The Andhra Agric. J 70 (3): 282-287, 2023
10.61657/aaj.2023.43

Effect of Rice Crop Residue Management Practices and Fertilizer Levels on Nutrient uptake in Rice fallow Maize

A Kavya, K Chandrasekhar, S Jaffar Basha and P Madhuvani
Department of Agronomy, Agricultural College, ANGRAU, Bapatla, Andhra Pradesh

ABSTRACT

A field experiment was carried out during *rabi* 2022-23 on sandy clay soil at the Agricultural College Farm, Bapatla to study the effect of crop residues and fertilizer levels on the growth and yield of rice fallow maize. The experiment was laid out in Split plot design with five residue management practices as main plots (M_1: Burning of residue, M_2: Rice crop residue incorporation with PUSA decomposer, M_3: Rice crop residue incorporation without PUSA decomposer and M_4: Rice crop residue mulching with PUSA decomposer, M_5: Rice crop residue mulching without PUSA decomposer) and four fertilizer levels (Control, 75% RDF, 100% RDF and 125% RDF) as sub plot treatments. The results of the investigation revealed that M_4 (Rice crop residue mulching with PUSA decomposer) recorded significantly higher plant height, drymatter production, grain yield and NPK uptake by grain compared to other practices. Among the fertilizer levels, 125% RDF recorded the higher values for all the growth, yield and uptake of nutrients compared to other levels.

Key word: *Crop residue, Fertilizer levels, Growth, Rice fallow maize and Yield.*

Maize (*Zea mays* L.), 'queen of cereals' is a prominent cereal crop after rice and wheat. It is cultivated across diverse soil conditions, landscapes, seasons and farming methods throughout the nation. In India, it is grown in an area of 10.04 m ha with a production of 33.62 m t and productivity of 3349 kg ha^{-1}. In Andhra Pradesh, maize is cultivated in 0.34 m ha resulting in a production of 2.05 m t and the average productivity was 5990 kg ha^{-1} (Agricultural Statistics at a Glance, AP 2021-22). It serves as the dual-purpose crop i.e., grain and fodder and more recently it is also exploited as biofuel crop. Among coarse cereal crops, maize stands out as the most efficient crop displaying higher resistance to environmental hazards. Additionally, its lower production costs per kg of grain compared to other cereals make it an attractive choice for farmers in Andhra Pradesh and India.

In India, 516.3 tonnes of crop residues are being generated every year of which rice crop residues comprises of 122.6 tonnes (Devi *et al.*, 2017). The rice crop residue generated is around 23 million tons i.e., 62.4% of the total crop residue generated annually in Indian sub-continent (National Policy for Management of Crop Residue, NPMCR). On an average, rice crop residues contain 0.7% N, 0.23% P and 1.75% K. Traditionally rice straw is removed from fields for use as cattle feed and other purposes in South Asia. The advent of mechanized harvesting has led to the burning of significant amounts of *in-situ* crop residues particularly rice straw, which remains in the fields and hinders subsequent tillage and farming operations. In Andhra Pradesh alone, rice crop residues are burned across an area of 3.628 million hectares, according to the Directorate of Economics & Statistics, MOA, DAC, New Delhi (2012-2013).

Crop-residue retention promotes nutrient cycling, increases nutrient availability to crops and increases soil organic matter. Residue retention could play an important role in the Rice-Maize systems, where the residues of both crops are generally removed from the fields (Gathala *et al.*, 2015). The possible management options for rice residue are surface retention, incorporation, mulching and removal of rice straw. In this point of view, microbial decomposers can have a significant impact on the decomposition and break down of rice crop residue for the release of nutrients such as nitrogen, phosphorus and potassium into the soil.

