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# GROWTH, YIELD AND WATER USE OF MAIZE AS INFLUENCED BY DRIP IRRIGATION SCHEDULES AND NITROGEN LEVELS

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## ABSTRACT

The field experiment was conducted for two consecutive years (2013-14 and 2014-15) to evaluate the yield and economic returns from maize under different irrigation schedules and nitrogen levels. The experiment was laid out in split-plot design and replicated thrice by applying four irrigation schedules under the mainplot and three nitrogen levels under subplot. The growth parameters and yield of maize were found superior with weekly check basin irrigation, however, were on par with drip irrigation at 0.9 IW/CPE ratio. Among the nitrogen levels tried, 240 kg N ha$^{-1}$ recorded higher growth and yield. The interaction between the irrigation schedules and nitrogen levels indicated the better growth parameters and higher yield with irrigation scheduled either by weekly check basin method or through drip irrigation at 0.9 IW/CPE ratio along with 240 kg N ha$^{-1.}$ The water use efficiency was also higher with drip irrigation scheduled at 0.9 IW/CPE ratio. The results revealed that maize crop can be grown economically with the irrigations scheduledat 0.9 IW/CPE ratio through drip irrigation along with 240 kg N ha$^{-1}$.

**Keywords:** Maize, drip irrigation, nitrogen levels

## INTRODUCTION

Maize is grown throughout the year over a wide range of soils in India. Because of its high grain productivity, it has an enormous potentiality in ensuring food security. In India, area and production under maize are about 9.4 mha and 23.0 million tonnes, and the productivity is about 2500 kg ha$^{-1}$(FICCI, 2018). In Southern Climatic Zone of Andhra Pradesh, besides as a food crop, maize has been gaining importance as poultry feed due to well-established market of poultry feed units. Maize is fairly sensitive to water stress, thus, when water is limited, it is difficult to implement irrigation management strategies without any yield loss. One of the main reasons for the low water use efficiency is predominant use of flood method of irrigation, where conveyance and distribution losses are more. Traditional irrigation methods are no longer viable. Drip irrigation is a solution which reduces the conveyance and distribution losses allowing higher water use efficiency.Hence, widespread adoption of this drip irrigation to maize in recent years needs sharp focusing on efficient use of each drop of water. Since nitrogen is a constituent of protein, enzymes, hormones, vitamins, alkaloids and chlorophyll,

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it's deficiency in plants leads to improper growth and development. Hence, the study was undertaken to find out the appropriate irrigation schedule through drip method as well as nitrogen requirement for improving the water use efficiency and crop yield.

## MATERIAL AND METHODS

The field experiment was carried out during *Rabi* season of 2013-14 and 2014-15 at S.V. Agricultural College Farm, Tirupati. The experimental site is located at 13.5°N latitude, 79.3°E longitude and at an altitude of 182.9 m above the MSL, in the Southern agro- climatic zone of Andhra Pradesh. The soil was sandy loam in texture, slightly alkaline in reaction (7.9), low in organic carbon (0.25 %) and available nitrogen (178 kg $ha^{-1}$), medium in available phosphorus (24.9 kg $ha^{-1}$) and available potassium (174 kg $ha^{-1}$). The field experiments were laid out in split-plot design with total of twelve treatments, replicated thrice by taking irrigation schedules (surface drip irrigation at 0.7IW/CPE, 0.8 and 0.9 IW/CPE ratios and weekly check basin irrigation) underthe mainplot and nitrogen levels (160 kg $ha^{-1}$, 200 kg $ha^{-1}$ and 240 kg $ha^{-1}$) assubplot with plot size of 6.6m X 5.4m. Maize variety 'DHM 117'was grown in paired rows with a distance of 60/30 cm. Two seeds were dibbled per hill at a spacing of 20 cm. Nitrogen was applied as per the treatments in three splits *i.e.,* half at basal, one-fourth at knee high stage and the remaining one fourth at tasseling stage. The recommended dose of phosphorus and potassium each @ 80 kg $ha^{-1}$ were applied basally. Irrigations were scheduled as per the treatments. The total quantity of water applied at different IW/CPE ratios was kept the same. The volume of water to be applied to each plot to replenish the effective crop root zone depth (0-45cm) to field capacity (35mm) was calculated by

$$\text{Total quantity of water applied (L)} = \frac{\text{Plot size (m}^2) \times \text{depth of water (mm)}}{1000} \times 1000$$

