Madras Agric. J., 2019; doi:10.29321/MAJ 2019.000241

RESEARCH ARTICLE

Evaluation of Bio Complementary Organic Nutrient Management Practices on Growth and Yield of Rice in Rice Blackgram cropping Sequence

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Received : 7th Nov, 2018
Revised : 30th May, 2019
Accepted : 30th May, 2019

ABSTRACT

Field experiments were conducted to develop the suitable organic farming package for rice-blackgram crop sequence during samba seasons of 2016 and 2017 at farmers' holdings in Thirupparankundram block of Madurai district, Tamil Nadu. The organic manure combinations were evaluated for their growth parameters. viz., plant height, no of tillers, no of leaves per hill, root length, root volume, root dry weight and dry matter production at various stages of the crop growth. During both the seasons of study application of green manure @ 6.25 t ha^{-1}+split application of vermicompost @ 4t ha^{-1} in four equal splits (basal, AT,PI & F) + Panchagavya @ 3% as foliar spray twice (AT & PI) significantly recorded more number of tillers and highest plant height, dry matter production, root length, root volume, root dry weight, grain and straw yield over rest of the treatments. The recommended practice also recorded relatively, more number of tillers, leaves $hill^{-1}$, higher plant height, dry matter production, root length, root volume, root dry weight, grain and straw yield which is on par with the aforesaid treatment. Therefore the application of green manure @ 6.25 t ha^{-1}+split application of vermicompost @ 4t ha^{-1} in four equal splits (basal, AT,PI & F) + Panchagavya @ 3% as foliar spray twice (AT & PI) can be recommended for adoption in organic cultivation of rice-black gram crop sequence grown organically.

Keywords: *Complimentary, crop sequence, panchagavya, vermicompost, rice*

INTRODUCTION

Organic farming has assumed importance as an offshoot of environmental concerns in the Western world. The almost total dependence on chemical fertilizers, pesticides, herbicides and growth regulators for enhancing crop productivity, gradually culminated into a situation which necessitated reconsidering the alternative for chemical agriculture gradually developed in the Western world. The energy crisis, higher fertilizer cost, sustainability in the agri-production system and ecological stability are the important issues which renewed the interest of farmers and research workers in non-chemical sources of plant nutrients like bio-fertilizers, farmyard manure, green manure, composts etc. Awareness about crop quality and soil health increased the attention of people towards organic farming (Sharma *et al*., 2008). The organic manures are available in the form of green and dry plant residues, fresh animal wastes, decomposed materials from plants and animal (Palaniappan *et al.,* 1995).

Inclusion of a pulse crop in the cropping system is more beneficial than cereals after growing cereals (Kumpawat, 2001). Khatik and Dikshit (2001) indicated that the application of organic manures helped to sustain crop productivity besides maintaining soil health. Use of manures and biologically active preparations of animal and plant organic was most commonly used by those farmers who aimed for sustainable production in Tamil Nadu (Somasundaram, 2002). Rice-rice-blackgram cropping sequence plays a significant role in food security of India in general and particularly in Tamil Nadu. Hence, suitable organic farming practices have to be evaluated for rice based cropping system to assess the stability in production. Balanced use of nutrients through organic sources like farmyard manure, vermicompost, green manuring, neem cake and bio-fertilizers are prerequisites to sustain soil fertility, to produce maximum crop yield with optimum input level (Dahiphale *et al*., 2003). At present very scanty information is available on organic farming practices of rice-blackgram cropping sequence to have a sustainable production levels. Therefore, experiments were conducted to develop suitable organic package with different

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combinations of organic manures for rice-blackgram cropping sequence.