In recent times, there has been a growing trend of adopting the rice-maize sequence instead of the rice-blackgram sequence in the Krishna and Godavari agro-climatic zones of Andhra Pradesh. This shift is attributed to challenges such as delayed canal water release, severe weed infestation, diseases, poor yields, and less profits associated with rice-blackgram cultivation. The complexities arising from fertilizer management within the context of rice-maize system emphasize the necessity for further research to enhance the effective and optimal utilization of nutrients in rice- maize system. It is anticipated that adjustments in the timing and dosage of fertilizer application will be essential to ensure the optimal nutrient supply to zero till maize crops, which receive residual nutrients from the preceding rice cultivation. Keeping this in view, the present study was planned to reveal the effects of rice residue management practices and fertilizer levels on nutrient uptake in rice fallow maize.

MATERIAL AND METHODS

A field experiment was carried out during rabi, 2022-23 at Agricultural College Farm, Bapatla. The soil of the experimental site was sandy clay in texture, slightly alkaline in reaction, low in organic carbon (0.46) and available nitrogen (219.52 kg ha^{-1}), medium in available phosphorus (23.59 kg ha^{-1}) and available potassium (194.06 kg ha^{-1}). The mean maximum and minimum temperatures recorded during crop period were 41.2^0C and 16.1^0C, respectively. A total rainfall of 241.5 mm was received in 7 rainy days during the crop period. The experiment was laid out in Split plot design with three replications. The treatments were combination of five rice crop residue management practices viz., M_1: Burning of residue, M_2: Residue incorporation with PUSA decomposer, M_3: Residue incorporation without PUSA decomposer M_4: Residue mulching with PUSA decomposer and M_5: Residue mulching without PUSA decomposer and four fertilizer levels (S_1: Control, S_2: 75% RDF, S_3: 100% RDF and S_4: 125% RDF).

Application of nutrients was done as per the treatments in the form of urea, single super phosphate (SSP) and muriate of potash (MOP). Basal application of 1/3rd N was done and the remaining 1/3rd N was top dressed at knee high stage and 1/3rd N at Tasseling and Silking stage. Entire recommended dose of phosphorous was applied at basal in single super phosphate form while muriate of potash was applied in two splits at basal and flowering stage of the crop. After harvesting of rice panicles residues were retained and managed according to treatment in five main plots. In all the main plots residue produced from rice crop was distributed equally and was left for twenty days for decomposition of crop residues with the application of PUSA decomposer during the year of experimentation. Field operations such as irrigation and plant protection measures were taken as per requirement. The data on plant height, drymatter accumulation, grain yield and NPK uptakes were recorded as per standard procedures. Statistical analysis of all the data was carried out following the analysis of variance technique for split plot design as outlined by Panse and Sukhatame (1978).

RESULTS AND DISCUSSION

Effect of rice residue management practices and fertilizer levels on growth parameters

Plant height (cm)

The higher plant height values were recorded with mulching of residue after application of PUSA decomposer (M_4) and it was found on par with rice residue mulch without PUSA decomposer (M_5). The lower plant height was observed with burning of residue (M_1). This phenomenon could be attributed to the increased height of maize plants in conditions of higher mulch levels, likely facilitated by the greater presence of soil moisture available for their growth (Table. 1). Similar results were reported by Khurshid *et al.* (2006).

Fertilizer application of 125% RDF (S_4) recorded significantly taller plants compared to remaining fertility levels. It was followed by 100% RDF (S_3) in increasing the plant height over no fertilizer treatment. This could potentially be attributed to processes such as cell elongation, cell enlargement, and increased chlorophyll synthesis, which collectively contributed to the enhanced plant growth. The observed plant height in relation to increased fertilizer dosages further supported by the previous findings of Kaushik and Shaktawat (2005) and Verma *et al.* (2005).

Drymatter accumulation (kg ha^{-1})

The highest drymatter accumulation was observed in mulching of residue after application of PUSA decomposer (M_4) and it was on par with mulching without PUSA decomposer (M_5) at all crop growth stages except at 30 DAS (Table. 1). The treatments that received mulching found superior compared to incorporation treatments in increasing drymatter accumulation. The lowest drymatter accumulation was observed in burning of residue treatment (M_1). The utilization of straw mulch led to an increase in both stem and sheath output weight when compared to the treatments without straw mulch. These results were similar to the findings of Yan *et al.* (2018).

