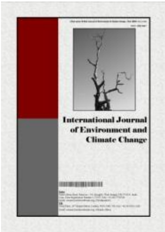

International Journal of Environment and Climate Change

12(10): 449-461, 2022; Article no.IJECC.86978
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Effect of Organic and Inorganic Sources of Nutrients on Yield Attributes and Yield of Maize in Aerobic Rice- Zero Till Maize Cropping System Under Sandy Clay Loam Soils in Southern Telangana Agro-Climatic Zone

J. S. Sudha Rani [a*φ], B. Sreedevi [b#], K. P. Vani [c†], P.C. Latha [d‡], M. Venkata Ramana [e‡], P. Surendra babu [f#] and K. Naganjali [g,h¥,⊦]

[a] Electronic wing, Agricultural Research Institute, PJTSAU, Rajendranagar, Hyderabad, India.
[b] Agronomy, ICAR-IIRR, Rajendranagar, Hyderabad, India.
[c] Agriculture College, Siricilla, PJTSAU, Telangana, India.
[d] AICRP on IFS, Rajendranagar, Hyderabad, India.
[e] Microbiology, ICAR-IIRR, Rajendranagar, Hyderabad, India.
[f] AICRP on Micronutrients, ARI, Rajendranagar, Hyderabad, India.
[g] Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad - 500 030, India.
[h] Agronomy, Agriculture College, Aswaraopet, PJTSAU, Telangana, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2022/v12i1030818

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/86978

Original Research Article

Received 20 February 2022
Accepted 29 April 2022
Published 16 May 2022

ABSTRACT

Continuous growing of rice –rice mono-cropping over the years and excessive dependence on chemical fertilizers alone has led to decrease in soil fertility and productivity. Rice–maize double cropping is gaining popularity in many Asian countries including India. fertilizer need of a crop in a

[φ] Scientist, Agronomy,
[#] Principal Scientist,
[†] Professor and Head,
[‡] Principal Scientist and University Head Agronomy,
[¥] Professor,
[⊦] Assistant Professor,
**Corresponding author: E-mail: sudharaniscientist@gmail.com;*

system is strongly influenced by the preceding crops and the amount of fertilizers applied to them. Cropping with two nutrient intensive cereals like rice-maize would remove a substantial quantity of plant nutrients from soil during continued agriculture round the year, envisaging the need for adoption of efficient nutrient management practices for sustained soil health and improving system productivity. A field experimentt was carried out to study the residual effect of organic nutrient sources and inorganic fertilizer levels on yield attributes and yield of zero till maize. The experiment was laid out in split plot design with four organic sources of nutrients applied to preceding rice as main plots *viz*: $M_{1:}$ Neem leaf manure @ 6 t ha^{-1}; M_2: Vermicompost @ 2 t ha^{-1}; M_3: Goat manure @ 5 t ha^{-1}; M_4: Microbial consortia [seed treatment @ 4 g kg^{-1} + soil application @ 4 kg ha^{-1}] and four subplots with graded doses of fertilizers *viz*: S_1: Control; S_2: 50% RDF; S_3: 75% RDF and S_4: 100% RDF (180:60:60). The study revealed that various organic nutrient sources and graded fertilizer doses exerted a remarkable effect on plant height, LAI, dry matter production and Days to 50% silking which resulted in significantly higher grain, stover yield and harvest index of zero till maize.

Keywords: Zero till maize; organic nutrient sources; inorganic fertilizer management.

1. INTRODUCTION

Maize (*Zea mays* L.) belonging to the family Poaceae is one of the important versatile cereal crop with wider adaptability, photo-insensitivity under the different ecological scenarios and rich in starch, proteins, oil and sucrose [1]. Among the maize growing countries, India rank 4th in area and 7th in production, representing around 4% of the world maize area and 2% of total production. During 2018-19 in India, the maize area has reached to 9.2 million ha [2] with 27.8 million MT production and 2965 kg/ha productivity [3] while in Telangana, it is grown in an area of 0.56 M. ha with production of 2.99 M. T and 5347 kg ha^{-1} of productivity [4]. Rice–maize double cropping is gaining popularity in many Asian countries including India and currently occupies around 3.5 M. ha in Asia [5]. The recent water shortage conditions for continuous rice cultivation and increased demand for maize in poultry and fish industries prompted studies for an economically viable rice-maize cropping system. The development of short duration rice varieties coupled with high yielding maize hybrids provided an opportunity for increasing the area under rice-maize cropping in India, Bangladesh, Pakistan, and Nepal as an important alternative to bridge productivity gap in rice–wheat (*Triticum aestivum*L.) cropping system.

Zero Tillage crop establishment practices reduce the fuel required to produce a crop with lower emissions of CO_2, better soil moisture conservation, reduced weeds and provide favourable thermal conditions in the soil. Timsina *et al.* [6] hypothesized that under improved nutrient management the establishment of maize after rice with reduced or no tillage, and retaining of crop residues, could help to conserve soil organic matter (SOM) and maintain soil fertility.

The fertilizer need of a crop in a system is strongly influenced by the preceding crops and the amount of fertilizers applied to them. Cropping with two nutrient intensive cereals like rice-maize would remove a substantial quantity of plant nutrients from soil during continued agriculture round the year, envisaging the need for adoption of efficient nutrient management practices for sustained soil health and improving system productivity [7]. Proper nutrient management of exhaustive systems like R-M should aim to supply fertilizers adequate for the demand of the component crops and apply in ways that minimize loss and maximize the efficiency of use.INM systems seek to maintain or improve soil fertility for sustaining the desired levels of crop production and productivity through optimization of benefits from all possible sources of plant nutrients in an integrated manner [8]. It entails the conjunctive use of compost FYM, vermicompost, crop residues, green manures, crop rotation, biofertilizers and chemical fertilizers in a compatible manner to achieve sustainable yields. For efficient nutrient management in rice based cropping systems, a quantitative evaluation of the role of preceding crop and the residual effect of nutrients applied assumes great importance.