MATERIAL AND METHODS

Field experiments were conducted at farmer's holding at Thoppur village, Thirupparankundram block of Madurai district during *samba* seasons of 2016 and 2017. The geographical location of the experimental field has the reference to is 9.9°N latitude, 78°E longitude at an altitude of 101 m above MSL. The average annual rainfall is 874.5 mm. The mean maximum and minimum monthly temperature vary from 37.4°C and 21.6°C, respectively. The soil was sandy loam, slightly alkaline (pH 8.1), low in available nitrogen(262 kg ha^{-1}),medium in P(18.2 kg P_2O_5 ha^{-1}) and high in K(576 kg K_2O ha^{-1}), medium in organic matter content (0.62%).The experiment was laid out in a randomized complete block design with three replications. A total of twelve treatments which includes eleven organic manure combinations and one with blanket recommendation (i.e,. inorganic NPK fertilizers). *viz*., T_1 : Green manure @ 6.25 t ha^{-1} + neem cake @ 250 kg ha^{-1},T_2: Enriched FYM (EFYM) @ 1.0 t ha^{-1},T_3: Green manure @ 6.25 t ha^{-1}+ tamarind seed powder @ 100kg ha^{-1} + neem cake @ 250 kg ha^{-1},T_4: EFYM @ 1.0 t ha^{-1} + tamarind seed powder @ 100 kg ha^{-1}+ neem cake @ 250 kg ha^{-1},T_5: Split application of vermicompost @ 4 t ha^{-1}(as basal, AT, PI and F) + neem cake @ 250 kg ha^{-1},T_6 : T_3 + Panchagavya @ 3% as foliar spray twice at (PI & F),T_7 : T_4 + Panchagavya@ 3% as foliar spray twice (PI & F),T_8 :T_5 + Panchagavya@ 3% as foliar spray twice (PI & F),T_9 : Green manure @ 6.25t ha^{-1}+ split application of vermicompost in four equal splits @ 4 t ha^{-1} (as basal, AT, PI & F) +Panchagavya @ 3% as foliar spray twice at AT & PI, T_{10}:Organic farmers practice (Multi varietal seed technique +herbal pest repellant spray,T_{11}: Absolute Control (FYM 12.5 t ha^{-1}) along with T_{12}: Control – State recommendation (FYM @ 12.5 t ha^{-1}+ Recommended NPK).The crops were raised under irrigated condition with recommended package of practices. The growth parameters were recorded from the net plot.

The pre-season green manuring of *Tephrosia purpurea* (L.) Pers. (Kolinji) was incorporated at 51 DAS during 2016 and at 49 DAS during 2017, to neutralize the fertility variation of the experimented field before transplanting of rice. The treatments were imposed only to rice crop and rice fallow blackgram was raised as a residual crop. Based on the treatments, the required quantities of organic manures were incorporated in the soil one week before transplanting of rice. The P and K were not applied. The rice variety, Co (R) 48was raised during *samba* 2016 and Co (R) 51 during *samba* 2017 while in summer 2017 and 2018, blackgram variety VBN 6 was raised. The plant protection was done through neem seed kernel extract, Panchagavya and *Pseudomonas flourescens* culture for organic manure treatments. The recommended NPK fertilizer (control) treatment received a full dose of NPK through inorganic fertilizers and plant protection through insecticides. Weeding was done manually. The growth parameters such as plant height, number of tillers, number of leaves per hill, root length, root volume, root dry weight and dry matter production was were recorded in three stages namely active tillering, panicle initiation and flowering and yield was recorded at the time of harvest.

