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Additive effect of rice straw mulching and legume residue incorporation on growth and productivity of *rabi* maize and groundnut in intensified rice-based cropping systems

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Abstract
A long-term field experiment was conducted at Institutional research farm, ICAR-National Rice Research Institute, Cuttack, Odisha since 2012-13. The experiment was conducted in split plot design involving two cropping systems i.e., rice-maize-cowpea (R-M-C) and rice-groundnut-cowpea (R-G-C) as main plots and five nutrient management options i.e., control-control-control (C-C-C), RDF-RDF-RDF (R-R-R), RI+RDF_{75}-RDF-RDF (RI+R_{75}-R-R), RI+RDF_{75}-SM + RDF-RDF (RI+R_{75}-SM+R-R) and RI+RDF_{75}-SM+RDF-RDF_{50} (RI+R_{75}-SM+R-R_{50}) in sub-plots, where R is RDF for respective crop, RI is the cowpea residue incorporation prior to rice transplanting and SM is the rice straw mulching in *rabi* season crops i.e., maize and groundnut. The present study was a part of this long-term experiment and the data presented here is the pooled data obtained during 2017-18 and 2018-19. Result revealed that RI+R_{75}-SM+R-R in maize being at par with RI+R_{75}-SM+R-R_{50} improved the leaf area index, dry matter accumulation and plant height of maize and groundnut throughout the crop period. RI+R_{75}-SM+R-R_{50} also recorded 22.37 and 16.36% higher seed and stover yield of maize and 14.51 and 10% higher pod and stover yield in groundnut respectively than R-R-R.

Keywords: Maize, groundnut, cropping system, residue incorporation, mulching

Introduction
Rice (*Oryza sativa*) is considered as the staple food grain in India with 116.4 mt production from an area of 43.79 m ha with national average productivity of 2.66 t ha^{-1} during 2018-19 (Anon., 2020) [5]. Rice-groundnut cropping system is an existing system in irrigated tract of Eastern India but the major problem associated with continuous practice of this system is sulfur mining. Maize is a good alternative to diversify this traditional rice-rice and rice-wheat cropping system and rice-groundnut system in Eastern India. Rice-maize system is an emerging cropping system in S-Asia (Timsina *et al*., 2010) [33]. In southern and north East part of India this cropping system is rapidly increasing under resource conservation technologies, mostly zero tillage (Jat *et al*., 2009) [17]. Though hybrid maize requires high input, especially nutrients, it has a very high productive potential which makes it over twice more profitable than wheat or *boro* rice (Ali *et al*., 2008, 2009) [3, 4]. Shifting from one crop to another is likely to have moderate impact on fertilizer demand; while shifting from a single to a double or from a double to a triple-crop system would result in increased fertilizer consumption and demand, but results in higher system productivity (Pasuquin *et al*., 2007) [26]. However, intensive cropping system without proper soil management exhaust soil nutrient leading to decline in soil quality and crop productivity but inclusion of legume in cropping system can sustain the system in long run. Introduction of summer legumes before transplanting of rice in rice-based cropping system can increase the productivity of rice-based system, besides improving the carbon and nitrogen status of soil (Prasad, 2011) [28].

Residue management is also a major concern in the present scenario. Rice straw is not even suitably incorporated in soil because of its higher C:N ratio which may generate priming effect. Thus, they can be suitably used as mulch in *rabi* season crops which can protect crops from low and high temperature, checks evaporation losses, checks weed growth and eventually add organic matter to soil. Mulch is also defined as materials covering soil surface and mulching is the technique of water conservation reducing surface runoff, reducing soil erosion and increasing the infiltration rate (Ghawi and Battikhi, 1986; Adekalu *et al*., 2007) [11, 1].

Mulching is an effective technique of manipulating crop micro-environment for increasing the productivity and quality of crop controlling soil temperature, moisture and evaporation from soil (Chakraborty *et al*. 2008) [9]. Use of straw mulch shown to be effective in storing precipitation by reducing runoff, decreasing evaporation and increasing infiltration. Considering all these points, it is important to know what are the impacts of rice straw mulch on growth and productivity of succeeding *rabi* maize and groundnut in intensified rice-based cropping systems.

