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Effect of organic manures and inorganic sources of nitrogen on growth, grain yield and its attributes in *Rabi* maize (*Zea mays* L.) of rice-maize cropping system

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Abstract
An investigation was carried out to study the effect of organic manures and inorganic sources of nitrogen on growth, grain yield and its attributes in *Rabi* maize of rice – maize cropping system planned with three organic manural options *viz*., no manuring, in-situ incorporation of green manure crop (Sesbania aculeata) and farm yard manure @ 10 t. ha^{-1} (M_1, M_2 and M_3, respectively) and four levels of Nitrogen *viz*., 0, 50, 100 and 150% RDN (N_1, N_2, N_3 and N_4) and also three more levels of Nitrogen i.e., 50, 100 and 150% RDN (N_5, N_6 and N_7) included among sub plot treatments to observe their residual and cumulative effect on sequence crop of *Rabi* maize in relation to different levels of Nitrogen i.e., 0, 50, 100 and 150% RDN imposed to maize crop. During kharif (rice) season, three organic manural options as main plot treatments and seven Nitrogen levels (N_1, N_2, N_3, N_4, N_5, N_6 and N_7) as sub plot treatments were tested in a split plot design and replicated thrice. In the same experimental lay out, *Rabi* maize was sown with three organic manural treatments imposed to kharif rice as main plot treatments and seven Nitrogen levels as sub plots; and replicated thrice. The experimental data was recorded on plant growth, development; yield and yield attributes of *Rabi* maize crop during both the years of study. The results indicated that the organic manural options i.e., in-situ incorporation of green manure crop (Sesbania aculeata) and farm yard manure @ 10 t. ha^{-1} (M_2 and M_3, respectively) significantly influenced the plant growth of *Rabi* maize in terms of plant height, dry matter production etc., in comparison to no manuring treatment (M_1). Similarly, the yield attributes and grain yield were also significantly enhanced due to both the organic manural options Variations in growth characters of maize due to residual effect of different N levels applied to rice crop (50, 100 and 150% RDN) were not significant and remained at par. Application of graded levels of nitrogen from 50 to 150% RDN to maize enhanced the plant height, dry matter production during both the years. The days to 50 per cent flowering and days to physiological maturity were not influenced due to residual effect of different pre-rice organic manuring options during both the years of study while, they were significantly shortened due to higher levels of nitrogen. Grain and Stover yield significantly increased due to pre-rice organic manuring options and nitrogen levels over the respective control treatments in both the years. (4224 and 3905 kg ha^{-1} in the first year; and 4428 and 4499 kg ha^{-1} in the second year, respectively).

Keywords: *Rabi* Maize, rice - maize cropping system

Introduction
In Indian sub-continent, rice-maize cropping system assumes prime importance under irrigated conditions. The area under rice-rice system is slowly dwindling in the state of Telangana owing to the problems associated with meeting the irrigation needs of the rice crop grown in post rainy season. In southern Telangana zone of Telangana State, medium and long duration varieties of rice are grown during *kharif* and harvested in October / November. A minimum turn around period of about a month is required for land preparation for sowing of the next crop in sequence, which usually coincides with onset of winter experiencing low temperatures. Traditional irrigated dry crops (ID crops) like sunflower, groundnut, black gram, green gram etc. are not able to produce sustainable yields due to poor germination and crop growth under such conditions and hence, growing a suitable high yielding ID crop like maize (*Zea mays* L.) may be a better option. Maize became a major contender to other post rainy season crops in *kharif* rice fallows due to its economic viability.
However, the cultivation of two cereal crops like rice and maize in quick succession on the same piece of land is not feasible with respect to soil fertility,