**The details of drip irrigation are as below:**

| Treatment | Cumulative Epan for irrigation (mm) | Lateral spacing (cm) | Emitter spacing (cm) | Flow rate (l $hr^{-1}$) | Irrigation duration (hours) |
|---|---|---|---|---|---|
| IW/CPE of 0.7 | 50.0 | 90 | 40 | 4 | 3.24 |
| IW/CPE of 0.8 | 43.7 | 90 | 40 | 4 | 3.24 |
| IW/CPE of 0.9 | 38.8 | 90 | 40 | 4 | 3.24 |

Each plant received 3.14 L of water at each irrigation. One control treatment through conventional check basin method with 50mm depth of irrigation was included for comparison. Soil samples collected from different depths (0-15 cm, 15-30 cm and 30-45 cm) before and after irrigation were used for estimation of soil moisture by thermo gravimetric method.The

Crop Evapotranspiration was estimated by using the following formula:

$$ETc = \sum_{i=n}^{n=l} \frac{M_1 i - M_2 i}{10} \bullet \rho bi \bullet Di$$

Wherein,

ETc : Crop Evapotranspiration from the effective root zone depth within one irrigation cycle

n : Number of soil layers sampled in the root zone depth

$M_1i$ : Mass water percentage measured 24 hours after $n^{th}$ irrigation in the $i^{th}$ layer

$M_2i$ : Mass water percentage measured one day before the $n^{th}$irrigation in the $i^{th}$ layer

ρbi : Bulk density of the soil in the $i^{th}$ layer

Di : Depth of $i^{th}$ layer of the soil (cm) i.e. 0-15, 15-30 and 30-45 cm

Ó : Represents summation

I : Is the integer representing soil layer

Water use efficiency of maize was calculated by dividing seed yield with evapotranspiration and water productivity was calculated by dividing seed yield with total water applied. Return per rupee invested was calculated for each treatment by dividing the gross returns with the corresponding cost of cultivation.

## RESULTS AND DISCUSSION

**Growth parameters:** Weekly check basin irrigation recorded significantly the highest growth parameters (plant height, leaf area index and total dry matter production), which were comparable with the irrigation scheduled at 0.9 IW/CPE ratio through the drip, during both the years(Table 1). All the above three growth parameters were lesser with drip irrigation at 0.7 IW/CPE ratio, during both the years.Increased plant height with increase in frequency of irrigation might be attributed to more nutrient mobility coupled with higher water uptake under more frequent irrigation regimes leading to increased cell division, cell elongation, increased photosynthetic activity and LAI which in turn might have enhanced the dry weight of the plant (Aulakh *et al.*, 2013).

Regarding nitrogen levels, application of nitrogen at 240 kg $ha^{-1}$ recorded significantly the highest values of all the growth parameters (Table 1). This indicated the positive effect of nitrogen in boosting crop growth. Basava*et al.* (2012) observed that application of nitrogen increased the plant height by increasing internodal length, rate of leaf emerging, leaf number and leaf size which would result in more and larger photosynthetic apparatus by increasing total leaf area and LAI of the crop consequently influencing assimilate production having direct bearing on dry matter production per plant and per unit area. The interactioneffect indicated that the highest values of all the growth parameters recorded with irrigation at weekly interval along with 240 kg N $ha^{-1}$, but on par with drip irrigation at 0.9 IW/CPE ratio with the same level of nitrogen. This might be due to the combined effect of adequate moisture under high nitrogen level, leading to better crop growth and dry matter production (Singh,2001).The lowest values for all the growth parameters were

**Table 1. Plant height, leaf area index and dry matter production (DMP) of maize as influenced by drip irrigation and nitrogen fertilizer levels**

| Treatment | Plant height (cm) | | Leaf area index | | DMP (kg $ha^{-1}$) | |
|---|---|---|---|---|---|---|
| | 2013-14 | 2014-15 | 2013-14 | 2014-15 | 2013-14 | 2014-15 |
| **Irrigation schedules** | | | | | | |
| $M_1$ : 0.7 IW/CPE under drip irrigation | 193.6 | 194.4 | 0.38 | 0.45 | 6263 | 6712 |
| $M_2$ : 0.8 IW/CPE under drip irrigation | 208.3 | 199.9 | 0.49 | 0.57 | 9247 | 9734 |
| $M_3$ : 0.9 IW/CPE under drip irrigation | 213.9 | 210.0 | 0.58 | 0.65 | 10965 | 11022 |
| $M_4$ : Weekly check basin | **Nitrogen levels** | 214.9 | 0.68 | 0.73 | 11087 | 11269 |
| | | | | | | |
| $N_1$ : 160 kg $ha^{-1}$ | 198.9 | 198.3 | 0.17 | 0.24 | 8964 | 8860 |
| $N_2$ : 200 kg $ha^{-1}$ | 203.8 | 204.6 | 0.66 | 0.73 | 9467 | 9964 |
| $N_3$ : 240 kg $ha^{-1}$ | 208.6 | 211.5 | 0.76 | 0.83 | 9740 | 10229 |

