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# Utilization of paddy straw as a source of nutrients for succeeding paddy and its effect on soil available nutrients, nutrient uptake and crop yield

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## ABSTRACT

Field experiment was conducted at Agricultural College and Research Institute, Killikulam, Tamil Nadu during October 2015 to February 2016 to study the different residue management options for combine harvested rice field and its effect on succeeding rice crop. The experiment was laid out in randomised block design with nine treatments replicated thrice. The treatments comprised rice residue without and with additives [25 kg additional N/ha as basal, biomineralizer (2 kg/tonne rice residue) and cow dung slurry (5%)]. Different rice residue management practices exerted significant influence on succeeding rice crop. Incorporation of combine harvested rice residue with 25 kg additional N/ha as basal + biomineralizer (2 kg/tonne of rice residue) and cow dung slurry (5%) recorded higher grain yield of 7,395 kg and straw yield of 8,440 kg/ha. Similarly highest plant NPK uptake and higher post harvest soil available NPK were also observed in the same treatment. The lowest crop yield and nutrient uptake were recorded in the treatment incorporation of straw whereas straw incorporated without any additives and the lowest soil available nutrients were recorded in control.

**Keywords:** Rice straw; cow dung slurry; biomineralizer; nutrients

## INTRODUCTION

Crop residues are the parts of crops left over after the usable portions have been removed. Incorporation of these residues into the soil can serve as a source of nutrients for plant growth and maintenance of soil fertility (Gaur 1987, Cooperband 2002). In India approximately 500-550 million tonnes of crop residue is generated on-farm and off-farm annually (Devi et al 2017). About one-third of the residues produced are available for direct recycling on the land. It can add 2.19 MT of NPK annually. Jain (1993) reported that in India large quantities of crop residues are made available every year by paddy 326.2 MT, wheat 105.5 MT, maize 29.7 MT, sorghum 62.3 MT, barley 3.7 MT, pulses 15.7 MT, soybean 3.7 MT etc and only a small portion of this is being effectively utilized but large quantities remain as waste.

Rice straw contains 0.5 to 0.8 per cent N, 0.16 to 0.27 per cent P, 1.4 to 2.0 per cent K, 0.05 to 0.1 per cent S and 4.0 to 7.0 per cent silica (Si) in its dry matter (Dobermann and Fairhurst 2002). In India about 106 MT of rice straw is produced annually and it adds about 0.61, 0.27 and 1.76 MT of N, P and K respectively (Manna and Ganguly 1998). The nutrient availability of rice straw is well known. The rice straw has lower decomposition rate due to its higher C-N ratio (33) compared to cow dung and Dhaincha (Chowdhury et al 2002). Under such condition if planting is taken up immediately after incorporating the straw of preceding crop, the establishment of the succeeding rice crop may be hampered (Udayasoorian et al 1997). To overcome these problems combine harvested paddy straw was incorporated along with additional N source, biomineralizer, cow dung slurry and their combinations to know the effect on succeeding rice crop yield, nutrient uptake and soil available nutrients.

