Enriched Charred Rice Husk to Improve the Nutrient Management in Rainfed Groundnut

P. Balasubramanian, C.R. Chinnamuthu

ABSTRACT

Background: The uncertainty of groundnut productivity in the rainfed areas could be minimized by in situ conserving the soil moisture received through precipitation during the cropping period and improving the nutrient status.

Methods: A field experiment was conducted at the Department of Agronomy, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, Tamil Nadu during 2014-2015 rabi season to find out the effect of charred rice husk and other organic materials enriched with or without fertilizer nutrient on the moisture retention and nutrient supply during the deficit period of crop growth. The treatment consists of charred rice husk, biochar, lignite and farm yard manure alone and enriched with the recommended dose of fertilizer (10:10:45 kg NPK ha⁻¹). The uncertainty of groundnut productivity in the rainfed areas could be minimized by in situ conserving the soil moisture received through precipitation during the cropping period and improving the nutrient status. Rice husk is the natural sheath or productive cover, which forms the cover of rice grains during their growth. Rice husk represents about 20 per cent by weight of the rice harvested. About 80 per cent by weight of the raw husk is made of organic components (Anonymous, 1979) and incorporation of rice husk into soil mixture was found to affect many crops (Sharma et al., 1989). Incorporation of rice husk can significantly improve soil properties by decreasing soil bulk density, enhancing soil pH, adding organic carbon, increasing available nutrients and removing heavy metals.
Enriched Charred Rice Husk to Improve the Nutrient Management in Rainfed Groundnut

from the system, ultimately increasing crop yields (Williams et al., 1972). Rice husk under different irrigation intervals can give good rice stand, better grain yield and higher water use efficiency (Abo-Soliman et al. 1990). So the present experiment was conducted to study the role of enriched rice husk as organic manure on groundnut pod yield and water retention capacity under rainfed condition with following objectives.

MATERIALS AND METHODS
Field experiment was conducted during rabi 2014-2015 under rainfed condition at the Central Farm, Department of Agronomy, Agriculture College and Research Institute, Madurai, Tamil Nadu. The site was located at $9^\circ. 54^\prime$ N latitude and $78^\circ.80^\prime$ E longitude at an altitude of 147 m above mean sea level. The region falls under the southern zone of Tamil Nadu. The ten treatments were selected with three replicates and each consisted of enriched charred rice husk ($T_1$), enriched biochar ($T_2$), enriched lignite ($T_3$), enriched farm yard manure ($T_4$), charred rice husk ($T_5$), biochar ($T_6$), lignite ($T_7$), farm yard manure ($T_8$), absolute control ($T_9$), and recommended dose of fertilizer (10:10:45 kg NPK ha$^{-1}$) ($T_{10}$) with Groundnut (VRI-2) crop having a plot size 5x4 m. The procedure of enriched organic manures is detailed below (Fig1). The treatments were replicated thrice and laid out under randomized block design (RBD).

After thorough field preparation initial soil samples were taken to analyze the initial soil properties. The initial soil sample was analyzed for available major nutrients; nitrogen (N), phosphorous (P), potassium (K) and sulphur (S), organic carbon (OC), pH and soluble salts. Table (1) and enriched different organic manures were collected and analyzed for chemical composition by SEM with EDAX. The results, for both soil and enriched organic manures, were presented in Table (2). Nitrogen, Phosphorus and Potassium were applied through Urea, SSP and MOP, respectively. Groundnut plant samples collected at 30, 60, 90 DAS and harvest stage for recording dry matter production were chopped into pieces, dried in hot air oven at 65 $^\circ$C ± 5 $^\circ$C and ground to fine powder in a Willey mill. The powdered

---

Table 1: Initial soil characteristics of experimental field.