Materials and Methods

The experiment was conducted at Institute Research Farm of ICAR – National Rice Research Institute, Cuttack (Odisha) located at 85° 55′ 48″ E to 85° 56′ 48″ E longitude and 20° 26′ 35″ N to 20° 27′ 35″ N latitude with the altitude of 24 m above MSL. The soil was sandy loam with acidic nature (6.42), low in organic C (0.48%), N (214 kg ha^{-1}) and medium in available P (14.74 kg ha^{-1}) and available K (151.9 kg ha^{-1}). The soil texture was determined by international pipette method (Black, 1965) [6], soil reaction or soil pH was determined by glass electrode pH meter (Piper, 1996) [27], soil organic carbon was estimated by Walkley and Black's rapid titration method (Black, 1965) [7], soil available N was estimated by Alkaline permanganate method (Subbiah and Asija, 1965) [32], soil available phosphorous was estimated by Olsen's method (Olsen, 1954) [25] and soil available potassium was estimated by flame photometric method (Jackson 1973) [15]. The experiment was conducted in split plot design involving two cropping systems i.e., rice-maize-cowpea (R-M-C) and rice-groundnut-cowpea (R-G-C) as main plots and five nutrient management options i.e., control-control-control (C-C-C), recommended dose of fertilizer application in *kharif* rice, *rabi* maize and groundnut and summer cowpea crop i.e., RDF-RDF-RDF (R-R-R), cowpea residue incorporation in rice along with 25% reduction in recommended dose of fertilizer application to rice crop, recommended dose of fertilizer application to *rabi* maize and groundnut and recommended dose of fertilizer application in summer cowpea i.e., RI+RDF_{75}-RDF-RDF (RI+R_{75}-R-R), cowpea residue incorporation in rice along with 25% reduction in recommended dose of fertilizer application to rice crop, rice straw mulching along with recommended dose of fertilizer application to *rabi* maize and groundnut and recommended dose of fertilizer application in summer cowpea i.e., RI+RDF_{75}-SM + RDF-RDF (RI+R_{75}-SM+R-R) and cowpea residue incorporation in rice along with 25% reduction in recommended dose of fertilizer application to rice crop, rice straw mulching along with recommended dose of fertilizer application to *rabi* maize and groundnut and half of the recommended dose of fertilizer application in summer cowpea i.e., RI+RDF_{75}-SM+RDF-RDF_{50} (RI+R_{75}-SM+R-R_{50}) in sub-plots, where RI is the cowpea residue incorporation prior to rice transplanting and SM is the rice straw mulching in *rabi* season crops i.e., maize and groundnut.

The cultivars taken for maize and groundnut were Vijaya-22 and Smruti respectively. The R-R and P-P spacing for maize was 60cm and 20cm respectively at a seed rate of 20 kg ha^{-1}. The R-R and P-P spacing for groundnut was 30cm and 10cm respectively at a seed rate of 80 kg ha^{-1}. The recommended dose of fertilizer used for maize was 150:50:50 kg N, P_2O_5 and K_2O ha^{-1} from which 50% N, 100% P&K were applied as basal and another 50% applied equally in two splits at Knee high stage and at tasseling stage. The recommended dose of fertilizer for groundnut was 20:40:20 kg N, P_2O_5 and K_2O ha^{-1} which was applied as basal only. In straw mulching treatments, 6t ha^{-1} rice straw used for mulching which were spread evenly in between crop rows. Plant height in both maize and groundnut was recorded at 30days intervals. Leaf area index (LAI) of both maize and groundnut at 30days interval were recorded using graph papers. For dry matter accumulation, above ground destructive plant samples were taken as 30 days interval and oven dried till constant weight and converted and expressed as gram per square meter (g m^{-2}). For calculating the crop growth rate (CGR), the following formulae was used;

$$\mathrm{CGR} = \frac{W_2 - W_1}{t_2 - t_1}$$

After maturity, maize seed yield from net plot area was taken after shelling cobs and was expressed in t ha^{-1}. The ground nut pod yield was converted from net plot pod yield to pod yield in t ha^{-1}. After drying the stover, harvest index (HI) was calculated using the following formulae;

$$\text{Harvest Index (\%)} = \frac{\text{Economic yield (t ha}^{-1})}{\text{Biological yield (t ha}^{-1})} \times 100$$

Although experiment was planned with split-plot design, the growth, yield and yield attributes of *rabi* season crops i.e., maize and groundnut were analyzed statistically in randomized complete block design (RBD). The data generated from the experiment during 2017-18 and 2018-19 were pooled and analyzed using the standard statistical procedure suggested by Gomez and Gomez (1984) [13] for randomized block design for the analysis of variance (ANOVA).

