Influence of organic and inorganic nutrients on yield, physicochemical properties and cooking quality of seeragasamba rice

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Abstract
Field experiments were conducted during samba seasons of 2017-2018 and 2018-2019 to study the effect of organic manures and inorganic nutrients on yield, physicochemical and cooking quality of Seeragasamba rice. The experiments were conducted in sandy clay loam with pH around 7.5. Fourteen treatments comprising different sources of organic manures and inorganic nutrients were replicated thrice under RBD. The treatments are as follows: T1- 100%N through Green Manure, T2-75%N through Green Manure+25%N through RDF, T3-50%N through Green Manure+50% N through RDF, T4 -100%N through FYM, T5-75% N through FYM+FYM+25% N through RDF, T6-50% N through FYM+FYM+50% N through RDF, T7-100% N through Composted Poultry Manure, T8-75%N through Composted Poultry Manure+25%N through RDF, T9-50% N through Composted Poultry Manure+50%N through RDF, T10-100%N through Vermicompost Pressmud, T11- 75% N through Vermicompost Pressmud+25% N through RDF, T12-50% N through Vermicompost Pressmud + 50% N, T13-RDF @ 56:37:37 NPK Kg/ha through organic and T14 - Control (No Nitrogen). The results revealed that in both samba seasons, the highest grain yield was obtained in (T1) application of 50% N through green manure + 50% N through RDF and it was followed by the (T12) application of 50% N through vermicomposted pressmud + 50% N through RDF. However, both treatments were found to be on par with each other. The milling recovery, head rice recovery, protein and starch amylase content were also found to be higher in these treatments as compared to others. The cooking quality evaluated internms of increased length and breadth of cooked rice were also enhanced in these treatments. The sensory evaluation attributes viz., colour, taste, texture and overall acceptability were also increased in T1 and T12.

Keywords: Grain yield, milling recovery head rice recovery, protein starch, amylase and sensory

Introduction
Rice can be classified as aromatic and non-aromatic rice by aroma. Aromatic rice emits a unique aroma with cooking. Indian sub-continenre is habitat for aromatic rice diversity (Bisne and Sarawgi, 2008) [10]. In aromatic rice, the flavor is expressed as one of the most significant factors in market business, which distinguishes aromatic rice from ordinary rice (Laohakunjit and Kerdchoechuen, 2007 [11]; Fitzgerald et al., 2009) [10]. This flavour compound is stemming primarily from its 2-Acetyl-1-pyrroline content (Bhattacharjee et al., 2002) [3], which generally plays a role in consumer acceptability of rice (Bergman et al., 2000) [2]. Aromatic rice such as ‘Seeragasamba’, ‘Rascadam’ and ‘Basmathi’ are known for their characteristics fragrance when cooked. They also fetch a premium price in the local and regional markets (often 3 to 4 times more than the ordinary rice varieties), besides attracting good exports. Although a promising foreign exchange earns the cultivation of aromatic rice has been largely confined to the states of Uttar Pradesh, Punjab and Haryana (Saha et al., 2007) [19]. Rice growers have traditionally used organic materials particularly farmyard manure and green manures in the preindustrial age. Green manuring can improve soil physical, chemical, and biological properties and consequently crop yields (Fageria, 2007) [8]. Importance of this soil ameliorating practice is increasing in recent years because of increasing prices and low efficiency of chemical N fertilizer and low organic matter content of soils, inclusion of green manuring crops in the rice- based cropping systems, deserves priority consideration (Bhuiyan and Zaman, 1996) [4].
But with the present day high yielding cultivars, which have higher nutrient requirements, the use of inorganic fertilizers has increased considerably leading to declining in the use of organic materials (Hossain and Singh, 2000) [12]. It is well known that sustainable production of crops cannot be maintained by using only chemical fertilizers and similarly it is not possible to obtain higher yield by using organic manure alone (Bair, 1990) [1]. For sustainable agriculture and to ensure the food production with high quality, it is necessary to combined use of organic and inorganic sources of nutrients (Mahmud et al., 2016) [10]. Keeping in view of the above, the present investigation was carried out to find out the effects of organic and inorganic nutrients on yield, physical, chemical grain quality and cooking quality of Seeragasamba rice.