| | SEm± | CD | SEm± | CD | SEm± | CD | SEm± | CD | SEm± | CD | SEm± | CD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **M** | 1.57 | 5.5 | 1.45 | 5.1 | 0.02 | 0.06 | 0.01 | 0.04 | 147 | 518 | 86 | 304 |
| **N** | 0.83 | 2.5 | 1.18 | 3.6 | 0.01 | 0.03 | 0.01 | 0.03 | 43 | 131 | 65 | 198 |
| **Mat N** | 2.07 | 6.7 | 2.41 | 7.7 | 0.02 | 0.08 | 0.02 | 0.07 | 163 | 559 | 137 | 442 |
| **N at M** | 2.72 | 5.5 | 2.51 | 7.5 | 0.03 | 0.07 | 0.02 | 0.06 | 254 | 298 | 149 | 422 |

**(CD at P=0.05)**

registered with the combination of irrigation at 0.7 IW/CPEratio through drip and 160 kg N ha$^{-1}$.

**Yield attributes and yield:**The yield attributes *viz.,* cob length, cob girth, kernel weight cob$^{-1}$, hundred kernel weight (Table 2) and yield (kernel and stover) of maize (Table 3) were significantly influenced by the drip irrigation schedules and nitrogen levels as well as their interaction except for cob girth, during both the years ofinvestigation. Betteryield attributes and higher yield were recorded under weekly check basin irrigation, which was on par with those recorded under IW/CPE ratio of 0.9 through drip irrigation.In weekly check basin irrigation, the growth and development of cob was better which might be due to adequate turgidity inside the plant. In addition to this, adequate turgidity prevailed inside the plant might have been congenial to translocate the photosynthates efficiently from the source to the development of sink consequently yield (Paolo and Rinaldi, 2008).Increase in kernel yield under drip irrigation at 0.9 IW/CPE was mainly due to increased soil moisture in the upper 30 cm soil layer, leading to higher plant relative water content and less negative leaf water potential (Viswanatha *et al.*, 2002). The decrease in tissue water potential affects several physiological processes. Plant water deficit affects the final yield through its influence on various physiological processes. These results are in conformity with the findings of Aulakh *et al.* (2013).Among the nitrogen levels, application of nitrogen at 240 kg ha$^{-1}$ produced significantly higher values of all the yield attributes and yieldas compared to the lower doses of nitrogen. This might be because of better pollination under higher nitrogen levels, helping to maintain the sink capacity thereby causing well-filled kernels in cob (Zakkam *et al.,* 2012).

Regarding interaction, weekly irrigations with 240 kg N ha$^{-1}$ registered thehighest yield attributes (cob length, kernel weight cob$^{-1}$ and hundred kernel weight) and yield (grain and stover), which were statistically on par with those recorded with the combination of drip irrigation at 0.9 IW/CPE ratio and 240 kg N ha$^{-1}$, during both the years of study. This might be due to the combined effect of adequate moisture under high nitrogen level, leading to better partitioning and translocation of photosynthates from source to sink (Singh, 2001). Drip irrigation at 0.7 IW/CPE ratio with nitrogen level of 160 kg ha$^{-1}$ recorded the lowest stature of yield components and yield during both the years.

### Water Studies

**Crop evapotranspiration (ETc) :** Increase in IW/CPE ratio from 0.7 to 0.9 significantly increased the ETc.The highest crop evapotranspiration was due to weekly irrigation through check basin compared with drip irrigation at 0.9 or 0.8 IW/ CPE ratio (Table 4). Lowest crop evapotranspiration was recorded with drip irrigation at 0.7 IW/CPE ratio, during both the years. Higher ETc at high frequent irrigation can be attributed to higher plant height at 90 DAS, higher LAI and high dry matter production. The results are in consistent with