Results and Discussion

Growth attributes Maize

The leaf area index (LAI) was increased up to 90DAS. LAI of maize at 30, 60 and 90DAS was significantly influenced by different nutrient management treatments. The leaf area index of all the nutrient management treatments was significantly higher than the control i.e., C-C-C across the growth stages. At early stage of 30DAS, no significant difference was observed among the fertilizer treatments. However, at 60DAS, straw mulched treatments i.e., RI+R_{75}-SM+R-R and RI+R_{75}-SM+R-R_{50} recorded significantly higher LAI compared to recommended fertilizer applied treatment. Leaf area index recorded in RI+R_{75}-SM+R-R_{50} was 10%, 23.4% and 7.07% higher than R-R-R at 30, 60 and 90DAS respectively (Table 1). Leaves are the assimilatory organs for photosynthesis and leaf area index envisages the leafiness or ground coverage of a plant, which is important for effective solar radiation utilization. Higher leaf area index in rice straw mulched treatments may be due to the favorable rhizosphere micro-climate as influenced by rice straw mulching. Straw mulching helps in maintaining the soil temperature warmer during winter, which prevents the stunted or slow growth of maize plant in *rabi* season. Increase in LAI on mulching over no mulch treatments was reported by Kar and Kumar (2007) [19] in potato and Qin *et al*. (2010) [29] in rice.

Table 1: Effect of residue and nutrient management on LAI and plant height of maize in intensified RBCS (Pooled over 2017-18 and 2018-19)

	Leaf Area Index			Plant Height (cm)		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
C-C-C	0.09	0.33	1.38	25.3	50.7	112.1
R-R-R	0.20	1.41	4.67	31.2	103.6	225.2
RI+R_{75}-R-R	0.22	1.55	4.69	33.2	101.3	224.4
RI+R_{75}-SM+R-R	0.24	1.76	5.20	34.3	107.5	243.9
RI+R_{75}-SM+R-R_{50}	0.22	1.74	5.00	35.1	106.9	242.3
S.Em±	0.01	0.03	0.22	0.2	2.6	3.4
CD (P=0.05)	0.05	0.11	0.73	0.8	8.6	11.0

The DMA of maize was significantly influenced by different nutrient management options. The highest (5.8 gm^{-2}) dry matter accumulation at 30DAS was recorded in RI+R_{75}-SM+R-R_{50} (Fig. 1) while at 60DAS, highest (150.7 gm^{-2}) dry matter accumulation recorded in RI+R_{75}-SM+R-R. At 90DAS, highest dry matter accumulation (1274.7 gm^{-2}) was recorded in RI+R_{75}-SM+R-R whereas at harvest, highest dry matter accumulation recorded in RI+R_{75}-SM+R-R_{50} (1529.6 gm^{-2}). Dry matter accumulation in RI+R_{75}-SM+R-R recorded 16.32, 9.44, 19.50 and 22.52%, while RI+R_{75}-SM+R-R_{50} recorded 18.37, 7.63, 18.75 and 22.52% higher DMA than R-R-R at 30, 60, 90DAS and at harvest. RI+R_{75}-SM+R-R recorded similar DMA with RI+R_{75}-SM+R-R_{50} at 30, 60, 90DAS and at harvest respectively. Higher dry matter accumulation could be due to higher leaf area production with mulched treatments. Higher leaf area with residue mulched plots could help in better utilization of sunlight and soil available nutrients in tern lead to higher dry matter accumulation. The result corroborated with the findings of Iqbal *et al*. (2003) [14] and Rajput *et al*. (2014) [30] in maize.

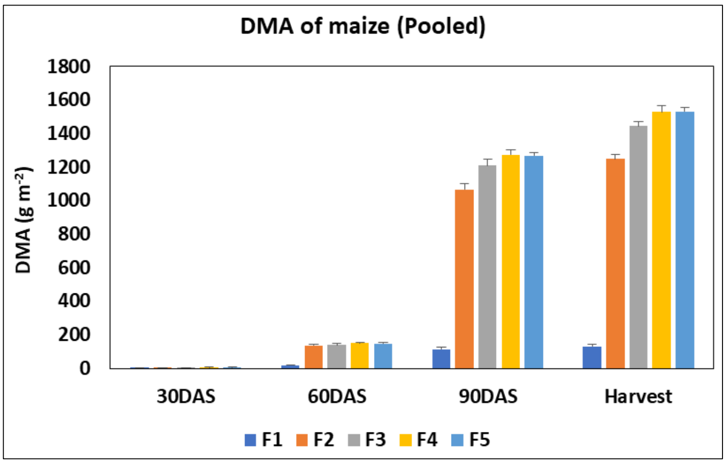

Fig 1: Effect of residue and nutrient management on DMA of maize (Pooled)