## MATERIAL and METHODS

A field experiment was conducted in Agricultural College and Research Institute, Killikulam, Tamil Nadu during Pishanam season of October 2015 to February 2016 to study the different rice residue management options in combine harvested rice field for using the rice straw as an organic manure so as to avoid the burning of paddy straw in the field itself. The experiment was laid out in randomized block design with nine treatments [$T_1$: Incorporation of straw, $T_2$: $T_1$ + 25 kg additional N/ha as basal, $T_3$: $T_1$ + biomineralizer (2 kg/tonne of rice residue), $T_4$: $T_1$ + cow dung slurry (5%), $T_5$: $T_1$ + 25 kg additional N/ha as basal + biomineralizer (2 kg/tonne of rice residue), $T_6$ : $T_1$ + 25 kg additional N/ha as basal + cow dung slurry (5%), $T_7$: $T_1$ + biomineralizer (2 kg/tonne of rice residue) + cow dung slurry (5%), $T_8$: $T_1$ + 25 kg additional N/ha as basal + biomineralizer (2 kg/tonne of rice residue) + cow dung slurry (5%), $T_9$: Control (no residue)] replicated thrice. Eight different rice straw residue management techniques were randomly allotted in the experiment along with one control plot for comparison. Rice variety ADT (R) 45 with the duration of 110 days was used as a test variety in the experiment. After combine harvesting the rice straw retained in the field was collected and quantified at 5 tonnes/ha. The rice straw was uniformly distributed to all the plots. The gross plot size and net plot size were 45 $m^2$ (7.5 m × 6.0 m) and 38.5 $m^2$ (7.0 m × 5.5 m) respectively except control. TNAU biomineralizer was made into slurry by mixing with water (2 kg material in 40 litres of water) and sprinkled on the straw of respective experimental plot at 2 kg/tonne of rice residue on the next day of combine harvest of preceding rice crop ie 15 days ahead of transplanting. Cow dung slurry (5%) was prepared and sprinkled over the paddy straw in the corresponding treatment plots on the next day of combine harvest of preceding rice crop ie 15 days ahead of transplanting. After 15 days every plot was individually puddled and leveled properly and rice transplanted with recommended dose of fertilizers and additional 25 kg N was added as a basal in appropriate plots as per the treatment. Apart from the treatment all the cultural practices for lowland rice were strictly followed as per TNAU crop production guide. At the time of harvesting the final grain weight was taken. Dry weight of straw per net plot was recorded after sun-drying for a week. The postharvest soil samples were collected from each treatment, air-dried under shade, sieved through 2 mm sieve and used for analysis of major nutrients (N, P and K). Soil available N, P and K were estimated by alkaline permanganate method (Subbiah and Asija 1956), Olsen's method (Olsen et al 1954) and neutral normal ammonium acetate method (Stanford and English 1949) respectively. N, P and K content in plant samples was estimated by Microkjeldahl method (Kjeldahl 1883), triple acid digestion with colorimetric estimation (Grimshaw 1987) and triple acid digestion with flame photometric method (Hald 1947) respectively. Uptake of nutrients was calculated by multiplying the nutrient content and dry matter production.

## RESULTS

Data on the effect of residue management on grain yield, straw yield, nutrient uptake and soil available nutrients are given in Table 1 (Fig 1).

### Effect of residue management on grain yield

Grain yield was significantly influenced by different residue management practices. Among the different treatments, rice straw incorporated without additives ($T_1$) and control ($T_9$) registered the lowest grain yield of 5,250 and 5,370 kg/ha respectively the two being at par. Highest grain yield (7,395 kg/ha) was recorded in case of $T_8$ [($T_1$ + 25 kg additional N/ha as basal + biomineralizer (2 kg/tonne of rice residue) + cow dung slurry (5%)], $T_6$ [$T_1$ + 25 kg additional N/ha as basal + cow dung slurry (5%)] (7,160 kg/ha) and $T_5$ [$T_1$ + 25 kg additional N/ha as basal + biomineralizer (2 kg/tonne of rice residue)] (6,960 kg/ha) all the three being at par.

### Effect of residue management on straw yield

Similar to grain yield, minimum straw yield was also recorded in $T_9$ and $T_1$ with 6,140 and 6,020 kg/ha respectively the two being at par and the highest in case of $T_8$ (8,440 kg/ha), $T_6$ (8,170 kg/ha) and $T_5$ (7,960 kg/ha) the three being at par. Combined application of additives with straw incorporation resulted in positive effect on straw yield.

### Effect of residue management on nutrient uptake

Significant impact on nitrogen, phosphorus and potassium uptake was observed with different residue management practices. Minimum N, P and K uptake was recorded in case of $T_9$ (78.5, 28.4 and 93.2 kg/ha respectively) and $T_1$ (76.7, 27.7 and 90.9 kg/ha respectively) the two treatments being at par. The

Table 1. Effect rice residue management on grain yield, straw yield, nutrient uptake and soil available nutrients of rice crop