In the light of above context, an experiment was planned and investigations were carried out for two consecutive years of *kharif* and *rabi*, 2017-18; *kharif* and *rabi*, 2018-19 to to generate more information on contribution of various organic manuring and nutrient management practices for rice and then cumulative effect of both the practices on maize under zero tillage after aerobic rice during *rabi* season.

2. MATERIALS AND METHODS

Present field experiment was conducted during *kharif* – *rabi* consecutive years, 2017-18 and 2018-19 at Research Farm, ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad. The farm is geographically situated at an altitude of 542.6 m above mean sea level (MASL) at 17^o 19' N latitude and 78^0 23' E longitude. The region is categorized under the Southern Telangana Agro-climatic zone under semi-arid tropic region (SAT). The soils were sandy clay loam in texture with pH of 8.14, Electrical conductivity (EC) 0.0.33 d S/m, low in organic C (0.41%), available N (208 kg/ha), and high in available P (28 kg/ha) and available K (382 kg/ha). Experiment was laid out in split plot design, undisturbed layout to both crops, with four main treatments as organic sources of nutrients applied to aerobic rice *viz:* M_1: Neem leaf manure @ 6 t ha^{-1}, M_2: Vermicompost @ 2 t ha^{-1}, M_3:Goat manure @ 5 t ha^{-1} and M_4: Microbial consortia (seed treatment @ 4 g kg^{-1} + soil application @ 4 kg ha^{-1}) and four sub treatments as fertility levels S_1: Control, S_2: 50% RDF, S_3: 75% RDF and S_4: 100% RDF which was replicated thrice.

2.1 Neem Leaf Manure

In *kharif* season neem leaves @ 6 t ha^{-1} were uniformly spread in aerobic rice plots followed by rice sowing. Initially neem leaves served as mulch preventing weeds and conserving soil moisture and at later stages decomposed and served as manure.

2.2 Vermicompost (VC) @ 2 t ha^{-1} and Goat Manure (GM) @ 5t ha^{-1}

Organic manures were applied in respective plots 10 days before aerobic rice sowing and incorporated in to the soil.

2.3 Consortium of Plant Growth Promoting Rhizobacteria (PGPR)

Methylobactor fugisavence, Glucanoacetobactor diacetophicus and *Bacillus subtilis* @ 4g kg^{-1} was treated to seed one day before sowing and shade dried.

Subsequently, nitrogen, phosphorus and potassium fertilizer requirement of each of the individual treatment was determined and applied to the maize crop in the form of urea, single super phosphate and muriate of potash, respectively. Nitrogen dosage was applied in three equal splits i.e., ⅓rd as basal ⅓rd at knee high stage and remaining ⅓rd at tasseling stages. Entire dose of P_2O_5 was applied as basal and K_2O was applied in two equal splits ½ as basal ½ at tasselling stage.

3. RESULTS AND DISCUSSION

3.1 Plant Height (cm)

Data presented in Table. 2. and Fig.1 revealed that plant height of maize increased continuously up to harvest during 2017-18 and 2018-19. Rate of increase in plant height was high up to 60 DAS and thereafter slowed down. Plant height at 30 DAS during both years of study was not influenced by residual nutrient sources and nutrient levels however, these practices had shown significant effect on plant height at 60, 90 DAS and at harvest. The interaction of residual nutrient sources and cumulative nutrient levels in *rabi* maize was found to be non-significant on plant height of maize.

Pooled mean analysis revealed that M_3 treatment *i.e.* goat manuring 5 t ha^{-1} had resulted in taller plants followed by M_2 *i.e.* vermicompost @ 2 t ha^{-1} both were on par with each other *fb* M_1 *i.e.* neem leaf manure @ 6 t ha^{-1}. Significantly shorter plants are produced with M_4 *i.e.* microbial consortia @ 4 g/ kg ST 4 kg ha^{-1} SA at 60, 90 DAS and harvest.

Table 1. Composition of Nutrient sources used in experiment

S.No.	Nutrient	Neem leaf manure		Vermicompost		Goat manure	
		2017	2018	2017	2018	2017	2018
1	Nitrogen (%)	0.89	0.91	1.98	2.02	1.14	1.23
2	Phosphorus (%)	0.22	0.24	0.52	0.58	0.14	0.15
3	Potassium (%)	0.54	0.53	1.38	1.42	0.32	0.38

S_4 [100% RDF] produced tallest plants with height of 111.0, 166.8 and 214.4 cm, which were equivalent to S_3 [75% RDF] (105.8, 159.0 and 204.3 cm). At periodic intervals, the lowest plant height of 84.2, 127.2 and 163.6 cm was observed with S_1 [Control].

The improvement in plant height in response to organic manures (M_2 and M_3) over rest of treatments might be due to enhanced availability of both macro and micro nutrients; in particular nitrogen, besides improvement in soil microbial activity. These results are supported by the findings of Pramanik *et al.* [9], Sudhakar [10].

Taller plants may have resulted from higher stem growth due to enhanced meristematic cell activity, cell division and cell elongation of internodes which were facilitated by available nutrients. Similar results were found by Raju *et al.* [11] and Thakur and Vinod Sharma [12] and Singh *et al.* [13], Padmaja [14], Prasada Rao [15]) and Hillary *et al*. [16].