The CGR of maize increased from 0-30DAS to 30-60DAS and from 30-60DAS to 60-90DAS but then declined sharply during 90DAS-harvest. The highest and lowest CGR of maize at 0-30DAS, 30-60DAS and 60-90DAS was recorded by RI+R_{75}-SM+R-R and C-C-C respectively (Fig. 2). CGR recorded in RI+R_{75}-SM+R-R was at par with RI+R_{75}-SM+R-R_{50} throughout the crop growth period. CGR recorded in RI+R_{75}-SM+R-R_{50} was 18.75, 7.22, 20.37 and 44.79% higher than R-R-R at 0-30DAS, 30-60DAS, 60-90DAS and 90DAS to harvesting respectively. The rate of dry matter accumulation decreased towards maturity. Higher crop growth rate in residue applied treatments due to higher dry matter accumulation and leaf area index as a result of higher soil nutrient availability and favorable rhizosphere ecology for crop growth than control and recommended dose of fertilizer application (Zhang *et al*., 2019) [35]. The lowest crop growth rate in control irrespective of years of experiment and stages of crop growth is due to low fertility status of the soil.

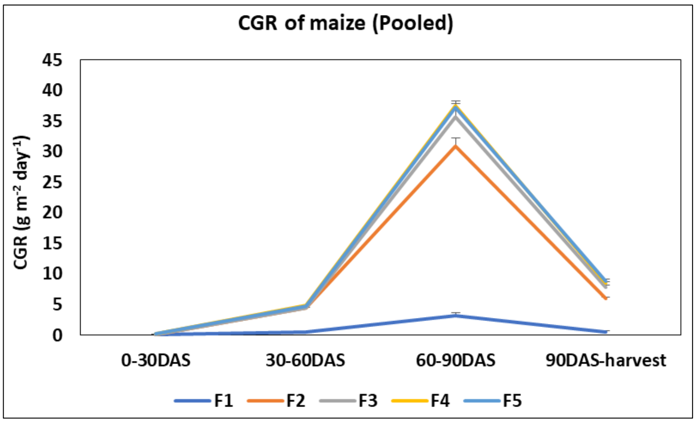

Fig 2: Effect of residue and nutrient management on CGR of maize (Pooled)

The plant height increased with growth stages up to harvesting. The plant height of maize crop ranged from 25.3cm in C-C-C to 35.1cm in RI+R_{75}-SM+R-R_{50} at 30DAS (Table 1). Whereas, at 60 and 90DAS, highest plant height was recorded in RI+R_{75}-SM+R-R which was at par with RI+R_{75}-SM+R-R_{50}. RI+R_{75}-SM+R-R_{50} recorded 9.94, 3.76 and 8.30% higher plant height than R-R-R at 30, 60 and 90DAS respectively. Increase in plant height with mulching compared to non-mulched treatments could be attributed to better soil moisture conservation and moisture availability to crop for extended period (Brahma *et al.*, 2007) [8]. Higher plant height in *rabi* maize under mulched treatments might be due to higher leaf area index and higher rate of biomass accumulation. Higher plant height in cereals under mulched treatments was also reported by Khurshid *et al.* (2006) [21] and Rajput *et al.* (2014) [30].

Groundnut: Leaf area index (LAI) of groundnut was significantly influenced by different nutrient managements in rice-groundnut-cowpea cropping system (Table 2). Irrespective of nutrient management, the LAI of groundnut increased with crop growth stages. LAI recorded in straw mulched treatments i.e., RI+R_{75}-SM+R-R and RI+R_{75}-SM+R-R_{50} were at par with each other and recorded highest LAI at 30, 60, 90 and 120DAS. LAI recorded in RI+R_{75}-SM+R-R_{50} was 21.43%, 15.32%, 17.39% and 26.87% higher than R-R-R at 30, 60, 90 and 120DAS respectively. Higher leaf area index in straw mulching or residue applied treatments are due to improved soil health and favorable soil rhizosphere environment. Residue incorporation in soil increases the nutrient availability and improves the soil resilience. Higher leaf area per plant and LAI in mulched treatment over no mulch in groundnut was also reported by Jayaramaiah and Thimmegowda (1997) [18] and Shinde *et al.* (2001) [31].