Among the fertilizer levels the highest drymatter accumulation was observed with the application of 125% RDF (S_1) and it was significantly superior to that of other fertility levels at all growth stages of crop. It was followed by 100% RDF (S_3) over 75% RDF (S_2) in increasing the drymatter production. The lowest drymatter accumulation was observed with control (S_1) and was significantly inferior to rest of the fertility levels. Higher fertilizer doses promoted robust vegetative growth by increasing chlorophyll content leading to larger photosynthetic surfaces that captured more solar radiation and ultimately generated more dry matter. Similar results were reported by Sandhu and Mahal (2014) and Tomar *et al.* (2018) in their studies.

Effect of rice residue management practices and fertilizer levels on kernel yield of maize

Kernel yield (kg ha^{-1})

The treatments with PUSA decomposer found significantly higher kernel yield over that of treatments without decomposer (Table. 2). Mulching of rice residue significantly recorded higher kernel yield over other treatments. However, it was found on par with rice residue incorporation with PUSA decomposer (M_2). The treatments with rice residue incorporation with PUSA decomposer (M_2) and rice residue incorporation without PUSA decomposer (M_3) found on par with each other. The treatment differences among rice residue incorporation without PUSA decomposer (M_3), rice residue mulch without PUSA decomposer (M_5) and burning of residue (M_1) were not significant in increasing the kernel yield. The lower kernel yield was recorded with (M_1) which was significantly inferior to rest of the treatments. Mulching reduced maize water demand and significantly increased soil moisture, reduced runoff, improved germination and yield. Moisture enhanced nutrient accessibility to roots increased the kernel yield. Smilar results were reported by Bhardwaj and Sindhwal (1998) and Gathala *et al.* (2015).

Among the fertilizer levels application of 125% RDF (S_4) i.e., 300:100:100 kg ha^{-1} recorded higher kernel yield compared to other treatments. It was followed by 100% RDF (S_3) 240:80:80 kg ha^{-1} which recorded significantly higher yield over that of 75% RDF (S_2). Higher fertilizer levels potentially increased protein synthesis and growth-promoting substances, consequently accelerating photosynthesis through efficient CO_2 utilization with minimal energy. These results are similar to the findings of Bedse *et al.* (2015).

Effect of rice residue management practices and fertilizer levels on nutrient uptake by kernels

NPK uptake by kernel (kg ha^{-1})

Among the residue management practices, rice residue mulch with PUSA decomposer (M_4) recorded higher NPK uptake by kernel and it was found on par with rice residue incorporation with PUSA decomposer (M_2) except with P uptake. Burning of rice residue (M_1) recorded the lowest nutrient uptake by kernel compared to other residue management practices (Table. 2). Mulching enhances NPK uptake, aided by retained crop residue for gradual nutrient release and notably reduces evaporation, maintains temperature, enhances moisture retention and facilitates nutrient absorption, resulting in increased uptake. These results are in line with the findings of Kumawat *et al.* (2018) and Shivakumar *et al.* (2019).

The NPK uptake was the highest with increasing dose of fertilizer i.e., 125% RDF (S_4) and it was superior among all other treatments followed by 100% RDF (S_3) was found superior to that of 75% RDF (S_2) and control (S_1). The significant increase in NPK uptake by the crops is linked to the higher grain yield achieved through higher fertilizer application. These results are comparable with the findings of Marapi *et al.* (2019) and Naher and Paul (2017).

Thus, the results clearly indicated that residue mulching along with PUSA decomposer and application of 125% RDF had positive impact on maize crop growth, yield and nutrient uptake.