| Particulars                                      | 2014-2015       |
|-------------------------------------------------|-----------------|
| **Mechanical analysis** (Piper, 1966)            |                 |
| Clay (Per cent)                                 | 21.45           |
| Silt (Per cent)                                 | 9.05            |
| Fine sand (Per cent)                            | 24.25           |
| Coarse sand (Per cent)                          | 43.96           |
| Texture class                                   | Sandy clay loam |
| **Physical constants** (Dakshinamurthy and Gupta, 1968) |         |
| Bulk density (g cm$^{-3}$)                       | 1.38            |
| Hydraulic conductivity (cm hr$^{-1}$)            | 4.70            |
| Particle density (g cm$^{-3}$)                   | 2.08            |
| Pore space (Per cent)                           | 37.50           |
| Available soil moisture (mm/60 cm)              | 101.05          |
| Field capacity (Per cent)                       | 20.07           |
| Permanent wilting point (Per cent)              | 9.86            |
| **Chemical analysis**                            |                 |
| Available N kg ha$^{-1}$ (Subbiah and Asija, 1956) | 154.00          |
| Available P kg ha$^{-1}$ (Olsen et al., 1954)    | 20.00           |
| Available K kg ha$^{-1}$ (Stanford and English, 1949) | 195.00          |
| Organic carbon (per cent) (Walkley and Black, 1934) | 0.44            |
| pH (1:2 soil water suspension) (Jackson, 1973)   | 7.50            |
| Electrical conductivity (dSm$^{-1}$) (1:2 soil water suspension) (Jackson, 1973) | 0.42 |
samples were used for the analysis of N, P and K content and expressed in percentage on oven dry weight basis. The nutrient uptake was worked out by multiplying the dry matter with the respective nutrient content and expressed in kg ha\(^{-1}\). The plant samples nitrogen was estimated by micro Kjeldahal method (Humphries 1956). For P and K in the extract was determined by Triple acid digestion–colorimetric (Jackson 1973). Surface soil samples (0-15 cm depth) were collected for chemical analysis after harvesting the crop each year from all plots. For available N, determined by (Subbiah and Asija, 1956), P content in the extracts was determined as described by (Olsen et al., 1954), and Available K was determined by extracting soil samples with Stanford and English, (1949). The observations on growth parameters such as plant height, Number of branches plant\(^{-1}\) number of flowers were recorded manually on five randomly selected representative plants from each plot of each replication separately as well as yield and yield attributing character were recorded as per the standard method. Yield attributes were also recorded at physiological maturity stage. The pod and haulm yield were recorded from net plot area of each treatment. The data obtained from various characters under study were analyzed by the method of analysis of variance as described by (Gomez and Gomez, 1984).

**RESULTS AND DISCUSSION**

**Yield and yield attributes**

The data can be recorded and analyzed for yield attributing characters of groundnut (Table 4). Among the different treatment application of enriched farm yard manure (T\(_4\)) recorded higher values of yield attributes when compared to enriched biochar (T\(_2\)) and charred rice husk treatments (T\(_1\)). Among the treatments, organic manures (T\(_5\) and T\(_8\)) and recommended dose of fertilizer (T\(_{10}\)) showed significantly positive influence on all yield attribute characters than the control treatment. Information pertaining to number of pegs plant\(^{-1}\), number of pods plant\(^{-1}\) and peg-pod conversion percentage (Table 4).

Incorporation of T\(_4\) recorded significantly increased the peg to pod conversion (81.08%) with higher pod filling percentage (46.90%). Followed by T\(_2\) (80.49%) and T\(_1\) (79.92%) significantly improved the peg to pod conversion with pod filling percentage. The improved peg to pod conversion with higher pod filling percentage might be due to the production of higher crop growth rate even at later stages of crop growth resulting in higher translocation of photosynthetic from source to sink. This might be due to the supply of moisture retained in the organic materials facilitated the crop to utilize the natural resources effectively under

**Table 2:** Treatment details.

| Treatment | Description |
|-----------|-------------|
| T\(_1\)   | Charred rice husk +100 per cent Recommended dose of N and P through soil application |
| T\(_2\)   | Biochar + 100 per cent Recommended dose of N and P through soil application |
| T\(_3\)   | Lignite +100 per cent Recommended dose of N and P through soil application |
| T\(_4\)   | Farm yard manure (FYM) + 100 per cent Recommended dose of N and P through soil application |
| T\(_5\)   | Charred rice husk 5 tons ha\(^{-1}\) |
| T\(_6\)   | Biochar 5 tons ha\(^{-1}\) |
| T\(_7\)   | Farm yard manure 5 tons ha\(^{-1}\) |
| T\(_8\)   | Lignite 5 tons ha\(^{-1}\) |
| T\(_9\)   | Absolute Control |
| T\(_{10}\) | Recommended dose of fertilizer (RDF) (10:10:45 kg NPK ha\(^{-1}\)) |