Table 2: Effect of residue and nutrient management on plant height and LAI of groundnut in intensified RBCS (Pooled over 2017-18 and 2018-19)

	Leaf Area Index				Plant Height (cm)			
	30 DAS	**60 DAS**	**90 DAS**	**120 DAS**	**30 DAS**	**60 DAS**	**90 DAS**	**120 DAS**
C-C-C	0.11	0.56	1.73	1.64	8.5	12.6	23.8	35.1
R-R-R	0.14	1.24	2.53	2.68	10.0	15.9	31.8	49.6
RI+R_{75}-R-R	0.15	1.37	2.74	3.16	10.4	16.2	32.6	52.0
RI+R_{75}-SM+R-R	0.17	1.43	3.07	3.38	10.6	18.2	34.2	58.5
RI+R_{75}-SM+R-R_{50}	0.17	1.43	2.97	3.40	10.5	18.3	33.6	57.1
S.Em±	0.00	0.05	0.07	0.07	0.1	0.3	0.3	1.5
CD (P=0.05)	0.01	0.16	0.22	0.24	0.3	1.0	0.9	4.8

The dry matter accumulation (DMA) of groundnut at 30, 60, 90 and 120DAS was significantly influenced by different nutrient managements (Fig. 3). Throughout the growth period of groundnut, highest (23.55 g m^{-2} at 30DAS, 217.5 g m^{-2} at 60DAS, 516.1 g m^{-2} at 90DAS and 642.9 g m^{-2} at 120DAS and 719.1 g m^{-2} at harvest) and lowest (15.17 g m^{-2} at 30DAS, 76.8 g m^{-2} at 60DAS, 169.1 g m^{-2} at 90DAS and 201.1 g m^{-2} at 120DAS and 221.5 g m^{-2} at harvest) DMA was recorded in RI+R_{75}-SM+R-R and C-C-C respectively. DMA recorded in RI+R_{75}-SM+R-R was at par with DMA recorded in RI+R_{75}-SM+R-R_{50} throughout the crop growth period. DMA recorded in RI+R_{75}-SM+R-R_{50} was 13.05%, 16.15%, 17.99%, 24.39% and 26.09% higher than R-R-R at 30, 60, 90, 120DAS and at harvest respectively. The result is in corroboration with the findings of Mandal and Ghosh (1984) [23] and Mahalle *et al.* (2002) [22].

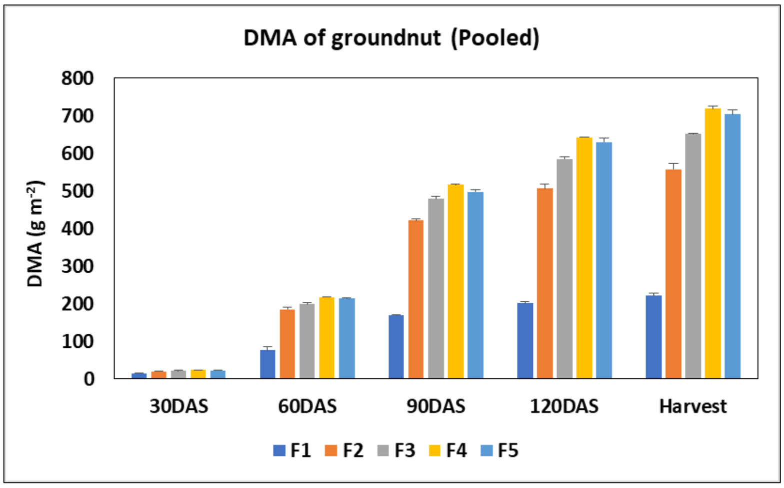

Fig 3: Effect of residue and nutrient management on DMA of groundnut (Pooled)

Crop growth rate (CGR) of groundnut at 0-30DAS, 30-60DAS, 60-90DAS, 90-120DAS and 120DAS-harvest was significantly influenced by different nutrient management practices (Fig. 4). CGR was increased from 0-30DAS to 30-60DAS and 30-60DAS to 60-90DAS, but then decreased from 60-90DAS to 90-120DAS and from 90-120DAS to 120DAS-harvest. Throughout groundnut growth period, highest (0.79 g m^{-2} day^{-1} at 0-30DAS, 6.47 g m^{-2} day^{-1} at 30-60DAS, 9.95 g m^{-2} day^{-1} at 60-90DAS and 3.35 g m^{-2} day^{-1} at 120DAS-harvets) and lowest (0.51 g m^{-2} day^{-1} at 0-30DAS, 2.05 g m^{-2} day^{-1} at 30-60DAS, 3.08 g m^{-2} day^{-1} at 60-90DAS, 1.07 g m^{-2} day^{-1} at 90-120DAS and 3.35 g m^{-2} day^{-1} at 120DAS-harvets) CGR was recorded in RI+R_{75}-SM+R-R and C- C-C respectively except at 90-120DAS where highest

CGR (4.42 g m^{-2} day^{-1}) was recorded in RI+R_{75}-SM+R-R_{50} which was at par with RI+R_{75}-SM+R-R. The increase in crop growth rate up to 60-90DAS was due to increase in assimilatory organs i.e., leaf area index and increasing dry matter accumulation. The rate of dry matter accumulation decreased towards maturity. Higher crop growth rate in residue applied treatments due to higher dry matter accumulation and leaf area index as a result of higher soil nutrient availability and favorable rhizosphere ecology for crop growth than control and recommended dose of fertilizer application. The lowest crop growth rate in control irrespective of years of experiment and stages of crop growth is due to low fertility status of the soil.