resulting in decline in yield of both crops. Against an annual depletion of 28 million tonnes (mt) of nutrients, against addition of 20 mt, leaving a net gap of 8 mt per annum, a deficiency which accumulating year after year, depleting soil quality. Under such circumstances, to obtain the optimum yields, farmers have to use more and more chemical fertilizers due to heavy depletion in soil fertility (Tiwari *et al.*, 2002) [14]. The possibility of growing many field crops in sequence with rice has been evaluated for their suitability and productivity, but little attention has been paid to the dynamics of the available nutrient status after rice and its effect on the subsequent crops. In recent years, the Indian rice soils are already started showing fatigue, as judged by decline in the yields of rice as well as lower response to applied chemical fertilizers. Other aspects of food quality have also been changed to worse. Instead of recycling wastes back into the soil as source of nutrients, farmers burning the residues which pollute the environment. Non-renewable energy resources are used to produce chemical fertilizers. If this trend continues, in future the mankind may be forced to make radical adjustments in such agricultural practices. It entails the conjunctive use of compost FYM, vermicompost, crop residues, green manures, crop rotation, bio fertilizers and chemical fertilizers in a compatible manner. Growing and *in-situ* incorporation of green manures *(Sesbania aculeata)* during summer with pre-monsoon showers result in a significant contribution to soil nutrient status by augmenting nitrogen and economics by reducing energy inputs (Bajpai *et al*., 2004) [2]. The benefits of green manuring are multifold. It increases the soil organic matter, available nitrogen, concentration of the nutrients near the soil surface in available form, and reduces the N losses through leaching and soil erosion. *In-situ* incorporation of *Sesbania rostrata* added 50 kg nitrogen, 20 kg phosphorus and 32 kg potassium per hectare (Balaji Naik and Yakadri, 2004) [3]. Nutrient recommendations for crops is usually made based on the responses of individual crops in the system without considering the total requirement of crops grown in cropping system as a whole and nutrient interactions between them. As a result, the recommendations often proved to be non-remunerative. Therefore, 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.

Material and Methods

The present investigation was conducted during two consecutive years (i. e. 2008-09 and 2009-10) at College Farm, College of Agriculture, Rajendranagar, Hyderabad to study the effect of continued use of organic and inorganic sources of nitrogen on the sustainable crop productivity in rice. The farm is geographically situated at an altitude of 542.6 m above mean sea level on 17º 19' N latitude and 78º 23' E longitude. It is covered under Southern Telangana Agro-climatic zone of Telangana State. According to Troll's climatic classification, it falls under semi-arid tropic region (SAT).The experiment was laid out in a split plot design comprising of three main plot treatments (organic manural options *viz*., no manuring, in-situ incorporation of green manure crop (*Sesbania aculeata*) and farm yard manure @ 10 t. ha^{-1} i.e., M_1, M_2 and M_3, respectively) and seven sub-plot treatments(four levels of Nitrogen *viz.*, 0, 50, 100 and 150% RDN (N_1, N_2, N_3 and N_4) and also three more levels of Nitrogen i.e., 50, 100 and 150% RDN (N_5, N_6 and N_7), replicated thrice. The experimental data was recorded on plant growth and development (Plant height (cm), Dry matter production (kg/ha), 50 per cent silking, Days to physiological maturity), yield attributes (Ears per plant, ear weight per plant, Number of grains and Grain weight per ear) and yield of maize during both the years of study (Grain yield (kg ha^{-1}), Stover Yield (kg ha^{-1}) and Harvest index (%)).

A. Main plot treatments: (Organic manuring options)

M_1 – No Manuring

M_2 – *in-situ* Incorporation of green manure crop (*Sesbania aculeata*)

M_3 – Farm yard manure @ 10 t. ha^{-1}

B. Sub-plot treatments: (Nitrogen levels)

Maize (*Rabi*)		Maize (*Rabi*)	
N_1	Control (No nitrogen)	N_5	50% RDN (80 N kg ha^{-1})
N_2	Residual effect of 50% RDN (60 N kg ha^{-1}) applied to rice on succeeding maize	N_6	100% RDN (160 N kg ha^{-1})
N_3	Residual effect of 100% RDN (120 N kg ha^{-1}) applied to rice on succeeding maize	N_7	150% RDN (240 N kg ha^{-1})
N_4	Residual effect of 150% RDN (180 N kg ha^{-1}) applied to rice on succeeding maize		

Note

The treatments N_5, N_6 and N_7 were repeated in kharif rice to assess the cumulative effect of these fertilizer levels in relation to nitrogen levels applied to *Rabi* maize. To have better interpretation of the kharif rice results, the duplicated treatments *viz*., F2 and N5 (50% RDN); N3 and N6 (100% RDN): and N4 and N7 (150% RDN) were averaged and represented as N2, N3 and N4. The mean values are subjected to statistical analysis.