RESULTS AND DISCUSSION

Plant height

The plant height was maximum at the flowering stage. During *samba* 2016 and 2017, the taller plant height was recorded with green manure @ 6.25 t ha^{-1} + split application of vermicompost in four equal splits @ 4 t ha^{-1} as basal, at active tillering, panicle initiation and flowering stages+ Panchagavya @ 3% as foliar spray twice at panicle initiation (43.3 and 43.7 cm) and flowering (60.9 and 56.7 cm) stages (T_9), respectively. However it was comparable with T_1, T_3, T_6, T_{12} at active tillering stage and with T_{12} during flowering and panicle stage. State recommendation (T_{12}) was found to be the next best in enhancing the plant height during active tillering (45.3 and 43.9 cm), panicle initiation (58.6 and 54.6 cm) and flowering (108.2 and 101.0 cm) stages, respectively in both the years. The absolute control (T_{11}) treatment registered shorter plants (37.0, 40.0 and 71.8 cm during *samba* 2016; 33.2, 38.8 and 68.3 cm during *samba* 2017, respectively) at all the three stages of crop growth (Table 1). Plant height was highly influenced by green manure incorporation @ 6.25 t ha^{-1} along with split application of vermicompost in four equal splits @ 4 t ha^{-1} as basal, at active tillering, panicle initiation and flowering stages and Panchagavya @ 3% as foliar spray twice at active tillering and panicle initiation stages (T_9) had 14.5, 34.3 and 36.8 per cent during samba 2016 and 24.0, 31.6 and 35.8 per cent during samba 2017 over control respectively at active tillering, panicle initiation and flowering stages. This might be due to organic manures in association with micro-organisms help in the synthesis of certain phytohormones and vitamins which promote the growth and development of crops. Findings of Singh and Shivay (2013) strongly support the results obtained from the present study.

Number of tillers

During *samba* 2016 and 2017, the number of tillers produced was more with green manure @ 6.25 t ha^{-1} + split application of vermicompost in four equal splits @ 4 t ha^{-1} as basal, at active tillering,

Table 1 . Effect of organic manures on plant height (cm) and number of tillers of rice at different growth stages

Treatments	*Samba* 2016						*Samba* 2017					
	Plant height (cm)			Number of tillers			Plant height (cm)			Number of tillers		
	AT	PI	F	AT	PI	F	AT	PI	F	AT	PI	F
T_1	40.5	52.9	96.8	8.8	16.7	38.6	36.7	51.2	90.5	9.1	15.5	36.7
T_2	37.3	44.3	84.4	6.7	10.2	33.5	36.7	40.9	78.5	6.8	13.9	31.6
T_3	41.2	53.2	97.5	11.1	16.7	39.0	39.9	52.5	94.8	9.3	16.6	37.0
T_4	37.1	45.5	86.3	7.3	10.0	36.3	39.4	42.7	77.9	7.4	14.2	34.7
T_5	39.4	49.4	91.7	8.7	11.0	37.9	39.8	44.0	88.7	8.9	15.4	35.4
T_6	40.9	54.3	99.4	8.8	17.1	39.5	42.6	52.1	95.9	11.6	16.8	37.2
T_7	038.0	46.9	88.7	7.0	10.2	37.5	39.5	43.4	87.3	7.6	14.9	35.3
T_8	37.9	49.3	91.0	8.5	10.2	37.6	38.4	43.2	86.4	7.9	14.8	35.1
T_9	43.3	60.9	113.6	11.1	17.4	29.8	43.7	56.7	106.4	11.7	17.5	28.6
T_{10}	33.3	42.9	81.7	5.2	9.9	32.4	32.0	39.8	72.8	6.2	11.7	31.0
T_{11}	37.0	40.0	71.8	6.0	9.9	30.9	33.2	38.8	68.3	5.4	9.6	29.2
T_{12}	45.3	58.6	108.2	12.7	17.2	40.6	43.9	54.6	101.0	12.4	17.0	38.7
SEd	2.49	2.59	3.52	0.43	0.73	1.03	1.85	2.00	3.21	0.52	0.69	0.98
CD P=0.05)	5.16	5.37	7.29	0.89	1.51	2.13	3.83	4.16	6.66	1.08	1.44	2.02

*AT- Active tillering, PI – Panicle Initiation, F- Flowering

panicle initiation and flowering stages+ Panchagavya 3% as foliar spray twice at active tillering and panicle initiation stages (T_9) at active tillering (11.1 and 11.7), panicle initiation (17.4 and 17.5) and flowering (41.8 and 39.6) stages respectively, which was however on par with State recommendation (T_{12}) and green manure @ 6.25 t ha^{-1} + tamarind seed powder @ 100 kg ha^{-1} +neemcake @ 250 kg ha^{-1} + Panchagavya@ 3% as foliar spray twice at (PI & F) (T_6). State recommendation of NPK fertilizers (T_{12}) recorded significantly higher number of tillers (12.7, 17.2 and 40.6 in *Samba* 2016; 12.4, 17.0 and 38.7 in *samba* 2017, respectively) at active tillering, panicle initiation and flowering stages. Absolute control (T_{11}) produced minimum number of tillers (6.0, 9.9 and 30.9 in *samba* 2016; 5.4, 9.6 and 29.2 in *Samba* 2017, respectively) at active tillering, panicle initiation and flowering stages (Table 1).