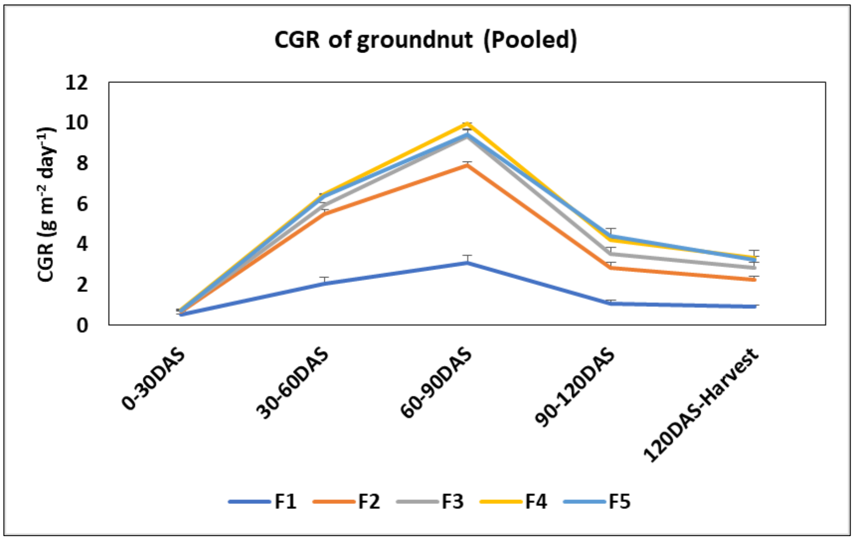

Fig 4: Effect of residue and nutrient management on CGR of groundnut (Pooled)

The plant height of groundnut was significantly influenced by different nutrient managements throughout the crop growing period. At 30, 90 and 120DAS highest plant height was recorded in RI+R_{75}-SM+R-R (Table 3). However, at 60DAS, highest plant height was recorded in RI+R_{75}-SM+R-R_{50}. In all the growth stages of groundnut, plant height was not differed significantly by nutrient management between straw mu.lched treatments, whereas RI+R_{75}-SM+R-R and RI+R_{75}-SM+R-R_{50} recorded significantly taller plants than R-R-R. The plant height recorded in RI+R_{75}-SM+R-R_{50} was 5.00%, 15.09%, 5.66% and 15.12% higher than R-R-R at 30, 60, 90 and 120DAS respectively. Higher plant height in straw mulched treatments over non-mulched treatments might be due to higher leaf area and dry matter accumulation. The *rabi* seasonzz groundnut is mostly affected negatively by the declined soil temperature and use of rice straw mulch insulates the rhizosphere from reaching low temperature declining germination and crop growth. Similar findings were also reported by Jayaramaiah and Thimmegowda (1997) [18], Shinde *et al*. (2001) [31] and Mahalle *et al*. (2002) [22].

Yield and Yield attributes Maize

Yield attributes of maize i.e., grains cob^{-1}, cobs $plant^{-1}$ and test weight were significantly influenced by nutrient managements (Table 3). Highest and lowest grains cob^{-1} was recorded in RI+R_{75}-SM+R-R and C-C-C respectively. The treatment RI+R_{75}-SM+R-R, was recorded significantly higher number of grains cib^{-1} than R-R-R and being at par with RI+R_{75}-R-R and RI+R_{75}-SM+R-R_{50}. Similarly highest (1.67) and lowest (0.67) cobs $plant^{-1}$ was recorded in RI+R_{75}-SM+R-R and C-C-C, respectively. However, the number of cobs $plant^{-1}$ recorded in RI+R_{75}-SM+R-R was at par with other nutrient management treatments except C-C-C. Unlike cobs $plant^{-1}$, the highest (220.0 g) test weight of maize was recorded in RI+R_{75}-SM+R-R_{50} and the lowest was recorded in C-C-C. The test weight recorded in RI+R_{75}-SM+R-R_{50} was **at** par with RI+R_{75}-R-R and RI+R_{75}-SM+R-R but significantly higher than R-R-R. Mulching in maize had significant effect on the cobs $plant^{-1}$, number of rows cob^{-1} and grains cob^{-1} in maize (Khurshid *et al*., 2006; Yaseen *et al*., 2014) [21, 34].