**Table 3:** Nutrient content of organic materials.

| Content               | Charred rice husk | Biochar | Lignite | FYM |
|-----------------------|-------------------|---------|---------|-----|
| Energy storage (per cent): Carbon | 64.31             | 66.65   | 63.64   | -   |
| Energy exchange nutrient (per cent): Oxygen | 28.42             | 24.55   | 24.96   | -   |
| **Major nutrient (per cent)** |                  |         |         |     |
| Nitrogen              | -                 | 6.58    | 2.56    | 0.48 |
| Phosphorus            | 0.20              | 0.23    | 0.22    | 0.25 |
| Potassium             | 0.25              | 0.43    | 0.36    | 0.50 |
| **Secondary nutrient (per cent)** |                  |         |         |     |
| Calcium               | 0.25              | 0.63    | 0.78    | 0.00 |
| sulphur               | 0.24              | 0.30    | 0.61    | 0.00 |
| **Micronutrients (per cent)** |                  |         |         |     |
| Manganese             | 0.23              | 0.00    | 0.00    | 32.5 (ppm) |
| Iron                  | 0.15              | 0.00    | 0.00    | 430 (ppm) |
| zinc                  | 0.00              | 0.00    | 0.00    | 105 (ppm) |
| copper                | 0.00              | 0.00    | 0.00    | 3.10 (ppm) |
| **Others (per cent)** |                  |         |         |     |
| Silica                | 5.96              | 0.26    | 1.05    | -   |
Table 4: Effect of enriched charred rice husk and other organic materials on yield characters.

| Treatments    | Flowering percentage plant \(^{-1}\) | Number of pegs plant \(^{-1}\) | Number of pods plant \(^{-1}\) | Number of matured pods plant \(^{-1}\) | Single seeded pods plant \(^{-1}\) | Double seeded pods plant \(^{-1}\) | Hundred pod weight (g) |
|---------------|--------------------------------------|---------------------------------|---------------------------------|--------------------------------------|----------------------------------|------------------------|------------------------|
| T\(_{1}\) (CRH+NP) | 8.50                                 | 28.81                           | 23.19                           | 19.78                                | 3.10                             | 16.79                  | 101.27                 |
| T\(_{2}\) (BC+NP)  | 8.47                                 | 29.47                           | 23.26                           | 20.14                                | 2.99                             | 17.45                  | 101.54                 |
| T\(_{3}\) (LN+NP)  | 7.84                                 | 26.67                           | 20.08                           | 17.09                                | 2.13                             | 14.51                  | 100.03                 |
| T\(_{4}\) (FYM+NP) | 9.16                                 | 31.78                           | 25.77                           | 22.97                                | 3.11                             | 20.22                  | 102.95                 |
| T\(_{5}\) (CRH)    | 6.20                                 | 22.87                           | 18.03                           | 14.02                                | 4.20                             | 10.54                  | 99.78                  |
| T\(_{6}\) (FYM)     | 7.24                                 | 24.16                           | 20.48                           | 16.24                                | 4.01                             | 11.78                  | 100.01                 |
| T\(_{9}\) (LN)      | 6.16                                 | 21.84                           | 16.94                           | 12.40                                | 4.00                             | 8.27                   | 98.83                  |
| T\(_{10}\) (Control)| 5.16                                 | 15.70                           | 11.41                           | 9.56                                 | 4.65                             | 5.84                   | 97.23                  |
| T\(_{11}\) (RDF NPK)| 7.60                                 | 27.48                           | 21.48                           | 16.21                                | 3.57                             | 13.72                  | 100.48                 |
| SEd             | 0.17                                 | 0.41                            | 0.47                            | 2.40                                 | 0.07                             | 0.22                   | NS                     |
| CD (p=0.05)      | 0.36                                 | 0.87                            | 0.99                            | 5.05                                 | 0.15                             | 0.47                   | -                      |