This might be due to enhanced microbial action and consequent plant nutrient supply, polysaccharides and other organic compounds release during decomposition of organic matter that led to an increased number of tillers. Hugar *et al*. (2009) also confirmed the above findings. Panchagavya is also known to contain beneficial micro organisms such as *Azospirillum*, *Azotobactor*, *Phosphobacteria* and *Pseudomonas* besides *Lactobacillus* which promotes the plant growth parameters (Yadav and Lourduraj, 2006).

Dry matter production

During both the years of study, the DMP increased steadily with the advancement of age, attaining its peak at the flowering stage in all the treatments. In *samba* 2016 and 2017, green manure @ 6.25 t ha^{-1} + split application of vermicompost in four equal splits @ 4 t ha^{-1} as basal, at active tillering , panicle initiation and flowering stages+ Panchagavya @ 3% as foliar spray twice at active tillering and panicle initiation stages (T_9) application recorded higher DMP (1159, 5066 and 9188 kg ha^{-1}; 998, 4715 and 8604 kg ha^{-1}) at active tillering, panicle initiation and flowering stages, respectively). However it was comparable with state recommendation (T_{12}) and T_3, T_5, T_6 at active tillering stage. The lower dry matter production at all the stages of crop growth period was associated in absolute control (T_{11}) (607, 2346 and 5954 kg ha^{-1}; 602, 2141 and 5632 kg ha^{-1} respectively).

The increased dry matter production than control to the tune of 47.6, 53.7 and 35.2 per cent during samba 2016 and 39.7,54.6 and 34.5 per cent during samba 2017, respectively at active tillering, panicle initiation and flowering stages which could be attributed to the continuous slow release of nutrients, which might have enabled the leaf area duration to extend, thereby providing an opportunity for plants to increase the photosynthetic rate which could have led to higher production of biomass thereby, good accumulation of dry matter. Similar results were obtained by Amanullah *et al*., (2006). Besides these, growth regulatory substances such as Indole acetic acid, gibberellic acid, cytokinin and essential plant nutrients present in Panchagavya (Perumal *et al*., 2006) might result in improved dry matter accumulation in rice. This was significantly inferior to the dry matter produced with the multi varietal seed technique+ herbal pest repellant spray (T_{10}) during both the years of study (Figure 1 and 2).

Root length

It was found that the root length was significantly influenced by the application of organic manures in both the years throughout the crop growth. During *samba* 2016 and 2017, green manure @ 6.25 t ha^{-1} + split application of vermicompost in four equal

splits @ 4 t ha^{-1} as basal, at active tillering , panicle initiation and flowering stages+ Panchagavya @ 3% as foliar spray twice at active tillering and panicle initiation stages (T_9) recorded significantly longer root length (21.8, 36.9 and 35.9 cm; 22.5, 36.5 and 34.3cm, respectively) at active tillering, panicle initiation and flowering stages and which was however on par with state recommendation (T_{12}) at panicle initiation stage (during samba 2017). The decreased root length (15.5, 21.1 and 20.1 cm in *samba* 2016; 15.8, 22.1 and 22.9 cm in *samba* 2017, respectively) at all the three stages was observed in absolute control (T_{11}) which was comparable with multi varietal seed technique+ herbal pest repellant spray (T_{10}) at flowering stage of *Samba* 2017 (Table 2).

