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RESEARCH ARTICLE

Influence of residue management on yield and yield components of zero till maize

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Abstract

Burning crop residue in open fields releases greenhouse gases into the atmosphere, which significantly pollutes the air and causes global warming. A huge number of issues related to soil and air quality came out due to burning, lowering the sustainability of the environment. To find an alternative, this study was started to investigate the possibility of using lignocellulolytic microbes to speed up the *in-situ* breakdown of crop residues. Studying the impact of fertilizers and residue management on maize production and yield components was the aim of this experiment. In *rabi* 2020-21 and 2021-22, respectively, the experiment on residue management with microbial consortium was carried out at college farm, college of Agriculture, Rajendranagar, Professor Jayashankar Telangana State Agricultural University, Hyderabad. It was set up in a strip plot design with three replications for each of the twenty-four treatments. Incorporating residues treated with SSP and consortium in conjunction with 75 % RDF (Recommended Dose of Fertilizers) resulted in increased cobs plant^{-1}, cob length, cob girth, number of kernel rows cob^{-1}, number of kernels cob^{-1}, test weight, grain and biological yields. For residue burning and removal operations using 125 % RDF application, these parameters were negligible. The plots with the lowest values of these parameters were those without residues and they likewise performed badly. The application of SSP (Single Super Phosphate) in conjunction with microbial consortium at a rate of 10 % of residual weight in incorporated plots was found to increase maize yield and yield components.

Keywords: microbial consortium; rice-wheat; residue burning; removal; yield parameters; yield

Introduction

With 143 million hectares of land dedicated to intensive agriculture, which produces about 285 million tons of food grains annually, agriculture is vital to the Indian economy. It has been assessed that ten primary crops (rice, wheat, sorghum, pearl millet, barley, finger millet, sugar cane, potato tubers, pulses and oilseeds) of India produce around 683 million tons (Mt) of crop residues (CR) both on-farm and off-farm (1). Approximately 140 Mt of CR are burned on open fields out of the entire amount of CR generated. CR from rice accounted for 40 % of the total residues burnt followed by wheat residue (22 %) and sugarcane trash (20 %) (2).

Rice-wheat systems of Indo-Gangetic Plains (IGP) are the main contributor to India's total cereal production, accounting for 23 % and 40 % of India's total rice and wheat area, respectively (3). Henceforth, it is quite predictable that IGP is the key contributor to rice and wheat residues.

Additionally, the absence of necessary equipment to incorporate crop residues in soil, labor shortages and the high expense of composting and incorporating/removing residues from fields have forced farmers to burn. An entire loss of roughly 79.38, 183.71 and 108.86 kg ha^{-1} N, P and K, respectively, could result from burning paddy straw (4, 5). Therefore, its continuous removal and burning may result in net nutrient losses, which will ultimately raise the short-term costs of nutrient inputs and, in the long-term, lower soil productivity and health. This brings up the importance of sustainable and alternate approaches to managing crop residues.

Although the practice of composting, or the *ex-situ* breakdown of crop leftovers, has been around for a few decades, it is still crucial to the recycling of crop residues in a sustainable manner. A recent study in India showed that cereal yields i.e., rice, wheat and maize, are greater where straw is incorporated than where it is removed under a diversified cropping system and different combinations of tillage (6). In response to this, researchers have conducted studies to evaluate using fungal inocula to speed up the decomposition rate (7, 8).

Fungi and actinobacteria have already been shown to be effective in breaking down complex lignocellulosic compounds found in agricultural residues. They are also utilized for the quick *ex-situ* breakdown of crop residues. Furthermore, a single microbe cannot secrete all the enzymes needed for the best possible biodegradation of lignocellulosic substrate. It has also been noted that ligno cellulolytic microbial consortia, as opposed to a single inoculum, are more effective at breaking down crop residues (9). This required the employment of microbial consortia, which are made up of powerful fungal strains that work well together to quickly decompose crop residues without the need for chemical pretreatment.

However, little research has been done on the *in-situ* or in-field breakdown of crop residue utilizing microbial inoculate. The more difficult task, though, is not only reaching full decomposition but also increasing the rate of in situ decomposition so that farmers can use the area for the following crop. Even though there aren't many studies on using ligno-cellulolytic microorganisms for *in-situ* residue decomposition (10, 11), more thorough research is still required to determine how well microbial inoculates work to reduce the annoyance of burning agricultural debris. Henceforth, the present study was undertaken to evaluate the effect of paddy residue management practices on the growth and yield of zero tillage maize grown after rice.