Table 5: Pod yield and Haulm yield by enriched charred rice husk and other organic materials.

| Treatments       | Pod yield (kg ha\(^{-1}\)) | Haulm yield (kg ha\(^{-1}\)) | Harvest Index |
|------------------|---------------------------|------------------------------|---------------|
| T\(_{1}\) (CRH+NP)| 2010                      | 5115                         | 62.81         |
| T\(_{2}\) (BC+NP) | 1983                      | 5118                         | 62.17         |
| T\(_{3}\) (LN+NP) | 1800                      | 4897                         | 60.30         |
| T\(_{4}\) (FYM+NP)| 2190                      | 5304                         | 63.62         |
| T\(_{5}\) (CRH)  | 1500                      | 4389                         | 57.84         |
| T\(_{6}\) (BC)   | 1559                      | 4399                         | 57.17         |
| T\(_{7}\) (FYM)  | 1681                      | 4628                         | 58.64         |
| T\(_{8}\) (LN)   | 1486                      | 4125                         | 55.01         |
| T\(_{9}\) (Control)| 1250                    | 3849                         | 51.46         |
| T\(_{10}\) (RDF NPK)| 1900                    | 5018                         | 62.30         |
| SEd              | 84.58                     | 112.64                       | -             |
| CD (p=0.05)      | 177.70                    | 236.66                       | -             |

Table 6: Effect of enriched charred rice husk and other organic materials on total nitrogen uptake of rainfed groundnut (kg ha\(^{-1}\)).

| Treatments        | 30 DAS | 60 DAS | 90 DAS | Harvest |
|-------------------|--------|--------|--------|---------|
| T\(_{1}\) (CRH+NP)| 27.89  | 58.96  | 129.52 | 125.43  |
| T\(_{2}\) (BC+NP) | 28.22  | 59.27  | 130.95 | 126.89  |
| T\(_{3}\) (LN+NP) | 26.18  | 55.21  | 126.28 | 122.21  |
| T\(_{4}\) (FYM+NP)| 30.15  | 62.73  | 134.57 | 129.82  |
| T\(_{5}\) (CRH)  | 24.28  | 46.78  | 118.41 | 115.21  |
| T\(_{6}\) (BC)   | 24.31  | 47.19  | 119.59 | 116.42  |
| T\(_{7}\) (FYM)  | 25.93  | 50.24  | 122.65 | 118.69  |
| T\(_{8}\) (LN)   | 22.46  | 42.71  | 116.21 | 112.37  |
| T\(_{9}\) (Control)| 20.11  | 38.38  | 110.93 | 106.33  |
| T\(_{10}\) (RDF-NPK)| 27.46  | 57.49  | 127.49 | 122.57  |
| SEd              | 0.59   | 0.93   | 2.96   | 2.51    |
| CD (p=0.05)      | 1.24   | 1.96   | 6.22   | 5.27    |

The double seeded pods increased steadily with time and reached the highest at harvest. The increased double seeded pods might be to greater uptake of nutrients in groundnut as a result of higher nutrient release from the manures like charred rice husk, biochar, lignite, FYM. Among the organic manures treatments, (T\(_{5}\)) application exerted significant increase on the double seeded pods plant\(^{-1}\). Followed by (T\(_{3}\)) and (T\(_{4}\)) produced higher double seeded pods compared to (T\(_{9}\)) treatment. This is in accordance with Chandrasekaran et al. (2007) to his findings, addition of farm yard manure positively influenced the number of pods plant\(^{-1}\) in groundnut. Further addition of enriched cattle manure (15-20 t ha\(^{-1}\)) produced significantly better yield compared to chemical fertilizer.