Table 2 . Effect of organic manures on root length (cm) and root volume (cc hill^{-1}) of rice at different growth stages

Treatments	*Samba* 2016						*Samba* 2017					
	Root length (cm)			Root volume (cc hill^{-1})			Root length (cm)			Root volume (cc hill^{-1})		
	AT	PI	F	AT	PI	F	AT	PI	F	AT	PI	F
T_1	18.9	30.3	29.6	16.1	26.0	24.4	18.9	30.1	29.3	17.6	25.1	24.4
T_2	17.9	28.5	26.6	14.5	22.2	21.8	17.8	27.1	26.2	15.4	21.7	23.0
T_3	19.1	31.5	30.4	16.2	26.1	24.8	19.3	31.3	29.3	18.3	25.6	25.5
T_4	18.0	28.5	27.0	15.0	23.7	22.5	18.0	28.6	26.3	16.2	21.8	23.2
T_5	18.7	29.1	28.6	15.8	25.1	23.8	18.7	29.1	27.6	17.6	24.7	24.1
T_6	19.3	31.9	30.9	16.7	26.7	25.0	19.4	31.6	29.4	18.8	26.0	25.9
T_7	18.2	28.7	28.2	15.7	24.1	21.2	18.4	28.7	28.0	16.9	23.0	23.2
T_8	18.4	28.8	28.4	15.8	24.8	23.1	18.6	29.0	28.3	17.1	24.4	23.3
T_9	21.8	36.9	35.9	17.6	28.2	25.7	22.5	36.5	34.3	19.7	26.5	27.8
T_{10}	17.2	24.3	23.2	14.1	20.8	20.6	17.1	24.1	22.0	14.3	21.4	20.5
T_{11}	15.5	21.1	20.1	13.2	17.3	16.6	15.8	22.1	22.9	13.7	16.7	17.4
T_{12}	20.2	34.3	31.0	17.0	28.0	25.3	19.5	34.9	32.4	19.2	26.3	26.9
SEd	0.44	0.99	0.76	0.47	0.70	0.76	0.62	0.79	0.68	0.49	0.53	0.54
CD (P=0.05)	0.92	1.99	1.57	0.97	1.46	1.58	1.30	1.63	1.41	1.01	1.09	1.12

*AT- Active tillering, PI – Panicle Initiation, F- Flowering

Root volume

The root volume increased significantly in the treatment of T_9 *viz*., green manure @ 6.25 t ha^{-1} + split application of vermicompost in four equal splits @ 4 t ha^{-1} as basal, at active tillering , panicle initiation and flowering stages+ Panchagavya @ 3% as foliar spray twice at active tillering and panicle initiation stages (17.6, 28.2 and 25.7 cc hill^{-1} in *Samba* 2016; 19.7, 26.5 and 27.8 cc hill^{-1} in *Samba* 2017, respectively) at active tillering, panicle initiation and flowering stages. However it was on par with state recommendation (T_{12}) and green manure @ 6.25 t ha^{-1} + tamarind seed powder @ 100 kg ha^{-1} + Neem cake @ 250 kg ha^{-1} + Panchagavya @ 3% as foliar spray twice at (PI & F) (T_6). In both the years of study, lower root volume was registered (13.2, 17.3 and 16.6 cc hill^{-1} in *samba* 2016; 13.7, 16.7 and 17.4 cc hill^{-1} in *samba* 2017, respectively) in absolute control (T_{11}) at all the stages of crop growth and it was on par with multi-varietal seed technique+ herbal pest repellant spray (T_{10}) at active tillering stage during both the years of study (Table 2). Similar trend was observed with respect to root dry weight also (Table 3).

Table 3 . Effect of organic manures on root dry weight (g hill^{-1}) of rice at different growth stages

Treatments	*Samba* 2016			*Samba* 2017		
	AT	PI	F	AT	PI	F
T_1	1.57	3.17	3.21	1.56	3.07	3.03
T_2	1.33	2.53	2.56	1.31	2.49	2.46
T_3	2.03	3.22	3.35	1.62	3.21	3.16
T_4	1.36	2.73	2.72	1.41	2.64	2.61
T_5	1.57	3.17	3.19	1.53	3.05	3.02
T_6	2.07	3.82	3.55	2.05	3.96	3.67
T_7	1.42	2.98	2.98	1.46	2.70	2.72
T_8	1.55	3.16	3.15	1.52	2.84	2.85
T_9	2.19	4.17	3.94	2.15	4.45	4.18
T_{10}	1.18	2.36	2.40	1.30	2.42	2.32
T_{11}	1.15	2.29	2.29	1.20	2.05	2.25
T_{12}	2.07	3.97	3.74	2.08	3.97	3.71
SEd	0.12	0.28	0.28	0.14	0.28	0.28
CD (P=0.05)	0.25	0.59	0.59	0.29	0.57	0.58