The major objectives of the experiment include : To evaluate the effect of paddy residue management practices on the growth and yield of succeeding zero tillage maize, to study the influence of paddy residue management options on soil fertility and microbial status, to find out the residual effect of paddy residue management practices on growth and yield of green gram and to find out the economics and energetics of the paddy residue management practices in zero till maize-green gram sequence.

Materials and Methods

A field experiment was conducted in field no: C-12 of Agricultural College farm, Rajendranagar, Hyderabad which has a height of 550 meters above mean sea level and is located at latitude 17°32'22"N and longitude 78°41'11"E. The experimental soil was medium in available phosphorous (38 kg ha^{-1}) and available potassium (277 kg ha^{-1}), low in organic carbon (0.38 %) and available nitrogen (145 kg ha^{-1}) and neutral in reaction (7.8).

Treatment details

There were eight treatments for managing residues, including R_1: Burning residue before sowing, R_2: Retention of residues, R_3: Removal of residues before sowing, R_4: Incorporation at 15 DAS, R_5: Incorporation at 15 DAS + SSP at equivalent to 'P' dose, R_6: Spraying consortia of decomposers @ 10 % of residue weight + surface retention, R_7: Spraying consortia of decomposers @ 10 % of residue weight + incorporation at 15 DAS, R_8: Spraying consortia of decomposers @ 10 % of residue weight + incorporation at 15 DAS + SSP at equivalent to 'P' dose and three fertilizer doses *viz.*, F_1: 75 % RDF, F_2: 100 % RDF and F_3: 125 % RDF. All these were tested in strip plot design and replicated thrice.

Deccan Hybrid Makka (DHM-117) was used for the study during the *rabi* seasons of year 2020 and 2021, released from All India Coordinated Research Project on Maize, (Indian Institute for Maize Research), Hyderabad, Telangana State in 2009. Maize seeds were sown under zero tillage situation during *rabi* season in the same experimental site where *kharif* rice was grown in the previous season. At harvest, the yield characteristics of maize were measured, including test weight, number of cobs plant^{-1}, length and girth of the cob, number of kernel rows cob^{-1} and number of kernels cob^{-1}. The tagged plants were used for recording yield attributes.

Data collection

From selected five plants, the cob length was measured from base to tip of the cob and computed as average cob length in cm. The girth was measured at the point of maximum girth using a thread and measured with a scale. The mean girth of the cob was computed and expressed in cm. Several kernel rows in each cob were counted manually. A grain sample was taken from each net plot; the sample was weighed and the seeds in the sample were counted. The 100-grain weight was computed and is reported in g. The gathered produce from each plot was tied in bundles separately, sun-dried and dry weight was recorded in kilogram with the help of electronic balance. Each plot's cleaned grain weight following shelling and threshing was noted. Five plants that were designated for post-harvest observations had their net plot grain and stover yields put together and the total yield was stated in kilograms per hectare.

Statistical analysis

The data which is generated on various parameters yield and yield components during investigation were analyzed statistically, applying the technique of analysis of variance procedure as outlined for strip plot design (SPD) suggested by Gomez and Gomez (1984). Whenever the treatment differences were found significant (F test) critical difference was worked out at 0.05 probability level and the values are furnished. The treatment differences that were not significant were expressed as non-significant and denoted by "NS".

Results and Discussion

Number of cobs plant^{-1}

It is revealed from the data in Table 1 that higher number of cobs per plant was significantly affected by the interaction of different residue management practices and fertility levels. Among the combinations, consortium + incorporation + SSP with 125 % RDF (R_8F_3) gave a maximum number of cobs per plant which was on

Table 1. No. of cobs plant^{-1} of zero till maize as influenced by paddy residue management and fertilizer levels during *rabi,* 2020-21 and 2021-22