Table 3: Effect of residue and nutrient management on yield attributes and yield of maize (Pooled over two years)

	Grains cob^{-1}	Cobs $plant^{-1}$	Test weight (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	HI
C-C-C	289.7	0.67	78.0	0.85	1.47	36.64
R-R-R	487.5	1.54	208.7	4.38	6.54	40.13
RI+R_{75}-R-R	511.3	1.56	216.5	5.10	7.17	41.60
RI+R_{75}-SM+R-R	540.2	1.67	215.5	5.33	7.55	41.37
RI+R_{75}-SM+R-R_{50}	526.4	1.65	220.0	5.36	7.61	41.31
S.Em±	12.2	0.05	3.0	0.08	0.11	0.86
CD (P=0.05)	39.9	0.16	9.7	0.26	0.35	2.80

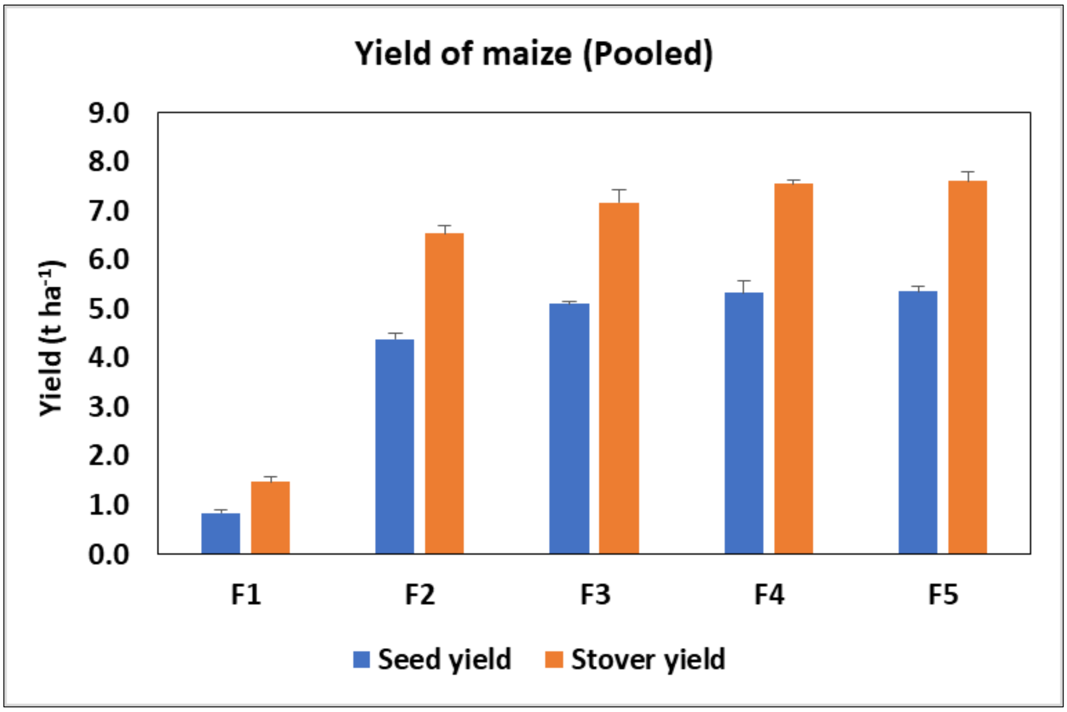

Fig 5: Effect of residue and nutrient management on yield of maize (Pooled)

The mean seed yield, stover yield and harvest index of maize was significantly influenced by nutrient managements (Table 3; Fig. 5). The highest seed yield (5.36 t ha^{-1}) and stover yield (7.61 t ha^{-1}) was recorded in RI+R_{75}-SM+R-R_{50} which was at par with RI+R_{75}-SM+R-R but significantly higher than rest of the treatments. The seed yield and stover yield recorded in RI+R_{75}-SM+R-R_{50} was 22.37 and 16.36% higher than R-R-R. Similar findings was also reported by Rajput *et al*. (2014) [30], Yaseen *et al*. (2014) [34] and Akhtar *et al*. (2018) [2].

Groundnut: Among yield attributes of groundnut i.e., number of pods $plant^{-1}$, number of seeds pod^{-1} and test weight, number of pods per plant was significantly influenced by different nutrient managements (Table 4). Highest number of pods $plant^{-1}$ (12.3) was recorded in RI+R_{75}-SM+R-R which was 14.95% higher than R-R-R. Although number of seeds pod^{-1} and test weight was not significantly influenced by nutrient managements, RI+R_{75}-SM+R-R_{50} recorded 5.07% higher number of seeds pod^{-1} than R-R-R. Similar findings was also reported by Mandal and Ghosh (1984) [23], Jayaramaiah and Thimmegowda (1997) [18] and Dutta *et al*., 2000 [10].