The root characters are a healthier index for vigorous rice plant since it supports the above

ground plant parts. The root length, volume and dry weight were greatly influenced by the application of organic manures. Green manure @ 6.25 t ha^{-1} + split application of vermicompost in four equal splits @ 4 t ha^{-1} as basal, at active tillering, panicle initiation and flowering stages + Panchagavya 3% as foliar spray twice at active tillering and panicle initiation stages (T9) increased the root length, root volume and root dry weight over control with 44.0, 35.4and 41.9 per cent during samba 2016 and 33.2, 37.4 and 46.2 per cent during samba 2017, respectively at AT, PTK flowering stages.

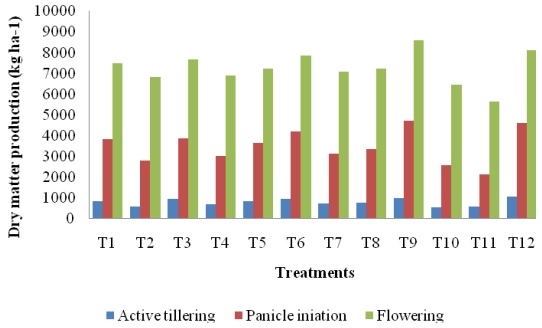

Figure 1. Effect of organic manures on dry matter production (kg ha^{-1}) of rice at different growth stages (Samba 2016)

This might be due to improvement in physico chemical properties of soil favoured by organic manures addition. Improvement in soil aeration and moisture content helps in better nutrient utilization. Reduction in bulk density might have increased root proliferation in organic manures applied plots.

Yield

Application of green manure @ 6.25 t ha^{-1} + split application of vermicompost in four equal splits @ 4 t ha^{-1} as basal, at active tillering , panicle initiation and flowering stages+ Panchagavya @ 3% as foliar spray twice at active tillering and panicle initiation stages (T_9) has recorded higher rice grain and straw yield (7465 and 6419 kg ha^{-1} grain and 8715 and 7751 kg ha^{-1} strain yield in *samba* 2016 and 2017, respectively), which was found to be on par with state recommendation (T_{12}) (Table 4). This might be due to the fact that steady and adequate supply of nutrients by the enhanced biochemical activity of microorganisms coupled with large photosynthesizing surface would have helped in the production of more tillers and dry matter with enhanced supply of assimilates to sink resulting in more number of spikelets, and higher yield. There are several reasons for increased yield in rice due to the spray of Panchagavya. Smaller quantities of IAA and GA present in Panchagavya when foliar sprayed could have created stimuli in the plant system which in turn increased the production of growth regulator in cell system and the action of growth regulators in plant system stimulated the necessary growth and development, leading to better yield (Udhaya Kumar, 2015).

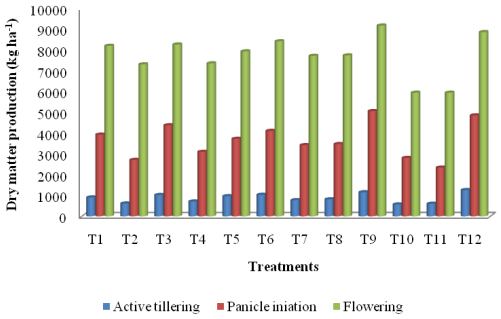

Figure 2. Effect of organic manures on dry matter production (kg ha^{-1}) of rice at different growth stages (Samba 2016)