3.2 Leaf Area Index (LAI)

Leaf area index (LAI) is a physiological feature that can be used to determine performance of plant canopy in terms of growth and productivity. Results of nutrient and weed management practices significantly influenced leaf area index of zero till maize during *rabi* 2017-18 and 2018-19 at various crop growth intervals displayed in Table 3 and Fig. 2 Leaf area index at different intervals followed a similar trend to number of leaves plant^{-1}.

According to pooled means of nutrient management practices in zero tillage maize, vermicompost @ 2 t ha^{-1} recorded maximum leaf area index at 30, 60, 90 DAS and harvest which was in congruity with goat manure @ 5 t ha^{-1}, while minimum leaf area index was noticed with microbial consortia @ 4 g/ kg ST 4 kg ha^{-1} SA {M_4} at different crop growth spells.

S_4 [100% RDF] had registered maximum leaf area index at different intervals which was statistically similar with S_3. The control treatment had shown the lowest leaf area index.

Continuous and slow available nutrients might have increased no. of leaves plant^{-1} and improved leaf expansion in plants led to increased leaf area index. Similar observations were made by Choudhary and Kumar (2013), Manwar and Mankar [17] and Mahato*et al*. [18].

3.3 Dry Matter Production (kg ha^{-1})

Residual nutrient sources and cumulative nutrient levels significantly influenced dry matter accumulation of maize at different growth intervals as elaborated in the Table 3 and Fig. 4. During both years, as crop age progressed, dry matter production of zero tillage maize increased. However, the pace of rise was faster up to 90 DAS and thereby it slowed down. In comparison to previous years, dry matter production was higher in 2018-19. The interaction effect of residual nutrient sources and cumulative nutrient levels on dry matter production was non-significant.

Dry matter production revealed that M_3 [goat manure @ 5 t ha^{-1}] recorded significantly highest crop dry matter 30, 60, 90 DAS and harvest and at par with M_2 [vermicompost @ 2 t ha^{-1}] *fb* M_1 [neem leaf manure 6 t ha^{-1}] However, lowest dry matter was observed with M_4 [microbial consortium 4 g kg seed^{-1}& 4 kg ha^{-1} soil application]

Significantly maximum dry matter of was developed by S_4 [100% RDF] *fb* S_3 [75% RDF] at different growth intervals. However, S_1 [Control] registered minimum dry matter as compared to S_2 [50% RDF].

Balanced supply of nutrients might have enabled maize plants to absorb adequate amounts of major nutrients, which increased their growth which in turn put forth more photosynthetic area, thus contributed to more dry matter accumulation. Enhanced dry matter accumulation with increased nutrient availability was reported by Padmaja [14] and Karan Varma (2018).

3.4 Days to 50% silking

A perusal of data presented in Table 5 revealed that days to 50% silking was significantly different for residual nutrient sources and nutrient levels during *rabi,* 2017-18 and 2018-19. There was no interaction found between main and sub plots with respect to days to 50% silking.

Perusal of data on nutrient management practices further indicated that lesser no. of days was taken to 50% silking with, M_3 [goat manure 5 t ha^{-1}] or M_2 [vermicompost 2 t ha^{-1}], while application of M_1 treatment *i.e.* neem leaf manure 6 t ha^{-1} and with M_4 [Microbial consortia seed treatment @ 4 g kg^{-1} + soil application @ 4 kg

Table 2. Plant height (cm) of maize at different intervals as influenced by nutrient sources and levels during *rabi*

Treatment	30 DAS			60 DAS			90 DAS			At harvest		
	2017-18	2018-19	Pooled mean	2017-18	2018-19	Pooled mean	2017-18	2018-19	Pooled mean	2017-18	2018-19	Pooled mean
Residual organic nutrient sources (M)												
M_1: Neem leaf manure 6 t ha^{-1}	35.3	40.4	37.8	100.4	104.9	102.7	141.8	144.9	143.3	151.7	154.8	153.2
M_2: Vermicompost 2 t ha^{-1}	39.8	44.5	42.1	107.3	113.7	110.5	152.6	160.7	156.7	164.2	167.5	165.8
M_3: Goat manure 5 t ha^{-1}	42.0	46.0	44.0	114.1	119.2	116.7	156.6	166.4	161.5	166.9	170.3	168.6
M_4: Microbial consortia 4 g kg $seed^{-1}$ & 4 kg ha^{-1} soil application	31.9	34.1	33.0	93.6	97.6	95.6	131.2	134.3	132.7	142.7	145.6	144.1
SEm±	0.86	0.98	0.92	1.79	1.86	1.82	2.59	2.07	2.26	2.47	2.52	2.50
CD (*P=0.05*)	NS	NS	NS	6.21	6.43	6.32	8.96	7.17	7.82	8.56	8.73	8.65
Fertilizer levels (S)												
S_1: 0% RDF	25.5	27.7	26.6	63.4	68.7	66.1	76.3	91.3	83.8	89.4	91.3	90.3
S_2: 50% RDF	38.0	42.2	40.1	101.8	105.0	103.4	137.8	141.5	139.6	147.2	150.2	148.7
S_3: 75% RDF	41.5	46.1	43.8	119.7	127.3	123.5	174.9	177.8	176.4	188.4	192.3	190.3
S_4: 100% RDF	43.8	49.0	46.4	130.5	134.5	132.5	193.2	195.7	194.4	200.4	204.5	202.4
SEm±	0.78	0.86	0.82	2.33	2.46	2.40	3.16	2.22	2.25	2.77	2.83	2.80
CD (*P=0.05*)	NS	NS	NS	6.81	7.18	6.99	9.23	6.48	6.55	8.10	8.26	8.18
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3. Leaf area index (LAI) of maize at different intervals as influenced by residual organic nutrient sources and fertilizer levels during *rabi*