| Treatment | Grain yield (kg/ha) | Straw yield (kg/ha) | Nutrient uptake (kg/ha) | | | Soil available nutrients (kg/ha) | | |
|---|---|---|---|---|---|---|---|---|
| | | | N | P | K | N | P | K |
| $T_1$ | 5,250 | 6,020 | 76.7 | 27.7 | 90.9 | 208 | 17.21 | 219 |
| $T_2$ | 6,615 | 7,580 | 96.9 | 35.0 | 114.9 | 218 | 17.46 | 231 |
| $T_3$ | 6,015 | 6,870 | 88.0 | 31.9 | 104.5 | 210 | 17.23 | 221 |
| $T_4$ | 6,230 | 7,130 | 91.9 | 33.1 | 108.1 | 212 | 17.27 | 224 |
| $T_5$ | 6,960 | 7,960 | 101.5 | 36.7 | 120.6 | 224 | 17.49 | 239 |
| $T_6$ | 7,160 | 8,170 | 104.6 | 37.9 | 124.7 | 230 | 17.6 | 242 |
| $T_7$ | 6,540 | 7,480 | 95.9 | 34.7 | 113.7 | 216 | 17.39 | 225 |
| $T_8$ | 7,395 | 8,440 | 108.8 | 39.1 | 128.2 | 234 | 17.83 | 247 |
| $T_9$ | 5,370 | 6,140 | 78.5 | 28.4 | 93.2 | 193 | 17.11 | 205 |
| SEd | 243 | 288 | 2.6 | 1.0 | 3.2 | 6.94 | 0.566 | 7.36 |
| $CD_{0.05}$ | 522 | 618 | 5.7 | 2.1 | 6.8 | 14.93 | NS | 15.80 |

$T_1$: Incorporation of straw, $T_2$: $T_1$ + 25 kg additional N/ha as basal, $T_3$: $T_1$ + biomineralizer (2 kg/tonne of rice residue), $T_4$: $T_1$ + cow dung slurry (5%), $T_5$: $T_1$ + 25 kg additional N/ha as basal + biomineralizer (2 kg/tonne of rice residue), $T_6$ : $T_1$ + 25 kg additional N/ha as basal + cow dung slurry (5%), $T_7$: $T_1$ + biomineralizer (2 kg/tonne of rice residue) + cow dung slurry (5%), $T_8$: $T_1$ + 25 kg additional N/ha as basal + biomineralizer (2 kg/tonne of rice residue) + cow dung slurry (5%), $T_9$: Control (no residue)

maximum uptake was observed in case of $T_8$ (108.8, 39.1 and 128.2 kg/ha respectively) and $T_6$ (104.6, 37.9 and 124.7 kg/ha respectively) which were at par with each other.

### Effect of residue management on soil available nutrients

In case of soil available nutrients, N was recorded lowest in case of $T_9$ (193 kg/ha) and maximum in case of $T_8$, $T_6$ and $T_5$ (234, 230 224 kg/ha respectively). K was minimum in case of $T_9$ and $T_1$ (205 and 219 kg/ha respectively) and maximum in case of $T_8$, $T_6$ and $T_5$ (247, 242, 239 kg/ha respectively). There were non-significant differences among the treatments in case of P.

## DISCUSSION

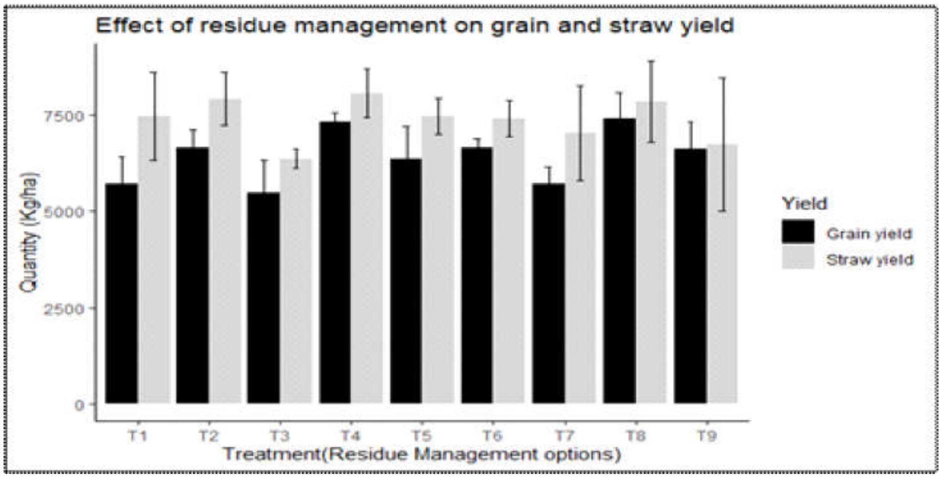
### Effect of residue management on grain and straw yield of rice

Grain and straw yield was significantly influenced by different residue management practices. Among the different treatments, rice straw incorporated without additives ($T_1$) registered the lowest grain and straw yield than other treatments. This could be due to the reduced availability of nutrients to the growing plants (Martin et al 1978). Incorporation of straw with additional N as basal recorded higher grain and straw yield by substituting the N needs of crop as it was immobilized by wide C-N ratio at initial stage of incorporation. The straw incorporated with cow dung slurry and biomineralizer resulted in rapid straw decomposition by microbes present in the biomineralizer and cow dung slurry as also supported by Joshi et al (2013) and Fitriatin et al (2016).