Statistical Analysis

The data recorded on various parameters were analyzed following the analysis of variance for split-plot design as suggested by Gomez and Gomez (1984). Wherever, the treatment differences were found significant (F-test), critical differences were worked out at five per cent probability level and furnished along with mean values of the parameter concerned in tables. Treatment differences that were non-significant were denoted by 'NS'.

Results and Discussions

The data on growth characters like plant height, dry matter production, days to 50% silking and days to physiological maturity varied significantly due to different pre-rice organic manuring options and nitrogen management practices (Table 1).

Table 1: Various growth parameters of rice – maize cropping system at harvest as influenced by organic manuring options and nitrogen levels

Treatments		Plant height (cm)		Dry matter production (kg ha^{-1})		Days to 50% Silking		Days to physiological maturity	
Pre–rice organic manuring options (M)		**2008-09**	**2009-10**	**2008-09**	**2009-10**	**2008-09**	**2009-10**	**2008-09**	**2009-10**
M_1- No manuring		169.6	168.4	9567	9254	61.5	61.5	100.6	99.3
M_2- *In-situ* Incorporation of *S. aculeata*		181.8	183.4	11210	11664	59.5	60.4	100.9	99.4
M_3- Farm yard manure @ 10 t. ha^{-1}		177.7	181.4	10414	11887	60.5	59.5	100.4	99.0
SEm ±		1.96	2.05	288.9	90.9	0.18	0.18	0.10	0.09
C.D. (P=0.05)		7.68	8.03	1134.2	356.7	NS	NS	NS	NS
Nitrogen levels (N)									
Kharif Rice	*Rabi* Maize								
N_1- Control (No nitrogen)	Control (No nitrogen)	165.1	162.2	7631	7969	61.6	61.8	101.1	100.1
N_2- 50% RDN (60 kg ha^{-1})	Control (No nitrogen)	167.7	165.2	7778	8253	61.2	61.7	101.0	100.2
N_3- 100% RDN (120 kg ha^{-1})	Control (No nitrogen)	169.2	167.0	8056	8457	61.2	61.2	101.0	100.1
N_4- 150% RDN (180 kg ha^{-1})	Control (No nitrogen)	171.6	169.8	8403	8693	61.3	61.4	101.1	100.0
N_5- 50% RDN (60 kg ha^{-1})	50% RDN (80 kg ha^{-1})	180.3	186.0	12428	12942	60.0	60.3	100.5	99.5
N_6- 100% RDN (120 kg ha^{-1})	100% RDN (160 kg ha^{-1})	187.7	193.4	13634	14300	59.4	59.7	99.9	98.9
N_7- 150% RDN (180 kg ha^{-1})	150% RDN (240 kg ha^{-1})	193.0	200.4	14850	15933	58.4	58.3	98.7	97.6
SEm ±		2.74	3.20	275.5	406.0	0.20	0.19	0.17	0.18
C.D. (P=0.05)		7.85	9.18	790.3	1164.6	0.57	0.55	0.49	0.52
Interaction (M X N)									
Between two N at the same M									
SEm ±		4.74	5.55	477.2	703.7	0.34	0.33	0.30	0.32
C.D (P=0.05)		NS	NS	NS	NS	NS	NS	NS	NS
Between two M at the same or different N									
SEm ±		5.11	5.43	730.3	346.7	0.45	0.46	0.26	0.25
C.D (P=0.05)		NS	NS	NS	NS	NS	NS	NS	NS

NS-Not significant

Plant Height (cm)

Perusal of the data indicated that significant effect of both organic manurial practices and nitrogen levels on plant height at harvest in first year where organic manural practices did not exhibit any positive influence on plant height. Pre-rice incorporation of *S. aculeata* (M_2) and FYM application @ 10 t ha^{-1} (M_3) were remained statistically on par and enhanced the plant height significantly over no organic manuring treatment (M_1) at harvest stages in both the years.