**Table 2. Yield attributes of maize as influenced by drip irrigation and nitrogen fertilizer levels**

| Treatment | Cob length (cm) | | Cob girth (cm) | | Kernel weight $cob^{-1}$ (g) | | Hundred kernel weight (g) | |
|---|---|---|---|---|---|---|---|---|
| | 2013-14 | 2014-15 | 2013-14 | 2014-15 | 2013-14 | 2014-15 | 2013-14 | 2014-15 |
| Irrigation schedules | | | | | | | | |
| $M_1$ : 0.7 IW/CPE under drip irrigation | 15.4 | 16.6 | 12.5 | 12.7 | 53.2 | 54.9 | 19.1 | 19.2 |
| $M_2$ : 0.8 IW/CPE under drip irrigation | 16.8 | 17.5 | 13.0 | 13.6 | 74.1 | 75.1 | 21.4 | 21.5 |
| $M_3$ : 0.9 IW/CPE under drip irrigation | 20.4 | 21.4 | 13.6 | 14.1 | 86.4 | 88.7 | 26.1 | 26.2 |
| $M_4$ : Weekly check basin | 21.8 | 22.4 | 13.9 | 14.3 | 88.8 | 90.1 | 26.6 | 26.8 |
| **Nitrogen levels** | | | | | | | | |
| $N_1$ : 160 kg $ha^{-1}$ | 16.9 | 18.3 | 12.9 | 13.1 | 68.1 | 69.1 | 22.5 | 22.7 |
| $N_1$ : 200 kg $ha^{-1}$ | 18.7 | 19.5 | 13.3 | 13.8 | 78.3 | 80.4 | 23.1 | 23.1 |
| $N_1$ : 240 kg $ha^{-1}$ | 20.1 | 20.5 | 13.5 | 14.2 | 80.5 | 82.0 | 24.3 | 24.4 |

| | SEm± | CD | SEm± | CD | SEm± | CD | SEm± | CD | SEm± | CD | SEm± | CD | SEm± | CD | SEm± | CD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M | 0.4 | 1.34 | 0.31 | 1.11 | 0.10 | 0.3 | 0.07 | 0.3 | 1.32 | 4.64 | 1.73 | 6.10 | 0.14 | 0.5 | 0.18 | 0.6 |
| N | 0.17 | 0.51 | 0.51 | 0.66 | 0.11 | 0.3 | 0.17 | 0.5 | 0.47 | 1.41 | 0.40 | 1.20 | 0.15 | 0.4 | 0.15 | 0.5 |
| Mat N | 0.47 | 1.57 | 1.57 | 1.54 | 0.20 | NS | 0.29 | NS | 1.52 | 5.17 | 1.85 | 6.40 | 0.28 | 0.9 | 0.30 | 1.0 |
| N at M | 0.66 | 1.13 | 1.13 | 1.42 | 0.16 | NS | 0.13 | NS | 2.28 | 3.17 | 2.99 | 2.75 | 0.25 | 0.1 | 0.31 | 1.0 |

**(CD at P=0.05)**

the findings of Krishnasamy *et al.* (2012) and Aulakh *et al*. (2012).Increase in nitrogen level from 160 kg ha$^{-1}$ to 240 kg ha$^{-1}$ significantly increased the ETc. Application of 240 kg N ha$^{-1}$ resulted in higher ETc, during both the years. Increase in ETc with increase in nitrogen level can be attributed to higher plant height, higher LAI and high dry matter production.

Interaction effect between the irrigation schedules and nitrogen levels on ETc indicated that combination of higher irrigation frequency and higher level of nitrogen resulted in significantly highest ETc during both the years. At all the IW/CPE ratios, difference in ETc due to nitrogen levels was not significant, during both the years. Improvement in growth parameters such as plant height, LAI, dry matter production contributed to high ETc at higher nitrogen levels.

**Water use efficiency :** Water use efficiency varied significantly due to irrigation schedules and nitrogen levels, during both the years (Table 4). Interaction of irrigation schedules and nitrogen levels was not significant during both the years. Scheduling irrigation at 0.9 IW/CPE ratio through drip irrigation resulted in significantly higher water use efficiency relative to 0.8 IW/CPE ratio but the difference between the weekly irrigation schedule and irrigation at 0.7 IW/CPE ratio was not significant in the first year. The same trend was observed in the second year also except that the difference between irrigation at IW/CPE of 0.8 and 0.9 was not significant. Weekly irrigation resulted in lower WUE compared to irrigations at 0.7, 0.8 and 0.9 IW/CPE ratios, during both the years. Higher WUE due to 0.8 and 0.9 IW/CPE ratios might be due to adequate supply of soil moisture for maize crop due to these treatments. The results indicated that maize was sensitive to both water stress and excess soil moisture (Akir, 2004). These results are in conformity with the findings of Al-Kaisi and Yin (2003), Paolo and Rinaldi (2008) and Aulakh *et al.* (2012).Water use efficiency progressively and significantly decreased with decrease in nitrogen level from 240 kg ha$^{-1}$ to 160 kg ha$^{-1}$ in the first year. However, in WUE the difference due to nitrogen levels between 240 kg ha$^{-1}$ and 200 kg ha$^{-1}$ was not significant in the second year.Higher WUE at higher levels of nitrogen application can be attributed to improvement in growth parameters like plant height, LAI, and dry matter production. Paolo and Rinaldi (2008) and Krishnasamy *et al.* (2012) reported similar results.