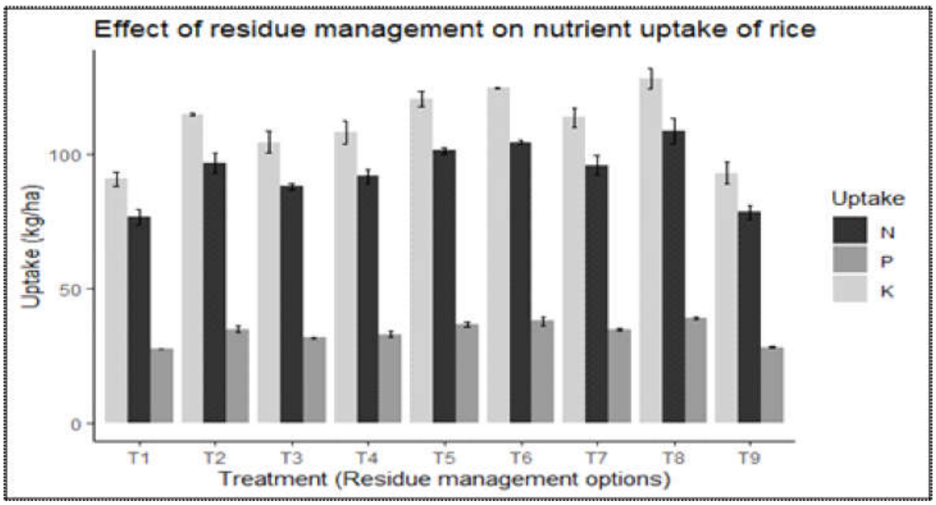
Straw incorporation with different combinations of additives resulted in positive effect on grain and straw yield. It may be the result of improved soil physical, chemical and biological properties by combination of all additives (Arshadullah et al 2012). It leads to better availability of nutrients to crop plant and subsequently more number of productive tillers and number of filled grains per panicle that results in highest grain yield, straw yield and harvest index. These results are in line with the findings of Jayadeva et al (2010) and Polthanee et al (2011).

### Effect of residue management on nutrient uptake of rice

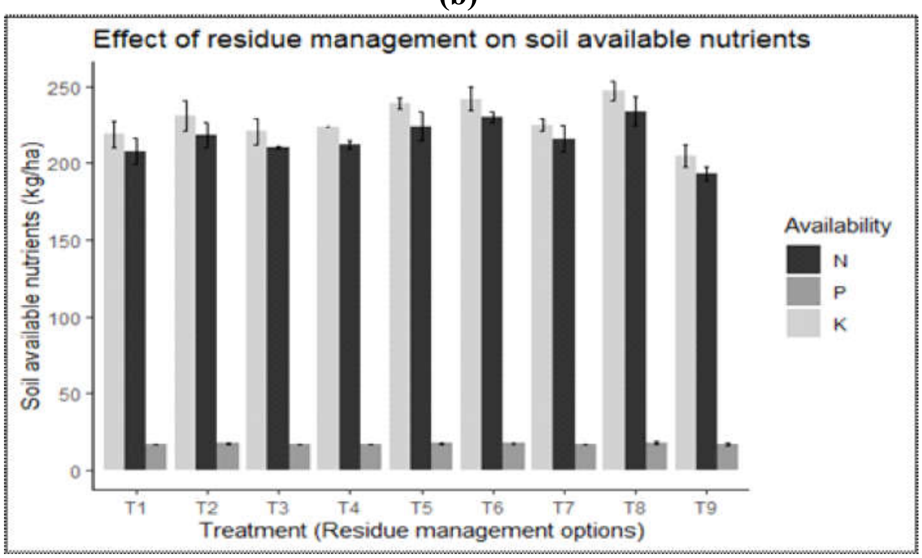
Significant impact on nutrient uptake was observed with different residue management practices. Rice straw incorporated without additives ($T_1$) registered the lowest N, P and K uptake than other treatments. It could be due to lesser availability of nutrients by forming organic complexes (Martin et al 1978). Incorporation of straw with application of 25 kg additional N/ha as basal increased the N, P and K