Treatment	30 DAS			60 DAS			90 DAS			At harvest		
	2017-18	**2018-19**	**Pooled Mean**	**2017-18**	**2018-19**	**Pooled Mean**	**2017-18**	**2018-19**	**Pooled Mean**	**2017-18**	**2018-19**	**Pooled Mean**
Residual organic nutrient sources (M)												
M_1: Neem leaf manure 6 t ha^{-1}	1.34	1.52	1.43	2.97	3.36	3.17	4.24	4.41	4.32	1.62	1.63	1.63
M_2: Vermicompost 2 t ha^{-1}	1.49	1.63	1.56	3.35	3.75	3.55	4.50	4.72	4.61	1.68	1.76	1.72
M_3: Goat manure 5 t ha^{-1}	1.50	1.66	1.58	3.46	3.77	3.57	4.58	4.78	4.68	1.74	1.83	1.78
M_4: Microbial consortia 4 g kg $seed^{-1}$ & 4 kg ha^{-1} soil application	1.29	1.43	1.36	2.70	3.17	2.99	3.94	4.10	4.02	1.59	1.63	1.61
SEm±	0.04	0.02	0.03	0.04	0.05	0.03	0.07	0.07	0.06	0.04	0.08	0.06
CD (*P=0.05*)	0.15	0.08	0.09	0.14	0.16	0.10	0.22	0.26	0.22	0.13	0.28	0.19
Fertilizer levels (S)												
S_1: 0% RDF	1.23	1.39	1.31	2.26	2.56	2.47	2.96	3.03	3.00	1.54	1.56	1.55
S_2: 50% RDF	1.38	1.55	1.46	3.18	3.44	3.32	4.46	4.61	4.53	1.61	1.65	1.63
S_3: 75% RDF	1.47	1.63	1.55	3.44	3.86	3.65	4.82	5.08	4.95	1.69	1.76	1.73
S_4: 100% RDF	1.55	1.66	1.61	3.59	4.18	3.83	5.03	5.29	5.16	1.79	1.89	1.84
SEm±	0.03	0.02	0.03	0.04	0.07	0.04	0.06	0.07	0.06	0.06	0.06	0.04
CD (*P=0.05*)	0.10	0.07	0.09	0.13	0.21	0.12	0.17	0.21	0.18	0.17	0.16	0.11
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4. Dry matter production (kg ha^{-1}) of maize at different intervals as influenced by residual organic nutrient sources and fertilizer levels during *rabi*

Treatment	30 DAS			60 DAS			90 DAS			At harvest		
	2017-18	**2018-19**	**Pooled Mean**	**2017-18**	**2018-19**	**Pooled Mean**	**2017-18**	**2018-19**	**Pooled Mean**	**2017-18**	**2018-19**	**Pooled Mean**
Residual organic nutrient sources (M)												
M_1: Neem leaf manure 6 t ha^{-1}	1038	1274	1156	5505	5691	5598	7917	8231	8113	11580	11885	11733
M_2: Vermicompost 2 t ha^{-1}	1213	1383	1298	5667	5868	5767	8725	9039	8882	12807	13181	12994
M_3: Goat manure 5 t ha^{-1}	1354	1536	1445	5787	6014	5901	8964	9308	9136	13156	13568	13362
M_4: Microbial consortia 4 g kg seed^{-1} & 4 kg ha^{-1} soil application	903	1115	1009	5134	5258	5196	7116	7347	7231	10382	10669	10525
SEm±	38	46	41	118	107	112	166	176	173	183	270	224
CD (*P=0.05*)	131	158	144	409	369	389	576	610	597	633	934	777
Fertilizer levels (S)												
S_1: 0% RDF	933	1093	1013	4091	4223	4157	5905	6122	6053	8629	8865	8747
S_2: 50% RDF	1059	1242	1151	5416	5605	5511	8120	8398	8259	11771	12093	11932
S_3: 75% RDF	1200	1423	1311	6175	6361	6268	9183	9515	9349	13435	13814	13624
S_4: 100% RDF	1317	1550	1433	6412	6642	6527	9514	9889	9701	14090	14531	14311
SEm±	46.3	52.5	49.3	119.9	111.3	115.3	148.2	167.0	318.6	188.6	227.7	198.9
CD (*P=0.05*)	135.2	153.4	143.9	349.8	324.9	336.7	432.4	487.5	1019.1	550.6	664.5	580.4
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 5. Days to 50 % silking (days) of maize as influenced by nutrient sources and levels during *rabi,* 2017-18 & 2018-19

Treatment	2017-18	2018-19	Pooled mean
Residual organic nutrient sources (M)			
M_1: Neem leaf manure 6 t ha^{-1}	64.72	66.67	65.69
M_2: Vermicompost 2 t ha^{-1}	62.88	64.77	63.82
M_3: Goat manure 5 t ha^{-1}	62.51	64.47	63.53
M_4: Microbial consortia 4 g kg $seed^{-1}$ & 4 kg ha^{-1} soil application	65.94	67.24	66.59
SEm±	0.83	0.85	0.84
CD (*P=0.05*)	2.86	2.93	2.89
Fertilizer levels (S)			
S_1: 0% RDF	66.18	67.99	67.08
S_2: 50% RDF	64.49	66.25	65.37
S_3: 75% RDF	63.49	65.23	64.36
S_4: 100% RDF	61.98	63.67	62.82
SEm±	0.35	0.36	0.35
CD (*P=0.05*)	1.01	1.04	1.03
Interaction	NS	NS	NS

ha^{-1}]. Significantly prolonged no. of days to 50% silking was noticed in *rabi*. The outcomes of *rabi* 2017-18 were similar to those of *rabi* 2018-19.