Treatment	**No of cobs plant^{-1} (2020-21)**				**No of cobs plant^{-1} (2021-22)**			
Fertilizer levels (F)								
Residue management (R)	**F_1- 75 % RDF**	**F_2- 100 % RDF**	**F_3- 125 % RDF**	**Mean**	**F_1- 75 % RDF**	**F_2- 100 % RDF**	**F_3- 125 % RDF**	**Mean**
R_1-*In-situ* burning	0.17	0.90	1.67	0.91	0.34	1.10	1.78	1.07
R_2- Retention	0.17	1.01	1.62	0.93	0.36	1.07	1.86	1.10
R_3- Removal	0.15	0.95	1.59	0.90	0.34	1.11	1.70	1.05
R_4- Incorporation	0.19	0.85	2.00	1.01	0.40	1.23	2.06	1.23
R_5-Incorporation + SSP	0.95	1.30	1.36	1.20	0.71	1.60	1.70	1.34
R_6-Retention + consortium	0.18	1.02	1.73	0.98	0.16	1.25	1.98	1.13
R_7-Consortium + incorporation	1.30	1.38	1.44	1.37	1.44	1.46	1.49	1.46
R_8-Consortium + incorporation + SSP	1.43	1.56	1.54	1.51	1.52	1.57	1.61	1.57
Mean	0.57	1.12	1.62		0.66	1.30	1.77	
For comparison the mean of	SE(m)±		CD (*P=0.05*)		SE(m)±		CD (*P=0.05*)	
Residue management	0.04		0.13		0.03		0.09	
Fertility levels	0.07		0.30		0.10		0.42	
R at levels of F	0.11		0.32		0.11		0.34	
F at levels of R	0.35		1.04		0.39		1.14	

par with consortium + incorporation + SSP with 100 % RDF (R_8F_2) and consortium + incorporation + SSP with 75 % RDF (R_8F_1) combinations. The reason for having statistically higher number of cobs per plant might with R_8 treatment might have been due to the concurrent availability of moisture and nutrients in synchrony with their need which resulted in better partitioning of photosynthates and increased the number of cobs plant^{-1} during both the years of experiment than other treatments. In 2020-21, removal with 75 % RDF (R_3F_1) had a lower number of cobs plant^{-1} and was on par with *in-situ* burning (R_1F_1), retention (R_2F_1), retention + consortium (R_6F_1) and incorporation (R_4F_1), but it was significantly higher in 2021-22. Poor availability of nutrients and moisture because of the loss of organic matter caused by burning and removal may be the cause of variation in the number of cobs plant^{-1} in relation to residue management practices (12).

Length of the cob

With the application of 125 % RDF in conjunction with consortium + incorporation + SSP, much longer cobs were seen and it was comparable to 100 % RDF and 75 % RDF (Table 2). Lower cob length was seen in removal with 75 % RDF which was comparable to *in-situ* burning with 75 % RDF, retention with 75 % RDF and consortium + retention with 75 % RDF. Similar findings were made former researchers (13), who reported that wheat treated with several fungal isolates had longer spikes than the untreated control.

Girth of the cob

When compared to other residue management techniques, the incorporation of residues treated with consortium and SSP along with 125 % RDF considerably increased the cob girth of maize and was found to be on par with 100 % RDF and 75 % RDF as shown in Table 3. It could be because the microbial consortium plays a significant role in degradation, produces favorable soil moisture, reduces soil temperature and enhances the absorption and utilization of available nutrients, all of which contribute to an overall improvement in crop growth. This reflects the relationship between the source and the sink, which in turn increased the yield characteristics of maize in both years.The results are in line with the findings of previous studies (14) in rice rotation system who observed similar increase in cob diameter of maize with increase in dose of nutrients.

Number of kernel rows cob^{-1}

During the two years of study, the data pertaining to the number of kernel rows cob^{-1} of maize showed that it was unaffected by residue management practices and fertility levels as well as their interaction as shown in Table 4.

Number of kernels cob^{-1}

As shown in Table 5, consortium + incorporation + SSP with 125 % RDF produced a higher number of kernels cob^{-1} than R_8F_2 (consortium + incorporation + SSP with 100 % RDF) and R_8F_1 (consortium + incorporation + SSP with 75 % RDF). However, this result was comparable to R_8F_2 and R_8F_1. In 2020-21, R_3F_1 (removal with 75 % RDF) was found to be on par with R_1F_1 (*in-situ* burning with 75 % RDF), R_2F_1 (retention with 75 % RDF), R_6F_1 (retention + consortium with 75 % RDF) and R_4F_1 (incorporation with 75 % RDF), while R_4F_1 (incorporation with 75 % RDF) was found to be superior to R_3F_1, R_1F_1, R_2F_1 and R_6F_1 during second year of experiment *i.e.,* 2021-22.