**(a)**




**(b)**




**(c)**

$T_1$: Incorporation of straw, $T_2$: $T_1$ + 25 kg additional N/ha as basal, $T_3$: $T_1$ + biomineralizer (2 kg/tonne of rice residue), $T_4$: $T_1$ + cow dung slurry (5%), $T_5$: $T_1$ + 25 kg additional N/ha as basal + biomineralizer (2 kg/tonne of rice residue), $T_6$ : $T_1$ + 25 kg additional N/ha as basal + cow dung slurry (5%), $T_7$: $T_1$ + biomineralizer (2 kg/tonne of rice residue) + cow dung slurry (5%), $T_8$: $T_1$ + 25 kg additional N/ha as basal + biomineralizer (2 kg/tonne of rice residue) + cow dung slurry (5%), $T_9$: Control (no residue)

**Fig 1. Effect of residue management on a) Grain and straw yield, b) Nutrient uptake of rice, c) Soil available nutrients**

uptake. The same results were also reported by Arshadullah et al (2012) as nitrogen starter dose helps in timely decomposition of straw by increased microbial population which gets energy from starter dose. Combined application of additives for straw incorporation further increased the N, P and K uptake by rice. These findings are in agreement with the findings of Rajkhowa (2012). The increased uptake of N by rice crop was mainly due to the application of additives which might have stimulated the mineralization process of N in the soil by way of more microbial load added to the soil along with incorporation of rice straw (Mishra et al 2001) and thus it enhanced the availability and more uptake of N by rice crop. Similar observation was made by Jayadeva et al (2010). Decomposition of rice residue increased the mineralization of N which resulted in production of organic acids and enhanced solubilization of native and applied P by microorganisms and increased the availability of various forms of soil phosphorus (Singh et al 2011). Incorporation of rice straw for increased P uptake was also reported by Ponnamperuma (1984). Increased K uptake was due to the solubilization of K from the straw by different additives containing microbes and in general K availability was high in soil incorporated with straw since rice straw is a source of K (Singh et al 2011). It leads to better uptake of K by crop. These results are in agreement with the findings of Khankhane et al (2009).

**Effect of residue management on soil available nutrients**

Straw incorporation with application of additional N as basal + biomineralizer + cow dung slurry significantly registered the higher soil available nitrogen and potassium status. It could be due to better decomposition of straw and release of nutrients thus increasing available N (Gaind and Nain 2007). Provision of time interval between stubbles incorporation and planting along with additives speeded up the degradation process and increased the available K status in the soil. Similar findings were also reported by Singh et al (2004). The efficiency of biomineralizer alone in lowland condition is poor while comparing with straw alone incorporation is advantageous due to consortium of microbes aided to straw decomposition (Fitriatin et al 2016) which is present in the biomineralizers. When rice straw was incorporated without additives it recorded the lowest availability of N and K due to wider C-N ratio that caused immobilization of N which resulted in lesser available N and K (Mohanty et al 2010).

## CONCLUSION

From this detailed discussion, rice straw incorporation without additives ($T_1$) registered lowest grain yield, straw yield, nutrient uptake and soil available nutrients than any other treatment. The treatment ($T_8$), straw incorporation with application of 25 kg additional N/haas basal + biomineralizer (2 kg/tonne of rice residue) + cow dung slurry (5%) showed highest grain yield, straw yield, nutrient uptake and soil available nutrients. Hence it is advisable to avoid straw incorporation without additives and incorporating with additives [25 kg additional N/ha as basal + biomineralizer (2 kg/tonne of rice residue) + cow dung slurry (5%)] make succeeding rice crop to use soil available nutrients, it will give better nutrient uptake and maximum grain and straw yield. Wherever biomineralizers not available farmers can incorporate the paddy straw with 25 kg additional nitrogen and cow dung slurry (5%) spray.

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