Materials and Methods
Field experiments were conducted during samba seasons of 2017-2018 and 2018-2019 at Madurai. It is located at Southern agro-climatic zones of Tamil Nadu at 9.54°N Latitude and 78.80°E longitude at an altitude of 147 m above MSL. In the first year experiment, a total of 278.1 mm of rainfall was received in 12 days. The maximum temperature ranged from 29.7 °C to 40.8 °C and minimum temperature ranges from 18.6 °C to 26.1 °C. In the second year experiment, a total rainfall of 377.8 mm was received in 11 days. The maximum and minimum temperature ranged from 29.7 °C to 38.4 °C and from 18.9 °C to 34.4 °C respectively. The soil of the experimental fields was sandy clay loam with pH around 7.5 and EC of 0.37 (dSm$^{-1}$). The experiment was conducted with fourteen treatments replicated thrice. The treatment details are as follows:

- T$_1$ - 100% N through Green Manure
- T$_2$ - 75%N through Green Manure+25% N through RDF
- T$_3$ - 50%N through Green Manure+50% N through RDF
- T$_4$ - 100% N through FYM
- T$_5$ - 75% N through FYM+25% N through RDF
- T$_6$ - 50% N through FYM+50% N through RDF
- T$_7$ - 100% N through Composted Poultry Manure
- T$_8$ - 75%N through Composted Poultry Manure+25% N through RDF
- T$_9$ - 50% N through Composted Poultry Manure+50% N through RDF
- T$_{10}$ - 100% N through Vermicomposted Pressmud
- T$_{11}$ - 75% N through Vermicomposted Pressmud+25% N through RDF
- T$_{12}$ - 50% N through Vermicomposted Pressmud+50% N through RDF
- T$_{13}$ - RDF @ 56:37:37 NPK kg/ha through inorganic
- T$_{14}$ - Control (No Nitrogen)

Table 1: Effect of different organic manures and inorganic nutrients on grain yield and physical grain quality of Seeragasamba rice

| Treatments | Grain yield (kg/ha) | Milking recovery (%) | Head rice recovery (%) |
|------------|---------------------|----------------------|------------------------|
|            | 2017-18 | 2018-19 | 2017-18 | 2018-19 | 2017-18 | 2018-19 |
| T$_1$      | 2701    | 2754    | 57.1    | 58.4    | 65.8    | 65.9    |
| T$_2$      | 3497    | 3567    | 61.6    | 62.8    | 69.1    | 68.6    |
| T$_3$      | 4573    | 4619    | 69.3    | 70.4    | 75.6    | 76.4    |
| T$_4$      | 2265    | 2288    | 55.2    | 56.5    | 62.5    | 64.1    |
| T$_5$      | 2934    | 2963    | 58.7    | 59.1    | 67.2    | 66.7    |
| T$_6$      | 3836    | 3875    | 65.1    | 66.5    | 73.8    | 72.3    |
| T$_7$      | 2562    | 2488    | 56.2    | 57.4    | 63.7    | 64.8    |
| T$_8$      | 3189    | 3222    | 59.4    | 60.2    | 67.9    | 67.4    |
| T$_9$      | 4070    | 4212    | 66.4    | 67.3    | 74.3    | 73.7    |
| T$_{10}$   | 2620    | 2673    | 56.5    | 58     | 64.4    | 65.3    |
| T$_{11}$   | 3392    | 3426    | 60.4    | 61.3    | 68.2    | 68.2    |
| T$_{12}$   | 4436    | 4481    | 67.1    | 68.1    | 73.6    | 74.5    |
| T$_{13}$   | 3760    | 3800    | 63.6    | 64.7    | 71.5    | 70.8    |
| T$_{14}$   | 2084    | 2105    | 54.1    | 55.6    | 61.3    | 62.1    |
| SEd        | 201.2   | 181.0   | 4.63    | 3.66    | 3.15    | 3.60    |
| CD (P=0.05)| 413.5   | 372.0   | 9.52    | 7.31    | 6.46    | 7.41    |

Physical grain quality
The milking recovery (per cent) and head rice recovery (per cent) are the most important characters which decides the physical quality of rice. With respect to milking recovery, the highest milking recovery (69.3 per cent in 2017-2018 and 70.4 in 2018-2019) were recorded due to the application of 50% N through green manure + 50% N through RDF (T$_5$) and it was followed by T$_{13}$ (67% in 2017-2018 and 68.14 in 2018-2019), T$_9$ (66.4 in 2017-2018 and 67.3 in 2018-2019). The treatments were found to be significantly higher than the other treatments.
The head rice recovery was significantly improved by the application of organic manures and inorganic nutrients. Significantly, the highest head rice recovery (75.6 in 2017-2018 and 76.4 per cent in 2018-2019) was recorded in T5, followed by T9 (74.3 per cent 2017-2018) and T12 (67.3 per cent in 2018-2019). These treatments viz., T3 and T8 were found to be significantly higher than the other treatments during 2017-2018 and T3 and T12 were found to be significantly higher than the other treatments in 2018-2019. The superior performances of these treatments might also be owing to improvement in physical, chemical and microbiological environment of soil favouring increased availability of nutrients to the rice crop. On the other hand, chemical fertilizers reduces the physical and microbiological properties of soil. Similar results was reported by Hemalatha et al. (2004)\textsuperscript{[11]}.