Table 2. Cob length (cm) of zero till maize as influenced by paddy residue management and fertilizer levels during *rabi,* 2020-21 and 2021-22

Treatment	Cob length (2020 -21)				Cob length (2021-22)			
Fertilizer levels (F)								
Residue management (R)	F_1- 75 % RDF	F_2- 100 % RDF	F_3- 125 % RDF	Mean	F_1- 75 % RDF	F_2- 100 % RDF	F_3- 125 % RDF	Mean
R_1- *In-situ* burning	10.1	12.5	15.9	12.8	10.7	14.1	16.5	13.8
R_2- Retention	11.0	13.3	14.7	13.0	11.4	13.9	16.5	13.9
R_3- Removal	9.8	13.1	14.9	12.6	9.9	14.6	16.2	13.6
R_4- Incorporation	11.7	13.8	15.3	13.6	13.5	15.3	17.5	15.4
R_5-Incorporation + SSP	12.2	15.8	16.6	14.9	14.0	17.4	18.1	16.5
R_6-Retention + consortium	10.0	13.3	16.3	13.2	12.1	13.8	16.5	14.1
R_7-Consortium + incorporation	15.6	16.3	16.6	16.2	16.8	17.3	17.8	17.3
R_8-Consortium + incorporation + SSP	17.2	17.4	17.9	17.5	17.7	18.1	18.5	18.1
Mean	12.2	14.4	16.0		13.3	15.6	17.2	
For comparison the mean of	SE(m)±		CD (P=0.05)		SE(m)±		CD (P=0.05)	
Residue management	0.3		1.1		0.2		0.6	
Fertilizer levels	0.4		1.4		0.3		1.2	
R at levels of F	0.4		1.1		0.4		1.0	
F at levels of R	1.1		3.3		1.1		3.3	

Table 3. Cob girth (cm) of zero till maize as influenced by paddy residue management and fertilizer levels during *rabi,* 2020 and 2021

Treatment	Cob girth (2020 -21)				Cob girth (2021-22)			
Fertilizer levels (F)								
Residue management (R)	F_1- 75 % RDF	F_2- 100 % RDF	F_3- 125 % RDF	Mean	F_1- 75 % RDF	F_2- 100 % RDF	F_3- 125 % RDF	Mean
R_1-*In-situ* burning	7.9	9.7	11.6	9.7	8.4	10.5	12.3	10.4
R_2- Retention	8.0	9.9	11.7	9.9	8.7	10.6	12.3	10.5
R_3- Removal	7.6	9.4	11.3	9.4	8.1	10.3	11.9	10.1
R_4- Incorporation	9.0	10.2	12.4	10.5	10.0	12.8	14.2	12.3
R_5-Incorporation + SSP	9.8	12.9	13.1	11.9	10.6	14.4	15.2	13.4
R_6-Retention + consortium	7.2	10.0	13.4	10.2	7.2	10.7	15.1	11.0
R_7-Consortium + incorporation	12.7	13.6	13.7	13.3	14.0	14.5	14.9	14.5
R_8-Consortium + incorporation + SSP	14.3	14.8	15.0	14.7	15.1	15.5	16.1	15.6
Mean	9.6	11.3	12.8		10.3	12.4	14.0	
For comparison the mean of	SE(m)±		CD (*P=0.05*)		SE(m)±		CD (*P=0.05*)	
Residue management	0.4		1.1		0.3		0.9	
Fertilizer levels	0.1		0.5		0.3		1.2	
R at levels of F	0.3		1.0		0.4		1.2	
F at levels of R	0.8		2.5		1.2		3.6	

Table 4. Kernel rows cob^{-1} and 100 kernel weight (g) of zero till maize as influenced by paddy residue management and fertilizer levels

Treatments	Kernel rows cob^{-1}		100 kernel weight (g)	
	2020-21	2021-22	2020-21	2021-22
Horizontal plots: Paddy residue management options (R)				
R_1- *In-situ* burning	14.1	14.7	22.3	24.6
R_2- Retention	14.5	14.9	23.3	25.5
R_3- Removal	13.8	14.5	22.2	24.2
R_4- Incorporation	14.8	15.4	24.5	26.7
R_5-Incorporation + SSP	15.0	15.6	24.7	27.1
R_6-Retention + consortium	14.6	15.2	24.0	26.2
R_7-Consortium + incorporation	15.4	16.0	24.9	27.3
R_8-Consortium + incorporation + SSP	15.8	16.3	25.6	27.5
SE(m)±	0.4	0.6	0.7	0.7
CD (*P=0.05*)	NS	NS	NS	NS
Vertical plots: Fertilizer levels (F)				
F_1- 75 % RDF	13.8	14.4	23.3	25.4
F_2- 100 % RDF	14.8	15.3	23.8	26.1
F_3- 125 % RDF	15.6	16.2	24.7	27.0
SE(m)±	0.4	0.3	0.3	0.3
CD (*P=0.05*)	NS	NS	NS	NS
Interaction				
R at levels of F				
SE(m)±	0.5	0.5	0.8	0.8
CD (*P=0.05*)	NS	NS	NS	NS
F at levels of R				
SE(m)±	1.4	1.1	2.0	2.0
CD (*P=0.05*)	NS	NS	NS	NS