The differences in plant height due to residual effect of nitrogen levels @ 0, 50, 100 and 150 per cent RDN applied to preceding rice (N_1, N_2, N_3 and N_4, respectively) were found to be significant. Progressive increase in plant height due to each increment in nitrogen application @ 50, 100 and 150% RDN to *Rabi* maize (N_5, N_6 and N_7, respectively) was found significant at all the crop growth stages in both the years of study. On an average, application of 150% RDN (N_7) increased the plant height by 17.8, 9.1 and 4.1% at 90 DAT; and by 20.3, 6.9 and 3.1% at harvest over 0, 50, 100% RDN, respectively (N_1, N_5 and N_6). Maize crop responded to higher nitrogen level and resulted in highest plant height as compared to lower nitrogen levels. Similar results of increased plant height with increased nitrogen levels were reported by Srinivasa Raju *et al*., (1997) [10] and Thakur and Vinod Sharma (1999) [11] and Singh *et al*., (2003) [6].

Dry matter accumulation (kg ha^{-1})

Perusal of the data indicated the significant effect of both organic manurial practices and nitrogen levels on dry matter accumulation at harvest in first year. Pre-rice incorporated *S. aculeata* (M_2) exhibited residual effect and resulted in maximum dry matter accumulation at harvest in the first year (776, 6121, 10423 and 11210 kg ha^{-1}, respectively) over no organic manure application to rice (M_1). However, FYM application @ 10 t ha^{-1} (M_3) did not influenced the maize to considerable extent and remained statistically on par with no organic manuring treatment (M_1) at harvest in first year. But in the second year FYM contributed at par with green manuring. The cumulative residual effect of FYM applied to the same treatment in two consecutive years might have caused considerable build-up of macro and micro nutrients besides, improving the soil physical, chemical and biological properties thereby, enhanced the dry matter production during second year.

The residual effect of inorganic N levels i.e., 0, 50, 100 and 150 per cent RDN on dry matter yield of succeeding maize was not significant. Nitrogen application @ 50, 100 and 150% RDN to *Rabi* maize (N_5, N_6 and N_7, respectively) enhanced the dry matter accumulation and was found significant at harvest in both the years of study. Application of 150% RDN (N_7) increased the mean dry matter accumulation by 49.3, 17.6 and 9.3% at harvest over 0, 50, 100% RDN, respectively (N_1, N_5 and N_6). Higher dry matter production with high level of nitrogen might be due to significant improvement in growth parameters like plant stature and leaf area consequent to adequate supply of nitrogen and higher availability of native fixed P resulted in maintaining higher auxin levels which had favourable effect on cell enlargement and cell division. Enhanced dry matter with increase in nitrogen level was also reported by Thakur *et al*., 1997 and Singh *et al*., (2003) [6].

50 per cent silking and physiological maturity

The data on mean days to 50 per cent silking and physiological maturity as influenced by the various treatment combinations are presented in Table 2. The results indicated that days to 50 percent silking differed significantly due to pre-rice organic manuring options and nitrogen levels during both the years of experimentation. Pre-rice incorporation green manure (M_2) resulted in significantly shorter time for 50 per cent tasseling (59.5 days) followed by M_3 i.e., pre-rice application of FYM @ 10 t ha^{-1} (60.5 days). Contrastingly during the second year, M_3 taken lesser time for 50 per cent flowering (59.5 days) followed by M_2 (60.4 days). No organic

manuring to preceding rice (M_1) has delayed in attainment of 50 per cent tasseling stage during both the years of study (61.5 days; mean of two years). While, days to physiological maturity were not significantly influenced by different organic manuring treatments during both the years of the study.