Incorporation of (T\(_{9}\)) recorded significantly higher pod yield (2190 kg ha\(^{-1}\)). As that of FYM, the (T\(_{1}\)) and (T\(_{5}\)) produced comparable pod yield of 2010 kg ha\(^{-1}\) and 1983 kg ha\(^{-1}\), respectively. Besides supplying the macro and micro nutrients, the enriched organic materials also supplied the required amount of moisture during the critical stages of crop growth resulted in increased pod yield compared to T\(_{9}\) (1250 kg ha\(^{-1}\)) treatment. Data in Table 5 show that treatments had significant effect on pod and haulm yields of groundnut.

**Nutrient Uptake**

Data pertaining to nutrient uptake (kg ha\(^{-1}\)) at four different stages (30, 60, 90 DAS and harvest stage) are given in Table 6, 7 & 8. Generally, it was found that the enriched organic manure made profound impact on the nutrient uptake by the plants namely N, P and K. It was observed that nutrient uptake was significantly higher in enriched manure treatments (T\(_{1}\) to T\(_{5}\)) compared to organic manure alone (T\(_{5}\)) rainfall condition. This is similar to the findings of Senthil Kumar (1990) who had reported that the maintenance of adequate nutrients during the crop growth period resulted in higher peg to pod conversion ratio and matured pods.
and T₃), recommended dose of fertilizer and control treatments.

The results revealed that the early stage (30 DAS) of crop growth registered higher uptake of N (30.15 kg ha⁻¹), P (12.63 kg ha⁻¹) and K (25.49 kg ha⁻¹) with T₄ treatment. It was closely followed by T₅ and T₉. Among the treatment the absolute control plot treatment recorded the least quantity of NPK uptake (20.11, 6.81 and 11.46 kg ha⁻¹ respectively).

Results at peak vegetative stages (60 DAS) revealed that the T₄ registered higher nutrient uptake (N-62.73, P-20.02 and K-42.86 kg ha⁻¹) which was closely followed by T₅ and T₉. The T₄ treatment recorded the lower nutrient uptake of all the three major nutrients (N-38.38, P-8.92 and K-23.20 kg ha⁻¹).

It was observed that at the later stage (90 DAS) enriched farm yard manure registered higher nutrient uptake namely N (134.57 kg ha⁻¹), P (35.85 kg ha⁻¹) and K (81.88 kg ha⁻¹) which was closely followed by T₆ and T₇. The T₅ recorded the lower nutrient uptake (N-110.93, P-16.49 & K-56.34 kg ha⁻¹). The same trend was observed at the harvest stage.

Among various enriched organic manures, enriched FYM recorded higher N, P and K use efficiency. This might be due to higher content of nutrients available from enriched FYM as source which might have been efficiently converted to sink. It was followed by enriched biochar and charred rice husk treatments.

The use efficiency of applied N, P and K was higher due to addition of enriched FYM with urea and single super phosphate. This might be due to the synergistic effect between organic manure and in organic fertilizer. A positive correlation was observed between nutrient management practices with nitrogen, phosphorus and potassium use efficiency. This effect was reflected on pod yield.

The reason might be due to the increased root length and root volume which might have tapped the available nutrients from rhizophere at the increased soil moisture level.

### Table 7: Effect of enriched charred rice husk and other organic materials on total phosphorus uptake of rainfed groundnut (kg ha⁻¹).

| Treatments       | 30 DAS | 60 DAS | 90 DAS | Harvest |
|------------------|--------|--------|--------|---------|
| T₁ (CRH+NP)     | 23.41  | 38.49  | 77.86  | 85.24   |
| T₂ (BC+NP)      | 23.86  | 39.12  | 78.52  | 86.13   |
| T₃ (LN+NP)      | 21.84  | 35.05  | 74.16  | 82.49   |
| T₄ (FYM+NP)     | 25.48  | 42.86  | 81.88  | 89.78   |
| T₅ (CRH)        | 15.47  | 29.04  | 62.48  | 74.59   |
| T₆ (BC)         | 16.28  | 29.47  | 63.12  | 75.67   |
| T₇ (FYM)        | 18.46  | 32.49  | 66.98  | 78.69   |
| T₈ (LN)         | 12.49  | 26.69  | 59.10  | 71.37   |
| T₉ (Control)    | 11.46  | 23.20  | 56.34  | 67.55   |
| T₁₀ (RDF-NPK)   | 22.48  | 38.17  | 75.28  | 83.29   |
| SEd             | 0.24   | 0.78   | 1.18   | 1.56    |
| CD (p=0.05)     | 0.51   | 1.64   | 2.49   | 3.29    |