Table 4: Effect of residue and nutrient management on yield attributes and yield of groundnut in intensified RBCS (Pooled over 2017-18 and 2018-19)

	Pods $Plant^{-1}$	Seeds Pod^{-1}	Test weight (g)	Pod yield (t ha^{-1})	Stover yield (t ha^{-1})	HI
C-C-C	8.0	1.89	420.9	1.17	2.53	31.57
R-R-R	10.7	2.17	450.7	1.93	4.30	30.94
RI+R_{75}-R-R	11.1	2.11	448.7	2.12	4.58	31.66
RI+R_{75}-SM+R-R	12.3	2.33	453.9	2.27	4.79	32.15
RI+R_{75}-SM+R-R_{50}	12.1	2.28	454.4	2.21	4.73	31.88
S.Em±	0.2	0.12	7.6	0.03	0.06	0.45
CD (P=0.05)	0.7	NS	NS	0.11	0.19	NS

Yield of groundnut i.e., grain yield and straw yield was significantly affected by different nutrient managements (Table 4; Fig. 6). The highest pod yield (2.27 t ha^{-1}) and stover yield (4.79 t ha^{-1}) was recorded in RI+R_{75}-SM+R-R. The pod yield and stover yield recorded in RI+R_{75}-SM+R-R was at par with RI+R_{75}-SM+R-R_{50}. Pod and stover yield recorded in RI+R_{75}-SM+R- R_{50} was 14.51 and 10.00% higher than R-R-R. The higher pod and stover yield in residue mulched treatments may be due to higher leaf area index, dry matter accumulation, growth rate and number of pods per plant. Similar findnings was also reported by Khistaria *et al*. (1994) [20], Jayaramaiah and Thimmegowda (1997) [18], Ghosh *et al*. (2006) [12], Jadhav *et al*. (2017) [16] and Maurya *et al*. (2017) [24].

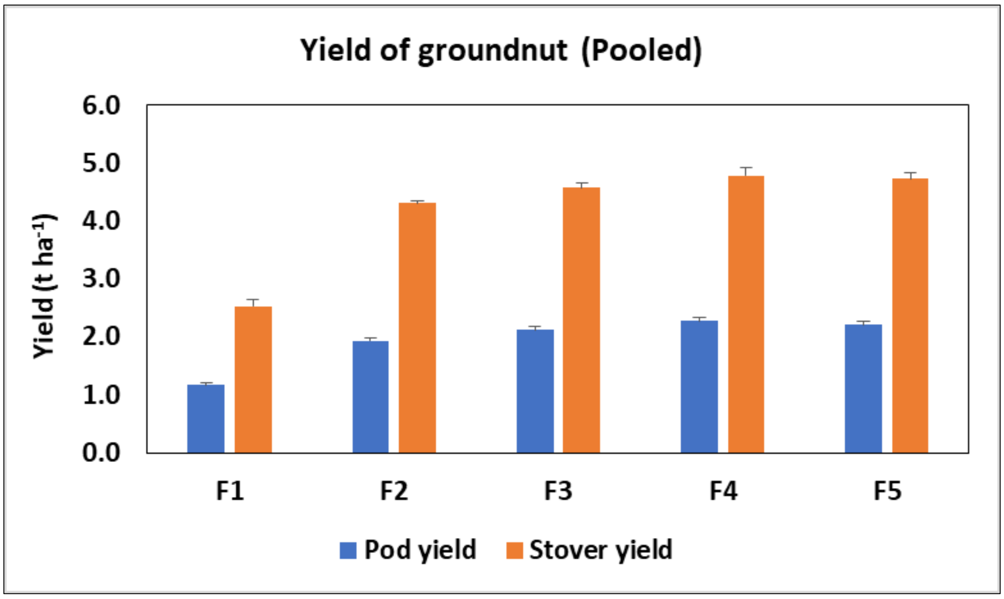

Fig 6: Effect of residue and nutrient management on yield of groundnut (Pooled)

Conclusion

Rice-groundnut cropping system is a prominent cropping system in Eastern India while rice-maize cropping system is an emerging one. Inclusion of cowpea have increased the land productivity of rice-maize/groundnut cropping system. Residual effect of incorporating cowpea residues with 75% RDF to rice increased the productivity of *rabi* crops significantly. Similarly, the rice straw mulching in maize and groundnut improved the productivity of *rabi* season crops as well as the subsequent cowpea and rice in the system. Reducing 50% of RDF in cowpea could not impact the growth and productivity of groundnut and maize in rice-based cropping systems.

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