**Water productivity:** There was no significant difference in water productivity when irrigation given at 0.8 and 0.9 IW/CPE ratios but both of which recorded significantly higher water productivity compared to 0.7 IW/CPE ratio (Table 4). Scheduling irrigation once in a week resulted in significantly lowerwater productivity, during both the years.Higher water productivity under 0.8 and 0.9 IW/CPE ratios compared to 0.7 IW/CPE ratio was due to the optimum moisture availability due to high frequency of irrigation as evident from WUE in these two treatments. Significantly, lower water productivity with weekly irrigation was due to higher ETc with these treatments. These results

**Table 3. Kernel yield and stoveryield (kg ha$^{-1}$) of maize as influenced by drip irrigation and nitrogen fertilizer levels**

| Treatment | Kernel yield (kg ha$^{-1}$) | | | | | | | | Stover yield (kg ha$^{-1}$) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2013-14 | | | | 2014-15 | | | | 2013-14 | | | | 2014-15 | | | |
| | $N_1$ : 160 | $N_2$ : 200 | $N_3$ : 240 | Mean | $N_1$ : 160 | $N_2$ : 200 | $N_3$ : 240 | Mean | $N_1$ : 160 | $N_2$ : 200 | $N_3$ : 240 | Mean | $N_1$ : 160 | $N_2$ : 200 | $N_3$ : 240 | Mean |
| $M_1$ : 0.7 IW/CPE under drip irrigation | 2073 | 2743 | 2929 | 2582 | 2339 | 2763 | 3049 | 2717 | 2458 | 3635 | 4078 | 3390 | 2897 | 3714 | 4298 | 3636 |
| $M_2$ : 0.8 IW/CPE under drip irrigation | 3063 | 4065 | 4194 | 3774 | 3101 | 4103 | 4236 | 3813 | 3920 | 5812 | 6333 | 5355 | 4035 | 5852 | 7026 | 5637 |
| $M_3$ : 0.9 IW/CPE under drip irrigation | 3759 | 4907 | 5051 | 4572 | 3723 | 4838 | 5015 | 4525 | 5059 | 7420 | 8095 | 6858 | 5094 | 7301 | 8079 | 6825 |
| $M_4$ : Weekly check basin | 3813 | 4948 | 5128 | 4630 | 3992 | 4976 | 5204 | 4724 | 5383 | 7945 | 8700 | 7343 | 5702 | 7929 | 8911 | 7514 |
| **Mean** | 3177 | 4166 | 4326 | | 3289 | 4170 | 4376 | | 4205 | 6203 | 6801 | | 4432 | 6199 | 7078 | |

| | S.Em± | CD (P=0.05) | S.Em± | CD (P=0.05) | S.Em± | CD (P=0.05) | S.Em± | CD (P=0.05) |
|---|---|---|---|---|---|---|---|---|
| **M** | 128 | 453 | 141 | 498 | 190 | 671 | 222 | 784 |
| **N** | 34 | 102 | 40 | 122 | 52 | 158 | 120 | 364 |
| **M at N** | 140 | 482 | 155 | 536 | 208 | 718 | 297 | 982 |
| **N at M** | 223 | 234 | 244 | 278 | 329 | 360 | 385 | 797 |

**(CD at P=0.05)**

**Table 4. Water use parameters and returns per rupee invested in maize as influenced by drip irrigation schedules and nitrogen fertilizer levels**