### Table 9: Effect of enriched charred rice husk and other organic materials on post-harvest soil nutrient status of rainfed groundnut (kg ha⁻¹).

| Treatments       | pH  | EC (dSm⁻¹) | OC (%) | Ava. N (kg ha⁻¹) | Ava. P (kg ha⁻¹) | Ava. K (kg ha⁻¹) |
|------------------|-----|------------|--------|------------------|------------------|------------------|
| T₁ (CRH+NP)     | 7.5 | 0.43       | 0.42   | 172.40           | 32.82            | 162.79           |
| T₂ (BC+NP)      | 7.6 | 0.45       | 0.41   | 173.40           | 33.15            | 163.41           |
| T₃ (LN+NP)      | 7.5 | 0.44       | 0.41   | 169.15           | 31.64            | 159.36           |
| T₄ (FYM+NP)     | 7.5 | 0.43       | 0.43   | 176.00           | 34.33            | 165.79           |
| T₅ (CRH)        | 7.5 | 0.44       | 0.41   | 161.37           | 29.23            | 154.69           |
| T₆ (BC)         | 7.5 | 0.44       | 0.41   | 162.58           | 30.51            | 155.34           |
| T₇ (FYM)        | 7.5 | 0.43       | 0.41   | 165.48           | 31.12            | 157.69           |
| T₈ (LN)         | 7.5 | 0.44       | 0.41   | 158.00           | 29.33            | 151.94           |
| T₉ (Control)    | 7.3 | 0.43       | 0.38   | 152.60           | 25.06            | 143.87           |
| T₁₀ (RDF-NPK)   | 7.4 | 0.44       | 0.40   | 168.71           | 27.43            | 159.24           |
| SEd             | NS  | NS         | NS     | 3.76             | 0.54             | 3.22             |
| CD (p=0.05)     | 7.90| 1.14       | 6.77   |                  |                  |                  |

**Abbreviations:**
- CRH-Charred Rice Husk 5 t ha⁻¹, BC- Biochar 5 t ha⁻¹, LN-Lignite 5 t ha⁻¹,
- FYM- Farmyard Manure 5 t ha⁻¹, N-Nitrogen 10 kg ha⁻¹, P-Phosphorus 10 kg ha⁻¹,
- K-Potash 45 kg ha⁻¹, RDF-Recommended dose of Fertilizer 10:10:45 kg NPK ha⁻¹.
Enriched Charred Rice Husk to Improve the Nutrient Management in Rainfed Groundnut

than non-application of enriched organic manure plots. The other reason could be that the applied organics might have created favorable physical, chemical, and microbial environment. These results are in line with the findings of Subbiah and Kumaraswamy (2000), Parasuraman and Mani (2001) and Tyagi (2004). Gupta et al. (1988) reported that available N content of the soil increased significantly with increasing application of FYM. Incorporation of charred manure practices had a positive effect with the nutrient uptake. This might be due to higher availability of nutrients owing to the addition of enriched organic manure and nutrients. Similar results were earlier reported by Palaniappan and Siddeswaran (1994).

Data on post-harvest soil analysis are given in Table 1. It was observed that the post-harvest soil recorded higher available N, P and K in T4 treatment with value of N-176.00, P-34.33 and K-165.79 kg ha⁻¹ respectively, followed by T2 and T1. While comparing all the treatments, the T4 was recorded the least available N, P and K (152.60, 25.06 and 143.87 kg ha⁻¹) respectively. Khoja et al. (2002) reported that application of nitrogen with phosphatic fertilizers improved soil fertility levels in chickpea over the control.

CONCLUSION

It is concluded that groundnut with enriched farm yard manure produced maximum pod yield of 2190 kg/ha and haulm 5304 kg/ha. It was closely followed by enriched biochar pod yield of 2010 kg/ha and haulm 5115 kg/ha and charred rice husk 1983 and haulm 5115 kg/ha. With respect to economics, among the organic manure treatments, the charred rice husk recorded the gross return of Rs. 60300/ha., maximum net return of Rs. 37457/ha and benefit cost ratio of 2.64 due to the cheaper material cost. This suggests that the charred rice husk has potential benefits for commercial agriculture in future.