Table 5. No of kernels cob^{-1} of zero till maize as influenced by paddy residue management and fertilizer levels during *rabi,* 2020-21 and 2021-22

Treatment	No of kernels cob^{-1} (2020 -21)				No of kernels cob^{-1} (2021-22)			
Fertilizer levels (F)								
Residue management (R)	**F_1- 75 % RDF**	**F_2- 100 % RDF**	**F_3- 125 % RDF**	**Mean**	**F_1- 75 % RDF**	**F_2- 100 % RDF**	**F_3- 125 % RDF**	**Mean**
R_1- *In-situ* burning	145	282	327	251	188	284	362	278
R_2- Retention	148	241	379	256	192	289	362	281
R_3- Removal	144	255	348	249	169	281	378	276
R_4- Incorporation	149	264	399	271	245	301	425	324
R_5-Incorporation + SSP	186	368	394	316	244	402	428	358
R_6-Retention + consortium	145	225	416	262	194	293	382	290
R_7-Consortium + incorporation	348	357	369	358	381	390	399	390
R_8-Consortium + incorporation + SSP	376	397	401	391	411	423	438	424
Mean	205	299	379		253	333	397	
For comparison the mean of		SE(m)±		CD (*P=0.05*)		SE(m)±		CD (*P=0.05*)
Residue management		8		26		9		28
Fertilizer levels		9		38		5		20
R at levels of F		10		31		9		26
F at levels of R		32		93		23		66

Test weight

Non-significant effect of fertility levels and residue management interaction was recorded with the test weight in maize (Table 4).

Grain

A critical look at the data indicates that the grain yield of maize was influenced significantly due to the different residue management practices and fertility levels as observed in Table 6 and 7. Maize kernel yield was significantly higher with consortium + incorporation + SSP in combination with 125 % RDF (R_8F_3) than with the other residue management practices examined. The kernel yield of maize mainly depends on the partitioning ability of photosynthates from source to sink *i.e.*, developing cobs and kernels which lead to increased yield. All the yield-promoting characters were significantly higher with consortium + incorporation + SSP due to better partitioning of photosynthates to developing cobs. Consortium + incorporation with 125 % RDF (R_7F_3) was the next best treatment in terms of higher maize yield and it distinguished itself significantly from the other treatments, namely, incorporation (R_4F_3) and incorporation + SSP (R_5F_3). The absence of consortium limited the availability of nutrients as well as activity of microbes in sole incorporation plots, hence the decomposition rate was slow. So an additional dose of nutrients (125 % RDF) limited the immobilization and improved the yield in R_4 and R_5 plots. According to previous research (12), the mere incorporation of residues into the soil has a negative impact on the available nutrients in the soil due to the immobilization of nutrients by the presence of residues with a wide C/N ratio, resulting in lower yields in rice and wheat. The grain yields under 125 % RDF + removal, 125 % RDF + *in-situ* burning and 125 % RDF + retention, 125 % RDF + retention + consortium were found to be statistically on par with each other and 125 % RDF + residue incorporation was also found at par during first year of study while it was significantly superior over R_3,R_1,R_2 and R_6 during second year *i.e.*, *rabi* 2021-22.