Table 2: Yield attributes of rice – maize cropping system at harvest as influenced by organic manuring options and nitrogen levels

Treatments		Ears per plant		Ear weight (g/plant)		Number of grains per ear		Grain weight per ear (g)	
Pre–rice organic manuring options (M)		**2008-09**	**2009-10**	**2008-09**	**2009-10**	**2008-09**	**2009-10**	**2008-09**	**2009-10**
M_1- No manuring		1.13	1.10	226.7	223.5	434.4	422.0	107.5	105.9
M_2- *In-situ* Incorporation of *S. aculeata*		1.11	1.11	277.0	282.7	464.3	462.6	121.3	120.8
M_3- Farm yard manure @ 10 t. ha^{-1}		1.11	1.10	267.6	285.7	447.9	467.0	115.7	117.3
SEm ±		0.02	0.02	1.16	1.66	4.2	2.3	2.1	1.6
C.D. (P=0.05)		NS	NS	4.56	6.51	16.7	8.9	8.4	6.3
Nitrogen levels (N)									
Kharif Rice	*Rabi* Maize								
N_1- Control (No nitrogen)	Control (No nitrogen)	1.14	1.13	168.3	156.6	269.3	282.3	76.2	75.9
N_2- 50% RDN (60 kg ha^{-1})	Control (No nitrogen)	1.14	1.12	174.2	159.6	276.7	287.3	79.5	78.3
N_3- 100% RDN (120 kg ha^{-1})	Control (No nitrogen)	1.13	1.12	177.1	163.7	278.0	292.7	78.6	78.3
N_4- 150% RDN (180 kg ha^{-1})	Control (No nitrogen)	1.13	1.11	182.9	168.1	283.1	293.7	81.8	78.5
N_5- 50% RDN (60 kg ha^{-1})	50% RDN (80 kg ha^{-1})	1.14	1.12	258.7	272.9	459.8	465.7	115.4	115.7
N_6- 100% RDN (120 kg ha^{-1})	100% RDN (160 kg ha^{-1})	1.13	1.12	288.7	298.4	489.7	504.0	122.4	126.6
N_7- 150% RDN (180 kg ha^{-1})	150% RDN (240 kg ha^{-1})	1.14	1.13	304.8	313.3	512.3	519.0	129.9	135.4
SEm ±		0.02	0.02	4.01	3.46	5.1	4.6	2.3	2.4
C.D. (P=0.05)		NS	NS	11.49	9.93	14.6	13.4	6.7	6.9
Interaction (M X N)									
Between two N at the same M									
SEm ±		0.01	0.01	6.94	6.00	8.8	8.1	4.1	4.2
C.D (P=0.05)		NS	NS	NS	NS	NS	NS	NS	NS
Between two M at the same or different N									
SEm ±		0.02	0.02	3.87	4.65	10.9	6.3	11.7	4.2
C.D (P=0.05)		NS	NS	NS	NS	NS	NS	NS	NS

NS-Not significant

Similarly, the influence of different nitrogen levels applied to maize on mean days to 50 per cent silking and days to physiological maturity was found to be significant during both the years Each increment in nitrogen application @ 50, 100 and 150% RDN applied to *Rabi* maize (N_5, N_6 and N_7, respectively) hastened the days to 50 per cent silking (61.7 days in control to 58.4 days in N_7; two year mean) and days to physiological maturity (100.1 days in control to 98.2 days in N_7; two year mean) in both the years of study. This might be due to adequate supply of nitrogen and more uptake of native P and k with balanced nutrition helped in faster vegetative growth and the crop would have shifted to reproductive phase early, resulting in earlier tasseling, silking and consequently early attainment of physiological maturity at higher levels of nitrogen. Early tassel emergence and silking in maize due to nitrogen fertilization has also been reported by Kamta Prasad and Prem Singh (1990) [1].

Yield attributes

Ears per plant and ear weight per plant (g)

The data on mean number of ears per plant and ear weight per plant as influenced by various treatments are presented in Table 2. The results indicated that the number of ears per plant was not influenced by pre-rice organic manuring options and inorganic nitrogen levels during both the years of investigation. While, ear weight per plant varied significantly due to pre-rice organic manuring options and nitrogen levels. Ear weight was significantly higher (277.0 g plant^{-1}) with pre-rice green manuring (M_2) in the first year. Whereas, in the second year, both pre-rice green manuring (M_2) and FYM application (M_3) registered on par and highest ear weight per plant (282.7 and 285.7 g plant^{-1}, respectively) over no manuring treatment (223.5 g plant^{-1}) manifesting superiority of both the organic manuring options in second year of study.