**Biochemical constituents**

In the case of protein content, it was significantly increased by the application of different organic manures and inorganic nutrients (Table 2). Among the treatments, T1 recorded the highest protein content of 8.40 per cent in 2017-2018 and 8.91 per cent in 2018-2019 followed by T2 - 8.21 per cent in 2017-2018 and 8.39 per cent in 2018-2019, T5 - 8.13 per cent in 2017-2018 and 8.29 per cent in 2018-2019. All treatments were significantly superior to the rest of the treatments. The treatments T14 recorded the lowest protein content (6.57). The data related to starch content revealed that it was significantly enhanced due to the application of different organic manures and inorganic nutrients. The highest starch content was registered in T5 - 68.72 per cent in 2017-2018 and 70.09 per cent in 2018-2019, followed by T12 - 66.32 per cent in 2017-2018 and T2 - 67.4 per cent in 2018-19. These treatments were found to be significantly higher than the other treatments. The lowest starch content (58.57 per cent) was recorded in T14.

Different treatments significantly influenced the amylose content of rice. Among the treatments, T5 recorded the highest amylose content of 24.10 per cent in 2017-2018 and 24.24 per cent in 2018-2019 followed by recorded T12 - 23.51 per cent in 2017-2018 and 25.75 per cent in 2018-2019 and which register T9 - 23.52 per cent in 2017-18 and 23.55 per cent in 2018-2019. All these treatments were found to be significantly higher than the other treatments and control. The control (T14) recorded the lowest amylose content (19.00 per cent).

The higher protein, starch and amylose content in these treatments might be due to the more availability of both macro and micronutrients from green manure and vermicomposted and farmyard manures. Improvement in quality parameters of rice due to the combined application of organic sources of nutrients along with inorganic fertilizer was also reported by Dixit and Gupta (2000)\textsuperscript{[17]}.

### Table 2: Effect of different organic manures and inorganic nutrients on biochemical constituents of Seeragasamba rice

| Treatments                                      | Protein (%) | Starch (%) | Amylose (%) |
|------------------------------------------------|-------------|------------|-------------|
|                                                | 2017-18     | 2018-19    | 2017-18     | 2018-19    | 2017-18     | 2018-19 |
| T1 100% N through green manure                 | 7.49        | 7.64       | 61.35       | 62.58      | 21.40       | 21.61   |
| T2 75% N through green manure+25% N through RDF| 7.88        | 8.04       | 63.50       | 64.77      | 22.45       | 22.67   |
| T3 50% N through green manure+50% N through RDF| 8.40        | 8.91       | 68.72       | 70.09      | 24.10       | 24.34   |
| T4 100% N through FYM                          | 7.26        | 7.41       | 60.23       | 61.43      | 20.38       | 20.58   |
| T5 75% N through FYM+25% N through RDF         | 7.57        | 7.72       | 62.12       | 63.36      | 21.96       | 22.18   |
| T6 50% N through FYM+50% N through RDF          | 8.09        | 8.25       | 65.68       | 67         | 23.27       | 23.5    |
| T7 100% N through composted poultry manure      | 7.37        | 7.52       | 60.82       | 62.04      | 20.84       | 21.05   |
| T8 75% N through composted poultry manure+25% N through RDF | 7.60 | 7.75       | 62.44       | 63.7       | 22.14       | 22.36   |
| T9 50% N through composted poultry manure+50% N through RDF | 8.13 | 8.29       | 66.01       | 67.33      | 23.32       | 23.55   |
| T10 100% N through vermin composted pressmud    | 7.44        | 7.51       | 61.00       | 62.22      | 21.02       | 21.22   |
| T11 75% N through vermin composted pressmud+25% N through RDF | 7.63 | 7.78       | 63.16       | 64.42      | 22.20       | 22.42   |
| T12 50% N through vermin composted pressmud+50% N through RDF | 8.21 | 8.37       | 66.33       | 67.64      | 23.51       | 23.75   |
| T13 RDF @ 56:37:37 NPK kg/ha through inorganic  | 8.00        | 8.16       | 64.12       | 65.4       | 22.73       | 23.00   |
| Control (No nitrogen)                          | 6.57        | 6.83       | 58.57       | 59.74      | 19.00       | 19.20   |
| SEd                                             | 0.298       | 0.547      | 3.343       | 3.654      | 0.937       | 1.370  |
| CD (P=0.05)                                    | 0.613       | 1.124      | 6.872       | 7.510      | 1.926       | 2.817  |