Table 1. Plant height and drymatter accumulation of maize at 30, 60, 90 DAS and at harvest as influenced by rice residue management practices and fertilizer levels

Treatments	Plant height (cm)				Drymatter accumulation (kg ha^{-1})			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
Main plots (Residue management practices								
M_1: Burning of residue	87.2	194.4	221.5	224.2	371.3	5965	14996	20333
M_2: Rice crop residue incorporation with PUSA decomposer	76.1	217.2	235.2	238.5	261.2	6924	17778	22217
M_3: Rice crop residue incorporation without PUSA decomposer	70.2	200.3	223.7	226.2	285.3	6264	17538	21062
M_4: Rice crop residue mulch with PUSA decomposer	87.9	237.2	248.8	257.7	342.8	7667	20517	25856
M_5: Rice crop residue mulch without PUSA decomposer	87.8	234.2	241.6	254.9	365.2	7292	20472	25152
S.Em±	2.09	4.53	6.04	4.8	7.61	224.27	556.92	738.94
CD (p = 0.05)	6.9	14.7	NS	15.6	24.8	731.4	1816	2409
CV (%)	8.8	7.2	8.9	6.9	8.1	11.4	10.6	11.1
Sub plots (Fertilizer levels)								
S_1: Control	60	157.7	192.5	202.7	146.9	4872	10967	14093
S_2: 75% RDF (180:60:60)	85.2	222.8	238.7	243.5	264	5955	17761	22316
S_3: 100% RDF (240:80:80)	88.7	236.2	248.2	251.9	349.9	6914	20925	25968
S_4: 125% RDF (300:100:100)	93.6	250.2	257.4	263.1	540.1	9467	23389	29319
S.Em ±	0.93	4.6	3.72	3.61	10.07	159.82	406.96	585.17
CD (p = 0.05)	2.7	13.2	10.7	10.4	29	462	1175	1690
CV (%)	4.4	4.6	6.1	5.8	11.9	9.1	8.6	9.8
Interaction								
M x S	S	NS	NS	NS	S	S	NS	NS
S x M	S	NS	NS	NS	S	S	NS	NS

Table 2. Maize Kernel Yield and NPK uptake by kernel as influenced by rice residue management practices and fertilizer levels

Treatments	Kernel yield (kg ha-^{1})	N uptake (kg ha-^{1})	P uptake (kg ha-^{1})	K uptake (kg ha-^{1})
Main plots (Rice residue management practices)				
M_1: Residue burning	5311	58.8	12.3	18.3
M_2: Residue incorporation with PUSA decomposer	5999	67.4	15.1	21.1
M_3: Residue incorporation without PUSA decomposer	5596	62.5	13.6	18.8
M_4: Residue mulching with PUSA decomposer	6281	70.2	17.4	23.9
M_5: Residue mulching without PUSA decomposer	5541	62	15.2	20.2
SEm (±)	139.76	1.45	0.46	0.52
CD (p=0.05)	456	4.7	1.5	1.7
CV (%)	8.4	7.8	10.7	8.8
Sub plots (Fertilizer levels)				
S_1: Control	3067	31.9	6.8	10
S_2: 75% RDF (180:60:60)	5621	60.4	13.3	18.9
S_3: 100% RDF (240:80:80)	6444	72.6	16.5	23
S_4: 125% RDF (300:100:100)	7851	91.9	22.4	29.9
SEm (±)	176.13	2.03	0.47	0.66
CD (P=0.05)	509	5.9	1.4	1.9
CV (%)	11.8	12.2	12.5	12.5
Interaction				
M x S	NS	NS	NS	NS
S x M	NS	NS	NS	NS

LITERATURE CITED

***Agricultural Statistics at a Glance* 2022.** Department of Agriculture & Farmers Welfare, Government of India. (https://desagri.gov.in)

Bedse R D, Patel A M, Raval C H, Rathore B S and Vyas K G 2015. Forage equivalent yield, quality, soil status and economics of maize (*Zea mays* L.) as influenced by intercropping of cowpea (*Vigna unguiculata* L.) and fertility levels during kharif season. *Research on Crops*. 16(2): 236-242.