Substitution of nitrogenous fertilizer with organic manures helped in earlier development of reproductive parts in maize due to continuous supply of all essential plant nutrients there by enhanced flowering as stated by Sudhakar [10]), Padmaja [14], Rao [15], Bekele *et al*. [19] and Kumar *et al*. [20].

3.5 Grain Yield (Kg ha^{-1})

During two years of the trial, residual effect of organic nutrient sources and cumulative effect of fertilizer levels resulted in pronounced effect on grain yield. However, statistically there was no significant interaction found between organic nutrient sources and fertilizer levels. In comparison to 2017-18, the yield in 2018-19 was greater. Table.6 and Fig.4 contain information on the yield.

According to pooled average data, grain yield of zero till maize gained higher with M_3 [goat manure 5 t ha^{-1}] which has statistical resemblance to M_2 [vermicompost 2 t ha^{-1}] and lowest grain yield of was yielded with M_4.

S_4 [100% RDF] accrued maximum grain yield followed by S_3 [75% RDF] and both of them were statistically comparable with each other. Grain yield of S_2 [50% RDF] was superior over S_1 [Control] which had registered lowest grain yield.

Organic manures releases plant nutrients slowly to crops over time. Higher growth, greater absorption and better translocation of assimilates from source to sink could have resulted in increased yield as and when the nutrients were available at more frequent intervals from organic and inorganic sources. These findings are similar to those of Lakshmi *et al*. [21], Pasha *et al*. [22], Rao [15], Ghosh *et al*. [23] and Sigaye *et al*. [24].

3.6 Stover yield (kg ha^{-1})

The amount of maize stover and grain production are inextricably related. Stover is related in proportion to amount of grain produced. Amount of stover produced depends on genetic makeup of crop, weather, soil nutrient status and management strategies. Stover yield is used in the estimation of harvest index.

During *rabi* 2017-18 and 2018-19, nutrient management practices had a substantial impact on stover yield of zero till maize. However, their interaction was not significant, as seen in Table 6 and Fig.4.

Maximum stover output was achieved with M_3 *i.e.* goat manure @ 5 t ha^{-1} and was similitude to M_2 [vermicompost @ 2t ha^{-1}] but significantly different from M_1 and M_4. While M_1 *i.e.*100% RDF had minimum stover output.

Table 6. Grain and straw yield (kg ha^{-1}) and HI (%) of maize as influenced by nutrient sources and levels during *rabi*

Treatment	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})			HI (%)		
	2017-18	2018-19	Pooled Mean	2017-18	2018-19	Pooled Mean	2017-18	2018-19	Pooled Mean
Residual organic nutrient sources (M)									
M_1: Neem leaf manure 6 t ha^{-1}	5175	5306	5241	6483	6683	6583	43.8	42.2	43.0
M_2: Vermicompost 2 t ha^{-1}	5622	5886	5754	7185	7428	7306	43.4	42.5	42.9
M_3: Goat manure 5 t ha^{-1}	5786	6082	5934	7370	7634	7502	43.6	42.7	43.2
M_4: Microbial consortia 4 g kg seed^{-1} & 4 kg ha^{-1} soil application	4579	4780	4679	5803	5990	5897	43.0	42.2	42.6
SEm±	111.0	111.6	110.7	187.8	192.7	190.2	0.98	0.96	0.96
CD (*P=0.05*)	384.0	386.2	383.1	649.9	667.0	658.1	NS	NS	NS
Fertilizer levels (S)									
S_1: 0% RDF	3162	3278	3220	5467	5644	5556	36.4	35.2	35.9
S_2: 50% RDF	5219	5461	5340	6550	6753	6651	44.4	43.7	44.0
S_3: 75% RDF	6139	6416	6278	7295	7535	7415	45.8	44.8	45.3
S_4: 100% RDF	6639	6897	6768	7529	7801	7665	47.2	45.7	46.5
SEm±	138.2	145.1	141.5	143.9	146.6	145.2	0.86	0.82	0.84
CD (*P=0.05*)	403.4	423.6	413.0	420.1	428.0	423.8	2.50	2.4	2.5
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS

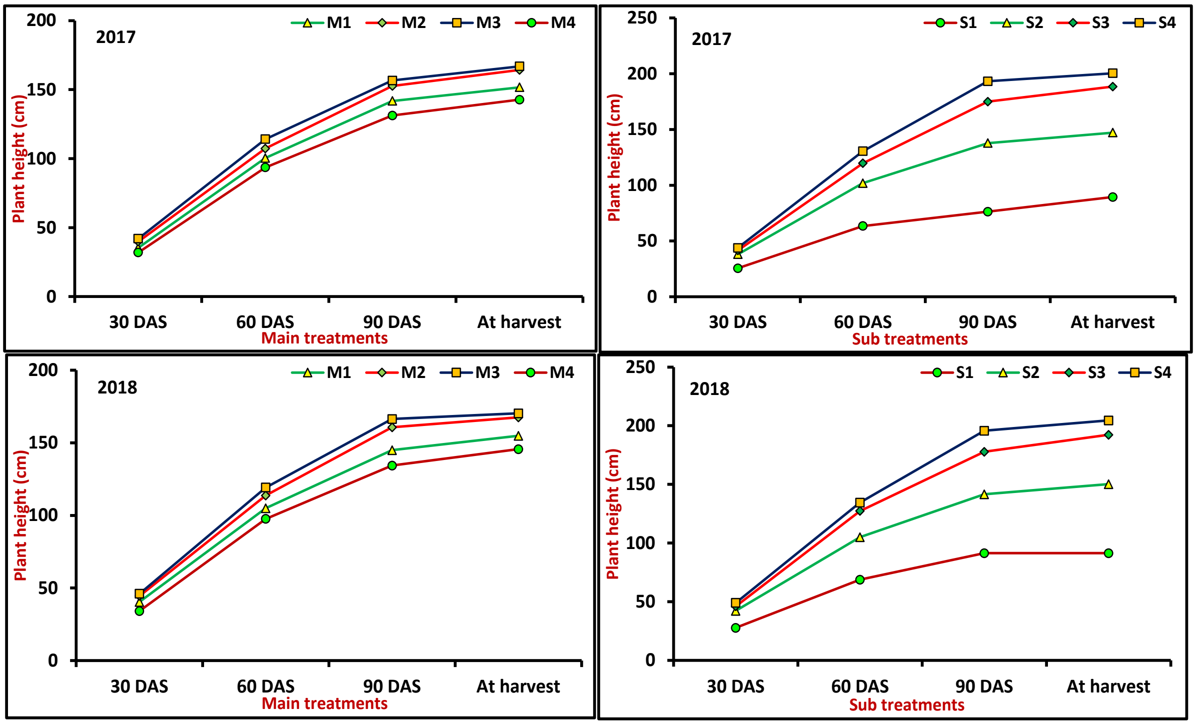

Fig. 1. Plant height of zero till maize as influenced by treatments

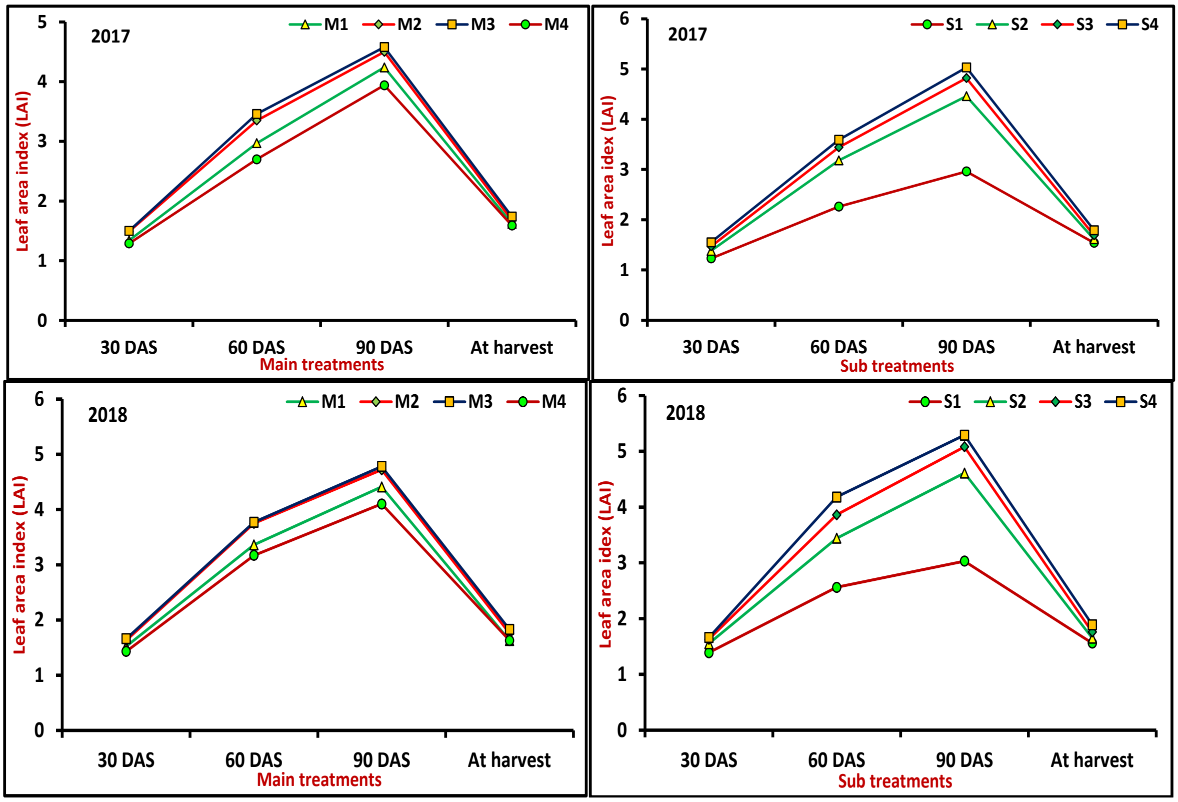

Fig. 2. LAI of zero till maize as influenced by treatments

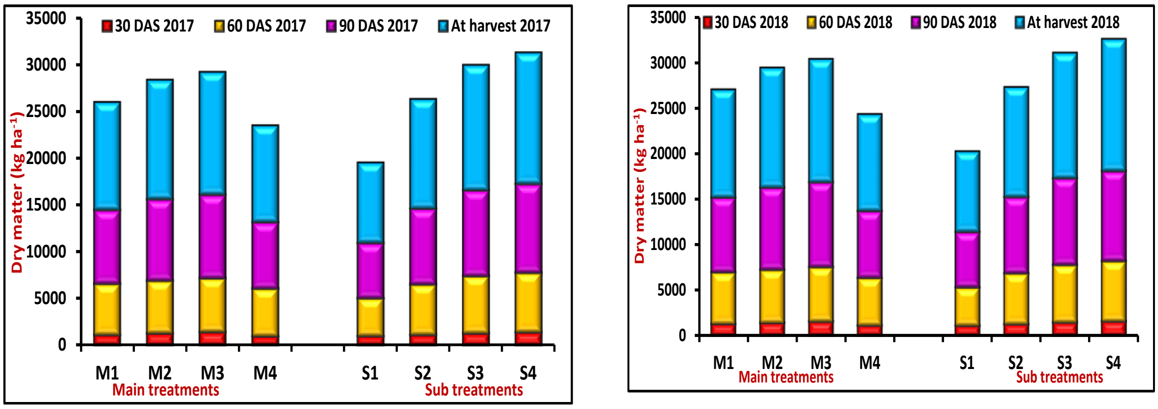

Fig. 3. Dry matter production of zero till maize as influenced by treatments

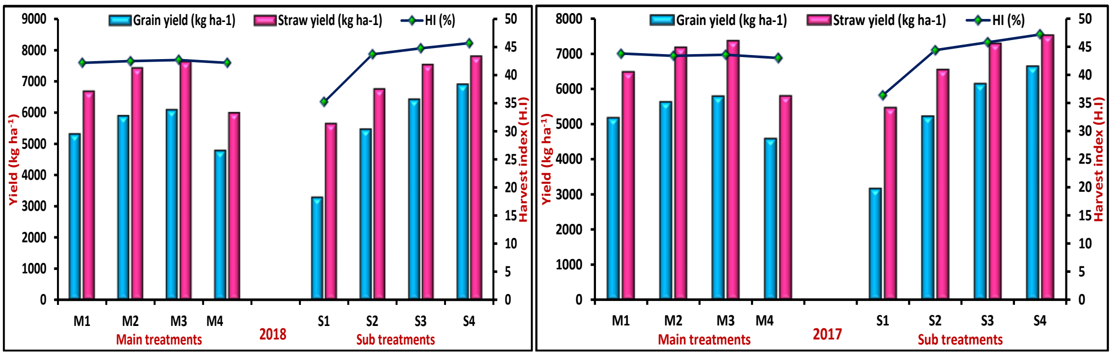

Fig. 4. Grain, straw yield kg ha^{-1} and HI% of zero till maize as influenced by treatments

The straw yield was significantly influenced by nutrient levels. 100% RDF (S_4) had significantly higher stover yield, which was statistically superior to the rest of the nutrient levels followed by S_3 [75% RDF] and S_2 [50% RDF] and S_1 [Control] produced minimum stover yield.

Increased stover output might be attributed to improved nutrient availability, which led to faster cell elongation as well as greater leaf area and photosynthate synthesis which resulted in increased dry matter. Reddy *et al*. [25], Kumari and Sudheer [26], Abid [27] and Ghosh *et al*. [23]reported similar findings.

3.7 Harvest Index

Residual effect of organic nutrient sources and cumulative effect of fertilizer levels had considerable impact on maize harvest index, but their interaction was not significant. However, as indicated in table 6 and Fig.4, the maximum harvest index in 2018-19 was greater than in 2017-18.

Nutrient sources had considerable residual impact on harvest index, according to two-year pooled mean data. Consistently M_3 [goat manure @ 5 t ha^{-1}] had higher harvest index which was statistically matching with M_2 [vermicompost @ 2 t ha^{-1}] followed by M_1 *i.e.* neem leaf manure @ 6 t ha^{-1}. On the other hand, M_4 [Microbial consortia seed treatment @ 4 g kg^{-1} + soil application @ 4 kg ha^{-1}] had the lowest harvest index.

Nutrient levels exerted major influence on harvest index. S_4 [100% RDF] had highest harvest index, followed by S_3 [75% RDF] and S_2 [50% RDF]. However, S_4 and S_3 were at par. When compared to other treatments, the S_1 treatment *i.e.* control, had the lowest harvest index.

The availability of nutrients may have resulted in enhanced nutrient uptake by maize crop and improved assimilate translocation from source to sink, resulting in rise in harvest index. The findings of various researchers, including Kumar *et al*. (2018) and Abid *et al*. (2020).