Straw yield

It is apparent from the data that residue management practices and fertility levels had recorded a significant impact on straw yield as shown in Table 6 and 7. The highest straw yield was achieved when consortium, incorporation and SSP (R_8) were used in conjunction with 125 % RDF (F_3). During both *rabi* 2020-21 and 2021-22, the straw yields under 125 % RDF + removal (R_3F_3), 125 % RDF + *in-situ* burning (R_1F_3), 125 % RDF + retention

Table 6. Yield (Kg ha^{-1}) of maize as influenced by residue management and fertilizer levels during 2020-21

Treatment	Grain yield (Kg ha^{-1})				Straw yield (Kg ha^{-1})			
	Fertilizer levels							
Residue management (R)	**F_1- 75 % RDF**	**F_2- 100 % RDF**	**F_3- 125 % RDF**	**Mean**	**F_1- 75 % RDF**	**F_2- 100 % RDF**	**F_3- 125 % RDF**	**Mean**
R_1- *In-situ* burning	4412	5161	5991	5188	5030	6232	7052	6105
R_2- Retention	4488	5438	5869	5265	4295	6245	7941	6160
R_3- Removal	4039	5255	6220	5171	5284	6180	6666	6043
R_4- Incorporation	4564	5418	6239	5407	4649	6553	8061	6421
R_5-Incorporation + SSP	5381	5923	6088	5797	5611	7492	7956	7020
R_6-Retention + consortium	4724	5355	5941	5340	5537	6254	7268	6353
R_7-Consortium + incorporation	6132	6211	6273	6205	7508	7581	7702	7597
R_8-Consortium + incorporation + SSP	6487	6529	6787	6601	7932	8164	8357	8151
Mean	5028	5661	6176		5731	6838	7625	
For comparison the mean of	SE(m)±		CD (*P=0.05*)		SE(m)±		CD (*P=0.05*)	
Residue management	125.2		379.8		159.1		482.7	
Fertilizer levels	127.7		501.6		184.0		722.5	
R at levels of F	139.9		405.3		217.9		631.2	
F at levels of R	413.9		1199.1		666.9		1932.1	

Table 7. Yield (Kg ha^{-1}) of maize as influenced by residue management and fertilizer levels during 2021-22

Treatment	Grain yield (Kg ha^{-1})				Straw yield (Kg ha^{-1})			
	Fertilizer levels							
Residue management (R)	**F_1- 75 % RDF**	**F_2- 100 % RDF**	**F_3- 125 % RDF**	**Mean**	**F_1- 75 % RDF**	**F_2- 100 % RDF**	**F_3- 125 % RDF**	**Mean**
R_1- *In-situ* burning	4828	5210	5807	5282	5170	6396	7219	6262
R_2- Retention	4909	5359	5723	5330	4816	6417	7797	6343
R_3- Removal	4520	5403	5801	5241	4352	6221	8041	6205
R_4- Incorporation	5383	5771	6292	5815	6206	6873	7887	6989
R_5-Incorporation + SSP	5867	6291	6489	6216	6970	7750	7814	7511
R_6-Retention + consortium	4976	5377	5854	5402	5060	6490	7839	6463
R_7-Consortium + incorporation	6518	6631	6693	6614	7915	8055	8143	8038
R_8-Consortium + incorporation + SSP	6929	6971	7096	6999	8269	8568	8828	8555
Mean	5491	5877	6219		6095	7096	7946	
For comparison the mean of	SE(m)±		CD (*P=0.05*)		SE(m)±		CD (*P=0.05*)	
Residue management	125.1		379.7		169.2		513.3	
Fertilizer levels	82.8		325.2		167.4		657.3	
R at levels of F	100.1		290.0		218.2		632.3	
F at levels of R	238.7		691.7		647.4		1875.4	

(R_2F_3) and 125 % RDF + retention + consortium (R_6F_3) were found to be statistically equivalent to one another. When fertilizers are combined with residues and microbial consortium, the physical properties of the soil will be improved, micronutrients will be replenished, soil moisture will be retained and fertilizer efficiency will increase for high yield. And increased vegetative growth in terms of plant height, leaf area index and dry matter production resulted in increased stover yield.

Conclusion

This experiment has shown that the incorporation of crop residues after the application of microbial consortium and SSP in conjunction with 125 % RDF significantly increased grain yield and straw yield of maize. The decomposition of crop residues can be enhanced with incorporation of residues treated with consortium and SSP in conjunction with 125 % RDF as compared to removal due to wide reduction in C:N ratio and increased microbial and enzyme activity observed during study. The yield components like number of cobs per plant, length of the cob, girth of the cob, number of kernels per cob, number of kernel rows per cob, test weight of maize were also found to be increased under zero tillage conditions.

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Authors' contributions

GR carried out field studies, also done the lab work and drafted the manuscript. BP and MMR conceived of the study and participated in its design and coordination. GSM participated in the design of the study and performed the statistical analysis. All authors read and approved of the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

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