Bhardwaj S P and Sindhwal N S 1998. Zero tillage and weed mulch for erosion control on sloping farmland in Doon Valley. *Indian Journal of Soil Conservation*. 26: 81-85.

***Directorate of Economics and Statistics.* (2012-13).** *https://eands.dacnet.nic.in*

Devi S, Gupta C, Jat S L and Parmar M S 2017. Crop residue recycling for economic and environmental sustainability: The case of India. *Open Agriculture*. 2(1): 486-494.

Gathala M K, Timsina J, Islam M S, Rahman M M, Hossain M I, Harun-Ar-Rashid M, Ghosh A K, Krupnik T J, Tiwari T P and McDonald A 2015. Conservation agriculture-based tillage and crop establishment options can maintain farmers yields and increase profits in South Asia's rice-maize systems: Evidence from Bangladesh. *Field Crops Research.* 172: 85-98.

Kaushik M K and Shaktawat M S 2005. Effect of row spacing, nitrogen and weed control on growth, yield & nutrient uptake of Sorghum (*Sorghum bicolor*). *Indian Journal of Agronomy.* 50(2): 140-142.

Khurshid K M, Iqbal M S, Arif and A Nawaz 2006. Effect of tillage and mulch on soil physical properties and growth of maize. *International Journal of Agriculture Biology.* 8: 593-596.

Kumawat C, Sharma V K, Meena M C, Dwivedi B S, Barman M, Kumar S, Chobhe K A and Dey A 2018. Effect of crop residue retention and phosphorus fertilization on P use efficiency of maize (*Zea mays*) and biological properties of soil under maize-wheat (*Triticum aestivum*) cropping system in an Inceptisol. *Indian Journal of Agricultural Sciences.* 88(8): 1184-9.

Marapi D K, Panda B B and Shrivastava G K 2019. Effect of tillage, residue and residual of nitrogen management on protein yield, factor productivity and nutrient uptake by maize under rice-maize cropping system. *International Journal of Chemical Studies.* 7(4): 1774-1777.

Naher M S and Paul A K 2017. Effect of integrated nutrient management on nutrient uptake and sustainable grain yield in transplanted Aman rice. *SAARC Journal of Agriculture.* 15(1): 43-55.

Panse V G and Shukhatme P V 1978. *Statistical Methods for Agricultural Workers, ICAR, New Delhi.* 145-150.

Sandhu S S and Mahal S S 2014. Performance of rice (*Oryza sativa*) under different planting methods, nitrogen levels and irrigation schedules. *Indian Journal of Agronomy.* 59(3): 392-397.

Shivakumar R, Bridgit T K and Ratheesh P K 2019. Study on N, P, K uptake influenced by the application of hydrogel and mulching on maize (*Zea mays* L.) in sandy soil. *Journal of Pharmacognosy and Phytochemistry.* 8(2): 1524-1527.

Tomar R, Singh N B, Singh V and Kumar D 2018. Effect of planting methods and integrated nutrient management on growth parameters, yield and economics of rice. *Journal of Pharmacognosy and Phytochemistry.* 7(2): 520-527.

Verma S S, Singh N, Joshi Y P and Deorari V 2005. Effect of nitrogen and zinc on growth characters, herbage yield, nutrient uptake and quality of fodder sorghum (*Sorghum bicolor*). *Indian Journal of Agronomy.* 50(2): 167-169.

Yan F, Sun Y, Xu H, Yin Y, Wang H, Wang C, Guo C, Yang Z, Sun Y and Ma J 2018. Effects of wheat straw mulch application and nitrogen management on rice root growth, dry matter accumulation and rice quality in soils of different fertility. *Paddy and Water Environment.* 16: 507-518.

Received on 10.06.2023 and Accepted on 20.07.2023