ACKNOWLEDGEMENT

The author would like to thanks Dr. C.R. Chinmanuthu and Dr. P. Venkatchalam, for his opinion and suggestion. The assistance of technician, farm labour and friends in performing some laboratory and field testing are also acknowledged.

REFERENCES

Abo-Soliman, M.S., Ghanem, S.A., Abd El-Hafezand, S.A, and El-Moweihl, N., (1990). Effect of irrigation regimes and nitrogen levels on rice production and nitrogen losses under tile drainage. Ministry of Agriculture and Land Reclamation Res. 1: 14-15.

Anonymous. (1979). Rice situation. Economics and cooperative service. US Department of Agriculture, Washington. D.C.20250.

Chandrasekaran, R., E. Somasundaram, Mohamed Amanullah, K. Nalin, K. Thirukkumaran and K. Sathyamoorthi. (2007). Response of confectionery groundnut (Arachis hypogaea L.) varieties to farm yard manure. J. of Applied Sci. Res. 3(10): 1097-1099.

Directorate of Economics and Statistics, Govt. Of India. 2015-16. Gomez, K.A. and A.A. Gomez. (1984). Statistical Procedures for Agricultural Research. New Delhi, India: John Wiley. 680.

Gupta, A. P., R. S. Patil and Narwal. (1988). Effect of Farmyard manure on Organic carbon, available N and P content of soil during different periods of wheat growth. J. Indian Soc. of Soil Sci. 36(2): 269-273.

Humphries, E.C. (1956). Mineral components and ash analysis. Modern methods of plant analysis. Springer - Verlag, Berlin. 1: 468-502.

Jackson, K.L. 1973. Soil chemical analysis. 2nd Indain Reprint. Prentice Hall of India Pvt. Ltd. New Delhi.

Khoja, J.R., Khangarot, S.S., Gupta, A.K., Kulhari, A.K. (2002). Effect of fertility and biofertilizer on growth and yield of chickpea (Cicer arietinum L.). Annals of Plant and Soil Research. 4:357-198 358.

Olsen, S.R., C.V. Cole, Fris Wantanable and L.A. Dean. (1954). Estimation of available phosphorus in soil by extraction with sodium bicarbonate. USDA Cir. No., 939.

Palaniappan, S.P. and K. Siddeswaran. (1994). Nitrogen uptake of rice as influenced by green manure, grain legumes and fertilizer In: SARP. Proc. 141-148.

Parasuraman, P. and A.K. Mani. (2002). Influence of coir pith on yield and economics of rice and paddy crops. Mysore J. Agric. Res. 35: 316-322.

Sarma, P.S. and M.V.K. Sivakumar. (1989). Response of groundnut to drought stress in different growth phases. Agric. water manag. 15: 301-310.

Senthilkumar, P. (1990). Studies on the response of groundnut to land, irrigation and water stress management. M.Sc. (Ag.) Thesis, TNAU, Coimbatore, Tamil Nadu, India.

Stanford, G. and L. English. (1949). Use of flame photometer in rapid soil test for K and Ca. Agron. J. 41: 446-447.

Subbiah, B.V. and G.E. Asija. (1956). A rapid procedure for the estimation of available nitrogen in soil. Curr. Sci. 25: 259-260.

Subbiah, B. and K. Kumaraswamy. (2000). Effect of different manure - fertilizer schedules on the yield and quality of rice and on soil fertility. Fert. Newa. 45(10): 61-62 and 65-67.

Tyagi, S.K. (2004). Studies on nutrient management through organic in direct sown rainfed finger millet. M.Sc., (Agri) Thesis, Tamil Nadu Agric. Univ., Coimbatore.

Williams, N.A., N.D. Morse and J.F. Buckman. (1972). Burning vs. incorporation of rice crop residues. Agron. J. 64: 467- 468.