| Treatment | Crop evapotranspiration (mm) | | Water use efficiency (kg ha-mm$^{-1}$) | | Water productivity (kg m$^{-3}$) | | Returns per rupee invested (`Rs. ha$^{-1}$) | |
|---|---|---|---|---|---|---|---|---|
| | 2013-14 | 2014-15 | 2013-14 | 2014-15 | 2013-14 | 2014-15 | 2013-14 | 2014-15 |
| **Irrigation schedules** | | | | | | | | |
| $M_1$ : 0.7 IW/CPE under drip irrigation | 220.8 | 223.1 | 11.7 | 12.2 | 1.054 | 1.109 | 1.29 | 1.36 |
| $M_2$ : 0.8 IW/CPE under drip irrigation | 255.8 | 254.9 | 14.7 | 14.9 | 1.348 | 1.362 | 1.86 | 1.89 |
| $M_3$ : 0.9 IW/CPE under drip irrigation | 279.2 | 280.0 | 16.4 | 16.5 | 1.452 | 1.437 | 2.23 | 2.20 |
| $M_4$ : Weekly check basin | 361.8 | 383.3 | 12.9 | 12.4 | 0.661 | 0.630 | 2.07 | 2.06 |
| **Nitrogen levels** | | | | | | | | |
| $N_1$ : 160 kg ha$^{-1}$ | 276.1 | 282.6 | 11.5 | 11.8 | 0.920 | 0.944 | 1.53 | 1.58 |
| $N_2$ : 200 kg ha$^{-1}$ | 279.2 | 285.4 | 14.9 | 14.7 | 1.209 | 1.198 | 2.00 | 1.99 |
| $N_3$ : 240 kg ha$^{-1}$ | 282.9 | 288.0 | 15.3 | 15.3 | 1.257 | 1.261 | 2.06 | 2.07 |

| | SEm± | CD | SEm± | CD | SEm± | CD | SEm± | CD | SEm± | CD | SEm± | CD | SEm± | CD | SEm± | CD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M | 1.17 | 4.1 | 1.07 | 3.8 | 0.43 | 1.53 | 0.54 | 1.91 | 0.04 | 0.14 | 0.04 | 0.15 | 0.06 | 0.22 | 0.07 | 0.24 |
| N | 0.61 | 1.9 | 0.30 | 0.9 | 0.12 | 0.37 | 0.21 | 0.63 | 0.01 | 0.03 | 0.01 | 0.04 | 0.06 | 0.05 | 0.02 | 0.06 |
| Mat N | 1.54 | 5.1 | 1.17 | 4.0 | 0.48 | NS | 0.64 | NS | 0.04 | 0.15 | 0.05 | 0.17 | 0.07 | 0.23 | 0.08 | 0.26 |
| N at M | 2.03 | 4.1 | 1.85 | 3.6 | 0.75 | NS | 0.94 | NS | 0.07 | 0.14 | 0.08 | 0.18 | 0.11 | 0.11 | 0.12 | 0.14 |

**(CD at P=0.05)**

are in accordance with the findings of Silungwe *et al.* (2010).Increase in nitrogen application from 160kg ha$^{-1}$to 240 kg ha$^{-1}$ significantly increased the water productivity, during both the years. High water productivity at higher levels of nitrogen can be attributed to higher yield and higher WUE with these treatments. These results confirms the findings of Tafteh and Sepaskhah (2012).

Interaction between irrigation schedules and nitrogen levels significantly varied the water productivity during both the years at all the nitrogen levels, scheduling irrigation at 0.8 and 0.9 IW/CPE ratios, recorded significantly higher water productivity compared to 0.7 IW/CPE ratio which might be due to adequate soil moisture availability with these treatments. At all the irrigation schedules, except at 0.7 IW/CPE ratio and with higher levels of nitrogen (240 kg ha$^{-1}$ and 200 kg ha$^{-1}$), recorded significantly higher water productivity compared with the lowest dose of nitrogen. At all nitrogen levels, scheduling irrigation at weekly intervals resulted in lowest water productivity as the wetter moisture regimes are not conducive for maize growth. Irrigation scheduled at 0.7 IW/CPE ratio with the lowest level of nitrogen (160 kg N ha$^{-1}$) significantly decreased the water productivity during both the years.Higher water productivity with higher nitrogen levels at all irrigation schedules was due to increased availability of nitrogen for maize growth.

**Returns per rupee invested:** Irrigation schedules as well as graded nitrogen levels significantly influenced the returns per rupee invested and the interaction effect between them was also significant, with similar trend, during both the instances of investigation (Table 4).The highest returns per rupee invested was realized with irrigation scheduled at IW/CPE ratio of 0.9, which was on par with weekly intervals by check basin method and the later treatment was in turn comparable with 0.8 IW/CPE ratio. Drip irrigation at 0.7 IW/CPE ratio resulted in the lowest returns per rupee invested. Similar findings have been reported by Reddy *et al*. (2012).