The variations in ears per plant and ear weight per plant due to residual nitrogen levels @ 0, 50, 100 and 150 per cent RDN applied to preceding rice (N_1, N_2, N_3 and N_4, respectively) were statistically at par during both the years. Application of 150% RDN resulted in highest ear weight per plant (309.0 g, two year mean) followed by 100% RDN (293.5 g, two year mean) in both the years. Higher production of photosynthates and their efficient translocation to the productive parts due to adequate available nutrients might have been responsible for beneficial effect on growth and development of maize ears in both the years of investigation.

Number of grains and Grain weight per ear (g)

An insight into data pertaining to number of grains, grain weight per ear (g) and test weight (100 seed weight) of maize as influenced by different treatments imposed to rice – maize cropping system are presented in Table. Perusal of data indicated that both the organic manuring practices *viz*., pre-rice green manuring (M_2) and FYM application (M_3) registered at par and maximum number of grains per ear (463.5 and 457.5, respectively; mean of two years) and maximum grain weight per ear (121.1 and 116.5 g, respectively; mean of two years) over no manuring treatment manifesting superiority of both the organic manuring options in both the years of study

Application of 150% RDN (N_7) to maize resulted in significantly higher number of grains per ear (515.7; mean of two years), maximum grain weight per ear (132.7 g; mean of two years) over the rest of N levels. Due to formation of ears of improved length and girth more number of ear rows were

formed, continued maintenance of higher vigor of the crop, consequent to good early start, pollination, fertilization and seed formation were more effective with higher nitrogen levels resulting in more number of bold grains per cob. These results are in agreement with the findings of Purushottam Kumar and Puri (2001) [7] and Rameshwar Singh and Totawat (2002) [8].

Grain yield (kg ha^{-1})

Grain and stover yield of maize as influenced by pre-rice organic manuring options and nitrogen levels are presented in Table 3 and Figure 1.

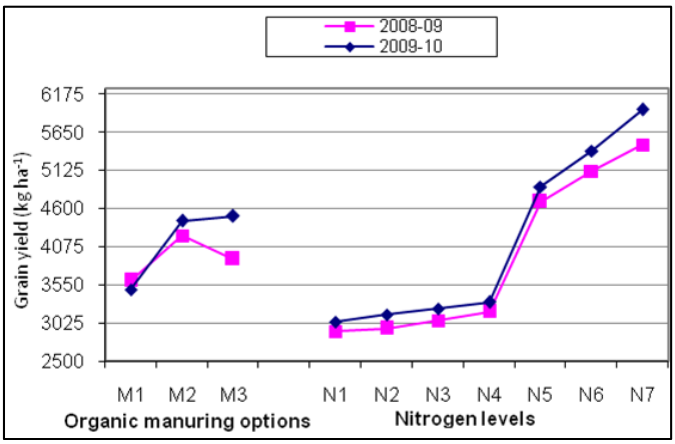
The grain yield of maize crop was significantly influenced by the residual effect of different pre-rice organic manuring options. Critical review of yield data indicated that both the organic manuring practices *viz*., pre-rice green manuring (M_2) and FYM application (M_3) registered on par and highest grain yield of maize during both the years (4326 and 4202 kg ha^{-1}, respectively; mean of two years) over no organic manuring treatment (3549 kg ha^{-1}; mean of two years). A similar result on residual effect of pre-rice organic manures on the yield of subsequent crop was reported by Aulakh *et. al.*, (2000) [1], who reported an increase in mean 3 year wheat yield to the tune of 15% due to residual effect of pre-rice incorporation of green manure.

