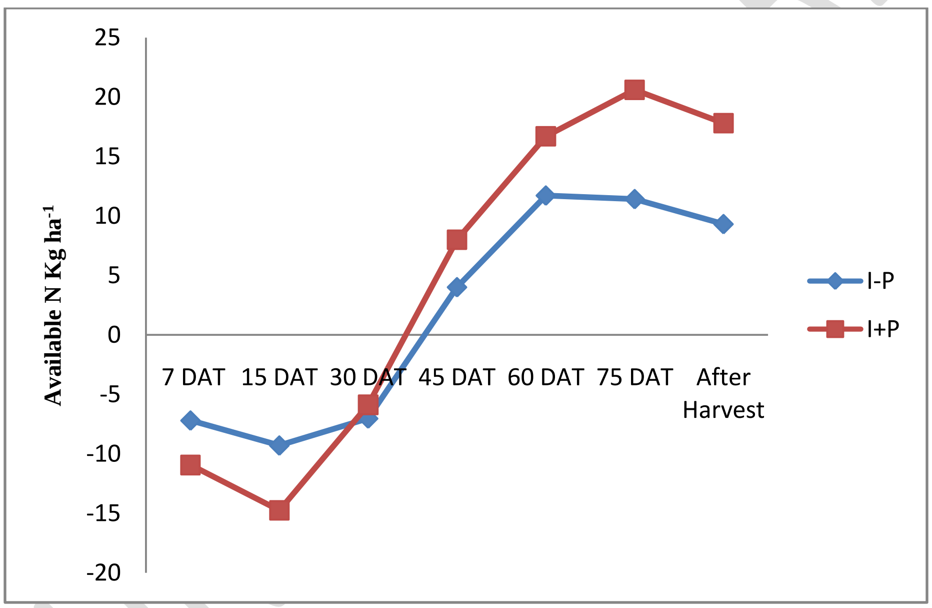

Fig. 3. Immobilization and mineralization of soil available nitrogen as influenced by *kharif* paddy straw management

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