Higher nitrogen level of 240 kg ha$^{-1}$ recorded significantly higher benefit-cost ratio. This was followed by the nitrogen level of 200 kg ha$^{-1}$, while lower benefit cost ratio was observed with the dose of 160 kg N ha$^{-1}$ which can be attributed to increased yields under higher nitrogen levels. These results corroborate with the findings of Reddy *et al.* (2012).

Drip irrigation at 0.9 IW/CPE ratio and weekly irrigations produced comparable benefit-cost ratios, irrespective of the nitrogen levels, except at lower nitrogen dose. With the any irrigation schedule, application of 240 kg N ha$^{-1}$ and 200 kg N ha$^{-1}$ resulted in the higher benefit cost ratios. The higher monetary returns under higher irrigation regimes of 0.9 IW/CPE ratio through drip and weekly irrigations along with higher nitrogen doses might be due to increased kernel and stover yields under favourable moisture conditions coupled with higher nitrogen level. The lowest monetary returns were noticed in drip irrigation at 0.7 IW/ CPE ratio along with 160 kg N ha$^{-1}$. The study confirmed the results of Pennaiah (2005) who reported similar findings.

## CONCLUSION

The study revealed that maize crop can be grown economically and efficiently with irrigation at 0.9 IW/CPE ratio through surface drip irrigation along with 240 kg N $ha^{-1}$ in Southern Climatic Zone of Andhra Pradesh.

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# INFLUENCE OF ORGANIC AMENDMENTS AND FERTIGATION ON SOIL PROPERTIES AND PERFORMANCE OF WATERMELON *(Citrullus lanatus Thunb.)*

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**ABSTRACT**

Effect of soil amendments with the recommended dose of fertilizers on soil properties growth and yield of watermelon in *Theri* soil (red sand dunes) was studied during the years 2017 and 2018. The experiment was laid out in Randomized Block Design with Factorial concept (FRBD) with two factors *viz.,* soil amendments and nutrients. A total of 18 treatments including three amendments and six nutrients level and application methods were replicated thrice. Among the treatment combinations, the tank silt application @ 100 t ha$^{-1}$ along with 100 per cent recommended dose of fertilizers (200:100:100 kg of NPK ha$^{-1}$) through fertigation at seven days interval ($A_1N_5$) produced maximum number of branches (10.7), longest vine (362.0 cm), number of fruits plant$^{-1}$ (2.6), weight of fruit (5.3 kg) and highest fruit yield (68.8 t ha$^{-1}$) with a gross returns of ₹4,09,320 ha$^{-1}$, benefit-cost ratio of 2.45 and uptake of N, P and K as 39.79 kg ha$^{-1}$, 4.04 kg ha$^{-1}$ and 30.49 kg ha$^{-1}$, respectively compared to other treatments. Significant build up of organic carbon (0.52%), available N (253 kg ha$^{-1}$ ), P (16 kg ha$^{-1}$) and K (218 kg ha$^{-1}$) were recorded with the application of tank silt @ 100 t ha$^{-1}$ with 100 per cent recommended fertilizer (200:100:100 kg of NPK ha$^{-1}$ ) through fertigation at seven days interval ($A_1N_5$).

**Keywords:** Watermelon, organic amendments, fertigation

## INTRODUCTION

Watermelon (*Citrullus lanatus* Thunb.) is one of the important fruit crops grown extensively in India. It is a major tropical crop in south Indian states of Karnataka, Andhra Pradesh and Tamil Nadu. India is the second-largest producer of watermelon fruit among the Asian countries accounting to 2.48 million tonnes from 1.01 lakh ha with the productivity of 24.58 t ha$^{-1}$ (GoI, 2017). In Tamil Nadu, the production is 1.63 lakh tonnes from an area of 6930 ha with average productivity of 23.52 t ha$^{-1}$ (Govt. of Tamilnadu, 2017).

The *Theri* lands (red sand dunes) are one of the major wastelands in Tirunelveli and Thoothukudi districts of Tamil Nadu. These *theries* are located between (77° 49' 44" to 78° 28' 22" E longitude and 8° 15'13" to 9° 11' 0" N latitude) which occupy an extent of 20,171 ha (Jawahar *et al.,* 1999). The soils have low nutrient status, low water holding capacity, low organic carbon content and susceptible to high wind erosion (Manikandan and Subramanian, 2010). The mean annual rainfall of the study area is in a range of 610 mm and 700 mm.