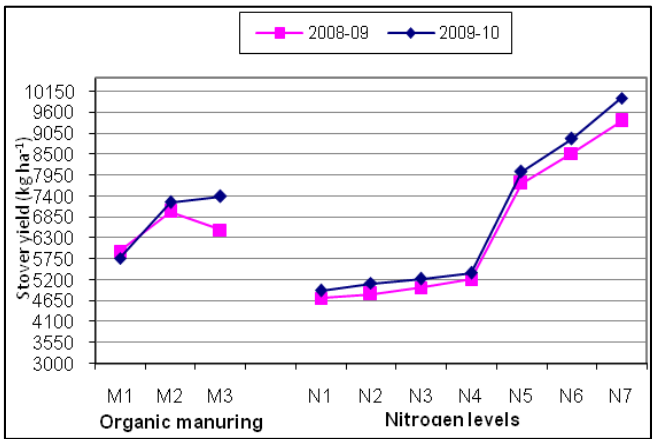
The inorganic N levels applied to rice did not influence the maize yields. Only the nitrogen levels applied to maize influenced the yield and the higher fertility level i.e., 150% RDN (N_7) produced significantly higher grain yield (5714 kg ha^{-1}; mean of two years) followed by 100% RDN (N_6) (5257 kg ha^{-1}; mean of two years). The beneficial effect of adequate nitrogen levels resulted in better growth and yield attributes and reflected in higher grain yield of maize. Further, nitrogen nutrition might have improved source-sink relationship, with better translocation of photosynthates for grain formation. Similar findings were also reported by Rameshwar Singh and Totawat (2002) [8], Thind *et al*., (2002) [13] and Singh *et al*., (2003) [6].

Table 3: Grain yield (kg ha^{-1}), stover yield (kg ha^{-1}) and harvest index of maize as influenced by different treatments imposed to rice – maize cropping system

Treatments		Grain yield (kg ha^{-1})		Stover yield (kg ha^{-1})		Harvest index (%)	
Pre – rice organic manuring options (M)		**2008-09**	**2009-10**	**2008-09**	**2009-10**	**2008-09**	**2009-10**
M_1- No manuring		3608	3489	5959	5765	37.76	37.77
M_2- *In-situ* Incorporation of *S. aculeata*		4224	4428	6986	7236	37.80	38.05
M_3- Farm yard manure @ 10 t. ha^{-1}		3905	4499	6509	7389	37.62	37.91
SEm ±		108.2	36.0	180.7	55.2	0.02	0.04
C.D. (P=0.05)		424.8	141.3	709.5	216.8	0.06	0.16
Nitrogen levels (N)							
Kharif Rice	*Rabi* Maize						
N_1- Control (No nitrogen)	Control (No nitrogen)	2909	3043	4722	4926	38.11	38.17
N_2- 50% RDN (60 kg ha^{-1})	Control (No nitrogen)	2956	3140	4822	5113	38.01	38.04
N_3- 100% RDN (120 kg ha^{-1})	Control (No nitrogen)	3058	3225	4997	5232	37.97	38.12
N_4- 150% RDN (180 kg ha^{-1})	Control (No nitrogen)	3183	3313	5221	5380	37.86	38.09
N_5- 50% RDN (60 kg ha^{-1})	50% RDN (80 kg ha^{-1})	4692	4898	7736	8044	37.75	37.84
N_6- 100% RDN (120 kg ha^{-1})	100% RDN (160 kg ha^{-1})	5117	5396	8517	8904	37.54	37.73
N_7- 150% RDN (180 kg ha^{-1})	150% RDN (240 kg ha^{-1})	5472	5956	9378	9977	36.85	37.38
SEm ±		103.8	152.1	171.9	254.1	0.05	0.06
C.D. (P=0.05)		297.8	436.4	493.1	728.8	0.16	0.18
Interaction (M X N)							
Between two N at the same M							
SEm ±		179.8	263.5	297.8	440.1	0.09	0.11
C.D (P=0.05)		NS	NS	NS	NS	NS	NS
Between two M at the same or different N							
SEm ±		273.6	133.0	456.8	214.4	0.05	0.11
C.D (P=0.05)		NS	NS	NS	NS	NS	NS