Thus all the growth and yield characteristics such as plant height, number of tillers m^{-2}, dry matter production and root characteristics were significantly enhanced by organic manure applications. However, application of green manure @ 6.25 t ha^{-1} + split application of vermicompost into four equal splits @ 4 t ha^{-1} as basal, at active tillering, panicle initiation and flowering stages+ Panchagavya @ 3% as foliar spray twice at active tillering and panicle initiation stages recorded higher values on all the rice growth parameters. The superiority of this treatment is mainly because of improved soil microbial conditions, better nutrient availability in soil coupled with improved chlorophyll content in the leaves. Singh and Agarwal (2001) observed that the increase in leaf number as well as size due to enough nutrition can be explained in terms of possible increase in nutrient absorption capacity of the plant as a result of better root development and increased translocation of carbohydrates from source to growing points.

CONCLUSION

From the above discussion it is clear that organic sources of nutrients have a significant influence on overall growth in rice. Green manure @ 6.25 t ha^{-1} + split application of vermicompost in four equal splits @ 4 t ha^{-1} as basal, at active tillering , panicle initiation and flowering stages + Panchagavya @3% as foliar spray twice at active tillering and panicle initiation stages acquired better growth characteristics besides improving the soil fertility with economic viability for sustainable organic rice production.

REFERENCES

Amanullah, M.M., A. Alagesan, K. Vaiyapuri, S. Pazhanivelan and K. Sathyamoorthi. 2006. Intercropping and organic manures on the growth and yield of cassava (*Manihot esculenta* Crantz.). *Res. J. Agric. Biol. Sci.,* **2(5):** 183-189.

Dahiphale, A.V., D.G. Giri, G.V. Thakre and M.D. Gin. 2003. Effect of integrated nutrient management on yield and yield contributing parameters of the scented rice. *Ann. Plant Physiol.,* **17(1):** 24-26.

Hugar, A.Y., Chandrappa, H., Jayadeva, H.M., Satish, A. and Mallikarjun, G.B. 2009. Comparative performance of different rice establishment methods in Bhadra command area. *Karnataka J. Agric. Sci.,* **22:** 992-994.

Khatik, S.K. and P.B. Dikshit. 2001. Integrated use of organic manures and inorganic fertilizers on yield, quality, economics and nutrition of sunflower grown in Haplustalf clay soil. *Agric. Sci. Digest.,* **21(2):** 87-90.

Kumpawat, B.S. 2001. Rice-rice-pulse and rice-rice-sesame are the existing dominant cropping system of Thanjavur district. *Indian J. Agron.,* **46 (4):** 573-577.

Palaniappan S.P. I. Jhonkutty and P. Prameela. 1995. Soil fertility management in cropping systems with organic manures. In: Organic Agriculture. P.K.Thampan (ed.) Peekay Tree crops Devt. Foundation, Cochin, pp.224-254.

Perumal, K., Praveena, K., Stalin, V. and Janarthanam, B. 2006. Assessment of selected organic manures as plant growth hormones and their impact on the growth attributes of *Allium cepa* Lin. *Current Science*, **8:** 46-51

Sharma, J.C. and M.S. Kuhad. 1993. Effect of *Sesbania aculeata* (Dhaincha) on rice. *IRRN*, **18:** 28-29.

Singh, A. and Shivay, Y.S. 2013. Residual effect of summer green manure crops and Zn fertilization on quality and Zn concentration of durum wheat (*Triticum durum* Desf.) under a Basmati rice-durum wheat cropping system. *Biological Agriculture & Horticulture: An International Journal for Sustainable Production Systems,* **29(4):** 271-287.

Somasundaram, E. 2002. Man's activities impaired the Agro-ecosystem beyond repair- A veterans attempt to rectify. *Agro Bios (India) News Letter*, pp: 25-28.

Udhaya Kumar. K. 2015. Studies on cropping system and crop management practices for organic rice production. Ph.D. Thesis. Tamil Nadu Agricultural University, Coimbatore-3

Yadav, B.K. and Lourduraj, A., 2006. Effect of organic manures and panchagavya spray on rice *(Oryzasativa*L.) quality, *Crop Res.,* **31(1):** 6-10.