4. CONCLUSION

Based on the Research results, it can be concluded that the integrated nutrient management through application of goat manure 5 t ha^{-1} or vermicompost 2 t ha^{-1} to preceding aerobic rice and recommended dose ha^{-1} to zero till maize produced similar growth *viz:* plant height, LAI, dry matter production and Days to 50% flowering resulted in significantly higher grain and stover yield and harvest index as compared to the application of neem leaf manure 6 t ha^{-1} or microbial consortium 4 g kg $seed^{-1}$ & 4 kg ha^{-1} soil application or control. Hence it is evident that application of organic manures *viz*., goat manure 5 t ha^{-1} or vermicompost 2 t ha^{-1} to preceding aerobic rice has positive residual effect on maize crop yield.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Tripati KK, Ranjini warier. Biology of *Zea mays. L*, series of crop specific documents. 2011;01
2. Dacnet2020@cda-adc.ca.nic.in.website
3. IIMR2021, India Maize Scenario, ICAR-IImr.icar.gov.in
4. CMIE. Economic Intelligence Service, Agriculture Centre for Monitoring Indian Economy. Mumbai; 2020.
5. Ali MY, Waddington SR, Hodson D, Timsina J, Dixon J. Maize-ricecropping systems in Bangladesh: Status and research opportunities. Mexico, D.F.: CIMMYT; 2008.
6. Timsina J, Mangi L, Jat, Kaushik Majumda. Rice-maize systems of South Asia: current status, future prospects and research priorities for nutrient managementPlant Soil. 2010;335:65–82
   DOI 10.1007/s11104-010-0418-y.
7. Surekha KV, Rao N, Shobha Rani PC, Latha RM. Kumar. Evaluation of Organic and Conventional Rice Production Systems for their Productivity, Profitability, Grain Quality and Soil Health Agrotechnologyl. 2013;S11,
   DOI: 10.4172/2168-9881.1000S11-006
8. Kundu DK, Pillai KG. Integrated nutrient supply system in rice and rice based cropping systems. Fertilizer News. 1992;37(4):95-101.
9. Pramanik MYA, Sarkar MAR, Kabir MH, Faruk GR. Effect of green manures and different levels of nitrogen on plant height, tillering behaviour, dry matter production and yield of transplanted Aman rice. Asian Journal of Plant Sciences. 2004;3(2):291-292.
10. Sudhakar C. Integrated nutrient management in rice-maize cropping system Thesis submitted to the Acharya N. G. Ranga Agricultural University; 2011.
11. Raju SM, Srinivas A, Raja V. Performance of promising pre-release maize varieties at different nitrogen levels under rainfed conditions. Annals of Arid Zone. 1997;36(4):377-379.
12. Thakur DR, Vinod Sharma. Effect of varying rates of nitrogen and its schedule of split application in baby corn (*Zea mays L*.). Indian Journal of Agricultural Sciences. 1999;69(2):93-95.
13. Singh RN, Sutaliya R, Ghatak R, Sarangi SK. Effect of higher application of nitrogen and potassium over recommended level on growth, yield and yield attributes of late sown winter maize (*Zea mays L*.). Crop Research. 2003;26(1): 71-74.
14. Padmaja. Fertigation studies in aerobic rice-zero tillage maize cropping system. Ph.D. (Ag) Thesis submitted to Acharya N. G. Ranga Agricultural University, Hyderabad; 2014.
15. Rao PV. Response of aerobic rice zero tillage maize cropping system to sub surface drip fertigation. Ph. D Thesis. Acharya N. G. Ranga Agricultural University, Bapatla; 2016.
16. Hillary MO, Otieno, Shamie Zingore, George N, CheminingWa and Charles KG. Maize (*Zea mays L*.) growth and yield response to tillage methods and fertilizer combinations in the midland agro-ecological zones of Kenya. Turkish Journal of Agriculture – Food Science Technology. 2020;8(3): 616-624.
17. Manwar BP, Mankar DD. Effect of land configuration and fertilizer management in kharif maize (*Zea mays* L.). Journal of Soils and Crops . 2015;25(1):220-225.
18. Mahato M, Biswas S, Datta D. Effect of integrated nutrient management on growth, yield and economics of hybrid maize. Current Journal of Applied Science and Technology. 2020;39(3):78−86.

19. Bekele A, Kibret K, Bedadi B, Balemi T, Yli-Halla, M. Effects of lime, vermicompost and chemical P fertilizer on yield of maize in Ebantu District, Western highlands of Ethiopia. African Journal of Agricultural Research. 2018;13(10):477–489.
20. Kumar P, Kumar M, Kaushal Kishore and Randhir Kumar. Effect of nutrient management on yield and yield attributes of Maize (*Zea mays* L.) under different tillage practices. Journal of Pharmacognosy and Phytochemistry. 2018;7(2): 807-810.
21. Lakshmi BM, Kumari MBGS, Srinivas M, Chitkala Devi T, Sujathamma. Agro techniques for increasing the productivity of rice fallow maize under zero tillage. Symposium on resource conservation technologies in agriculture in the context of climate change held from Bapatla, India PP7.; 2010.
22. Pasha. Md. Latheef, Bhadru D., Krishna, L, Naik RBM. Evaluation of Different Herbicides in Zero Tillage Maize. Madras Agric. J. 2012;99(7-9):471-472.
23. Ghosh D, Koushik Brahmachari, Marian Brestic, Peter Ondirisik, Akbar Hossain, Milan Skalicky, Sukamal Sarkar, DebojyotiMoulick, Nirmal Kumar Dinda., Anupam Das, Biswajit Pramanick, Sagar Maitra and Richard W. Bell. Integrated Weed and Nutrient Management Improve Yield. Nutrient Uptake and Economics of Maize in the Rice-Maize Cropping System of Eastern India. Agronomy. 2020;10 (12):1906-1915.
24. Sigaye MH, Nigussei A, Lulie B, Mekuria R, Kebede K. Effects of organic and inorganic fertilizers on soil properties, yield and yield components of maize (*Zea mays* L.) grown on an Andisoils at Hawassa Zuria, Ethiopia. Advances in Applied Science Research. 2020;11:4-9.
25. Reddy MM, Padmaja B, Veeranna G, Reddy V. Evaluation of popular kharif rice (*Oryzasativa L.*) varieties under aerobic condition and their response to nitrogen dose. Journal Research of ANGRAU. 2012;40(4)14-19.
26. Kumari RC, John Sudheer M. On farm demonstration of zero tillage maize in farmers fields of Anantapuram district of Andhra Pradesh. International Journal of Agricultural Sciences. 2016;12 (1):134-138.
27. Abid M, Tahira Batool, Ghulam Siddique, Shafaqat Ali, Rana Binyamin, Munazzam Jawad Shahid, Muhammad Rizwan, Abdulaziz Abdullah Alsahli and Mohammed Nasser Alyemeni. Integrated Nutrient Management Enhances Soil Quality and Crop Productivity in Maize-Based Cropping System. Sustainability. 2020;12: 2-15.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/86978