NS-Not significant





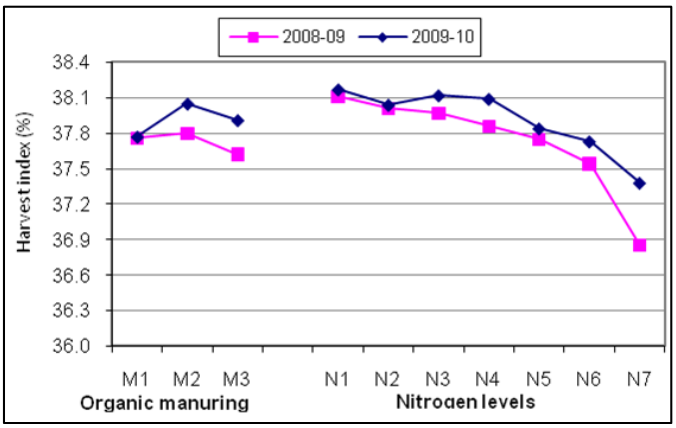


Fig 1: Grain yield (kg ha^{-1}), stover yield (kg ha^{-1}) and harvest index of maize as influenced by different treatments imposed to rice-maize cropping system

Stover yield (kg ha^{-1})

Same trend of grain yield was observed in respect of stover yield. A close perusal of data in Table 3 on mean stover yield indicated that stover yield was markedly influenced by organic manuring options and nitrogen levels. The data indicated that both the organic manuring practices *viz*., pre-rice green manuring (M_2) and FYM application (M_3) registered on par and highest stover yield of maize during both the years (7111 and 6949 kg ha^{-1}, respectively; mean of two years) over no organic manuring treatment (5862 kg ha^{-1}; mean of two years).

Among nitrogen levels, 150% RDN to both crops (N_7) gave significantly highest stover yield (9677 kg ha^{-1}; mean of two years) followed by 100% RDN (N_6) (8011 kg ha^{-1}; mean of two years) over rest of the nitrogen treatments imposed to rice and maize crops during both the years of study. The increased stover yield with increasing nitrogen levels attributed to significant increase in plant height accompanied by a larger leaf area. Both these beneficial effects were reflected in higher dry matter production, ultimately resulting in significantly higher stover yield. These results are in conformity with the findings of Baskaran *et al*., (1993) [4], Srinivasa Raju *et al*., (1997) [10] and Kumar and Singh (2003) [6].

Harvest Index

The data on mean harvest index (HI) as influenced by various organic manuring options and nitrogen levels are presented in Table 3.

Harvest index of maize was significantly highest with pre-rice green manuring (M_2) during both the years (37.80 in the 1st year and 38.05 in the 2nd year). The improvement in harvest index of maize due to pre rice organic manuring might be due to favourable increase in physiological capacity to metabolize the photosynthates towards grain consequent to better soil environment.

Among the nitrogen levels 0, 50, 100 and 150 per cent RDN applied to preceding rice (N_1, N_2, N_3 and N_4, respectively) were at par and resulted in the highest harvest index ranging from 38.14 to 37.97 (mean of two years). While, 150% RDN (N_7) applied to each crop in the system recorded the lowest HI value (37.11, mean of two years) followed by 100% RDN (N_6) to both the crops (37.64, mean of two years). In this case, higher levels of nitrogen might have favoured towards improvement in total biological yield rather than economical yield.

Conclusion

It is apparent from the findings of present study on INM in rice-maze cropping system that pre-rice organic manuring either with green manuring with *Sesbania aculeata* or incorporation of FYM @ 10 t ha^{-1} found to produce highest yields of maize crops and thus economically viable and more profit oriented because of less dependence on external inputs such as chemical source of nitrogen. It is clearly evident from the system studies that, the residual effect of inorganic nitrogen levels applied to preceding rice did not influence growth and development of *Rabi* maize crop. Besides improving the crop growth, yield attributes and yields, pre-rice organic manuring options improved the soil fertility. Application of 50% RDN in conjunction with either green manure or FYM has resulted in higher soil available N, P and K contents compared to that of sole application of 100% RDN and 150% RDN and offered sustainability both in terms of system productivity and soil fertility.

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