**Cooking quality**

The cooking quality characteristics viz. kernel length, kernel breadth, length breadth ratio after cooking of milled rice were estimated in samba seasons of both experiments 2017-2018 and 2018-2019 and the data are presented in Table 3. In the case of kernel length after cooking, the data revealed that the length of cooked rice was significantly increased by the application of different organic manures and inorganic nutrients in both experiments. Among the treatments, T1 recorded the (6.27 mm in 2017-18 and 6.40 mm in 2018-19) highest kernel length after cooking, followed by T12 (6.20 mm in 2017-18 and 6.30 mm in 2018-2019). All these two treatments found to be significantly superior to the rest of the treatments. The control recorded the lowest kernel length (5.42 mm) after cooking.

With regard to kernel breadth, T3 recorded the maximum breadth of kernel (2.25 in 2017-18 and 2.28 mm in 2018-19) followed by T12 (2.23 mm in 2017-2018 and 2.24 mm in 2018-2019). These two treatments viz., T3 and T12 were found to be significantly higher than the other treatments. The lowest kernel breadth after cooking was (1.82 mm) obtained in T14 (control). Similar increase in kernel length and breadth due to the application of organic sources of plant nutrients was also reported by Saha et al. (2007)\textsuperscript{[20]}.

The observation on length-breadth ratio after cooking revealed that the highest ratio was 3.0 and 3.5 was recorded in T14 during 2017-2018 and 2018-2019 respectively. However, the data were not significantly influenced by the different nutrients treatments.
Table 3: Effect of different organic manures and inorganic nutrients on cooking quality characteristics of Seeragasamaba rice

| Treatments                          | KLAC (mm) | KBAC (mm) | LBRAC |
|-------------------------------------|-----------|-----------|-------|
|                                    | 2017-18   | 2018-19   | 2017-18 | 2018-19 | 2017-18 | 2018-19 |
| T1 100% N through green manure      | 5.73      | 5.86      | 1.93   | 1.95    | 2.97    | 3.00    |
| T2 75% N through green manure+25% N through RDF | 5.88 | 6.00 | 2.04 | 2.06 | 2.88 | 2.91 |
| T3 50% N through green manure+50% N through RDF | 6.27 | 6.40 | 2.25 | 2.28 | 2.79 | 2.81 |
| T4 100% N through FYM               | 5.57      | 5.68      | 1.87   | 1.88    | 2.98    | 3.02    |
| T5 75% N through FYM+25% N through RDF | 5.78 | 5.90 | 2.00 | 2.02 | 2.89 | 2.92 |
| T6 50% N through FYM+50% N through RDF | 6.11 | 6.23 | 2.20 | 2.22 | 2.78 | 2.80 |
| T7 100% N through composted poultry manure | 5.63 | 5.74 | 1.89 | 1.90 | 2.99 | 3.02 |
| T8 75% N through composted poultry manure+25% N through RDF | 5.81 | 5.86 | 2.01 | 2.02 | 2.89 | 2.90 |
| T9 50% N through composted poultry manure+50% N through RDF | 6.15 | 6.27 | 2.21 | 2.23 | 2.78 | 2.80 |
| T10 100% N through vermicomposted pressmud | 5.69 | 5.80 | 1.90 | 1.92 | 3.00 | 3.02 |
| T11 75% N through vermicomposted pressmud+25% N through RDF | 8.54 | 5.97 | 2.02 | 2.04 | 2.90 | 2.93 |
| T12 50% N through vermicomposted pressmud+50% N through RDF | 6.20 | 6.30 | 2.22 | 2.24 | 2.78 | 2.81 |
| T13 RDF @ 56:37:37 NPK kg/ha through inorganic | 5.90 | 6.02 | 2.11 | 2.13 | 2.80 | 2.83 |
| T14 Control (No nitrogen)           | 5.42      | 5.52      | 1.82   | 1.85    | 2.98    | 3.05    |

Sensory evaluation

The sensory evaluation parameters viz, colour, texture, taste and overall acceptability were evaluated by using hedonic scale in samba seasons of both 2017-18 and 2018-19 experiments (Table 4). The highest colour score of 8.5 in 2017-18 and 8.7 in 2018-19 was recorded in T1. It was followed by T12 which recorded 8.3 in 2017-18 and 8.5 in 2018-19. Data pertaining to the texture of cooked rice, the highest score (8.8 in 2017-18 and 8.9 in 2018-19) was recorded in T1 and was followed by T12 (8.50 in 2017-18 and 8.6 in 2018-19). However, T3 and T12 were found to be on par with each other. Similar to the texture, the highest taste score (8.90 in 2017-18 and 9.0 in 2018-19) was recorded in T3. It was followed by T12 which registered the taste score of 8.70 in 2017-18 and 8.8 in 2018-19. The lowest score of 7.60 during 2017-18 and 7.9 in 2018-19 was recorded in T14.

Table 4: Effect of different organic manures and inorganic nutrients on sensory evaluation of cooked of Seeragasamaba rice

| Treatments                          | Colour (2017-18) | Colour (2018-19) | Texture (2017-18) | Texture (2018-19) | Taste (2017-18) | Taste (2018-19) | Overall acceptance (2017-18) | Overall acceptance (2018-19) |
|-------------------------------------|-----------------|-----------------|------------------|------------------|----------------|----------------|----------------------------|----------------------------|
| T1 100% N through green manure      | 7.8             | 7.9             | 7.9              | 8.0              | 8.10           | 8.2            | 7.9                        | 8.3                        |
| T2 75% N through green manure+25% N through RDF | 8.1 | 8.0 | 8.1 | 8.2 | 8.30 | 8.4 | 8.3 | 8.5 |
| T3 50% N through green manure+50% N through RDF | 8.5 | 8.7 | 8.8 | 8.9 | 8.90 | 9.0 | 8.8 | 8.9 |
| T4 100% N through FYM               | 7.8             | 7.9             | 7.9              | 8.0              | 8.10           | 8.2            | 7.9                        | 8.3                        |
| T5 75% N through FYM+25% N through RDF | 8.1 | 8.0 | 8.1 | 8.2 | 8.30 | 8.4 | 8.3 | 8.5 |
| T6 50% N through FYM+50% N through RDF | 8.3 | 8.5 | 8.5 | 8.6 | 8.70 | 8.8 | 8.7 | 8.8 |
| T7 100% N through composted poultry manure | 7.8 | 7.9 | 7.9 | 8.0 | 8.10 | 8.2 | 7.9 | 8.3 |
| T8 75% N through composted poultry manure+25% N through RDF | 8.1 | 8.0 | 8.1 | 8.2 | 8.30 | 8.4 | 8.3 | 8.5 |
| T9 50% N through composted poultry manure+50% N through RDF | 8.3 | 8.5 | 8.5 | 8.6 | 8.70 | 8.8 | 8.7 | 8.8 |
| T10 100% N through vermicomposted pressmud | 7.8 | 7.9 | 7.0 | 8.0 | 8.10 | 8.2 | 7.9 | 8.3 |
| T11 75% N through vermicomposted pressmud+25% N through RDF | 8.1 | 8.0 | 8.1 | 8.2 | 8.30 | 8.4 | 8.3 | 8.5 |
| T12 50% N through vermicomposted pressmud+50% N through RDF | 8.3 | 8.5 | 8.5 | 8.6 | 8.70 | 8.8 | 8.7 | 8.8 |
| T13 RDF @ 56:37:37 NPK kg/ha through inorganic | 8.1 | 8.2 | 8.3 | 8.4 | 8.60 | 8.6 | 8.6 | 8.7 |
| T14 Control (No nitrogen)           | 5.55            | 6.9             | 7.7              | 8.9              | 10.9           | 11.0           | 9.5                        | 10.6                       |

Hedonic 9 point scale: 1 - Dislike extremely, 2 - Dislike very much, 3 - Dislike moderately, 4 - Dislike slightly, 5 - Neither like nor dislike, 6 - Like slightly, 7 - Like moderately, 8 - Like very much, 9 - Like extremely

Conclusion

From the present investigation, it can be concluded that application of 50% N through green manure + 50% N through RDF as well as 50% N through vermicomposted pressmud + 50% N through RDF significantly increased the yield of Seeragasamaba. These treatments not only increased the yield but also enhanced protein, starch and amylose content. The milling recovery, head rice recovery, kernel length and breadth of cooked rice were also found to be increased by the combination of green manure or vermicomposted pressmud alone with inorganic nutrients. The cooked rice from these treatments were found to be have higher taste, texture, colour and overall acceptability.
and overall acceptability than the other treatments.

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