A soil amendment is any material added

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to a soil to improve its physical properties, such as water retention, permeability, water infiltration, drainage, aeration and structure. In theri soils (red sand dune), the addition of soil amendments such as tank silt, FYM, composted coir pith (CCP), *etc.* improve the physico-chemical properties of soil. Many organic and inorganic amendments contain plant nutrients and act as fertilizers. Monitoring soil and plant nutrient status is essential to ensure maximum crop productivity. It is well known that organic and inorganic amendments along with inorganic fertilizers are essential to increase the productivity of crops and fertility of soils.

The fertigation technology is the possible way to improve the crop production and soil productivity for profitable farming in constrained *Theri* soil. Fertigation within the rhizosphere matches with the physiological needs of the crop *viz.* root development, vegetative growth, flower and fruit development. Scientific information on fertigation in *theri* land (red sand dune), especially in watermelon, is very scanty. Hence, the field experiment was conducted to determine influence of amendments combined with inorganic fertilizers through fertigation on growth, fruit yield of watermelon and soil fertility of *Theri* land.

## MATERIAL AND METHODS

The experiment was conducted during *Kharif* - Winter seasons of 2016-2017 and 2017-2018 at Thirumaraiyur village, Sattan-kulam taluk, Thoothukudi district, Tamil Nadu. The sand dune ecosystem was formed in isomegathermic and ustic regime from the geogenic sand deposit under semi-arid climate. The soil at the experimental site was red sandy, with organic carbon 0.12%, electrical conductivity 0.13 dSm$^{-1}$ and neutral in reaction (pH 6.66). The soils have low available N (94 kg ha$^{-1}$), available P (8 kg ha$^{-1}$) and available K (89 kg ha$^{-1}$). Seeds of watermelon $F_1$ hybrid Suprit were sown in rows of 2 m width, with 60 cm plant-to-plant spacing, during the first week of November in both the years. The experiment was laid out in Factorial Randomized Block Design (FRBD) consisting of two factors *viz.,* organic amendments and nutrients level. The amendments *viz.,* tank silt @ 100 t ha$^{-1}$ ($A_1$), composted coir pith @ 12.5 t ha$^{-1}$ ($A_2$) and farm yard manure @ 20 t ha$^{-1}$ ($A_3$) were applied as basal doses before sowing. Different fertilizer levels and methods of application tested in the study were $N_1$: 75 % RDF (soil application), $N_2$: 100 % RDF (soil application), $N_3$: 75 % RDE at 7 days interval (fertigation), $N_4$: 75 % RDF at 15 days interval (fertigation), $N_5$: 100% RDF at seven days interval (fertigation) and $N_6$: 100% RDF at 15 days interval (fertigation).

Conventional fertilizers used in the experiment were urea, single super phosphate, di-ammonium phosphate and muriate of potash, whereas, 19 kg each of N, $P_2O_5$, $K_2O$ and $KNO_3$ was used as the source of water soluble fertilizer. Fertilizer was applied at 7 and 15 days intervals through fertigation treatments. Soil treatments received the entire $P_2O_5$ and $K_2O$ at sowing and N in two splits as basal during sowing and at 30 DAS. Drip irrigation was given to all the treatments. Growth observations were taken at 60 DAS. All agronomic and plant protection measures were adopted as per the guidelines of crop production guide for Tamil Nadu (TNAU, 2015). The crop was harvested at 90 DAS to 100 DAS, at fruit maturity, as indicated by a dull sound of the fruit, or, when the fruit tendril turned to straw colour, or when the fruit base turned creamy-yellow. The nutrient content was analysed through prescribed laboratory procedures and the uptake was calculated. Soil samples were analysed following Walkley and Black (1934) for organic carbon, alkaline permanganate oxidizable N as described by Subbiah and Asija (1956), 0.5 M $NaHCO_3$- extractable P (Olsen *et al.,* 1954) and available potassium by flame photometry after extracting with ammonium acetate 1 N $NH_4OAc$ (Schollenberger and Simon, 1945). Observations on crop growth, yield, yield parameters and quality were recorded and statistically analysed as per Gomez and Gomez (1984). Economics of watermelon cultivation as influenced by chemical fertilizer, drip fertigation and management practices were calculated by considering the prevailing market price of fruit and inputs used.

## RESULTS AND DISCUSSION

### Growth, yield and quality attributes

### Effect of amendments

The growth and yield attributing characters such as number of branches, number of fruits plant$^{-1}$ and fruit yield were significantly influenced by various amendments (Table 1).

Among the three amendments, the application of tank silt at the rate of 100 t ha$^{-1}$ ($A_1$) significantly registered more number of branches (8.72), more fruits (2.22), higher fruit yield (55.49 t ha$^{-1}$), total soluble solid (9.80%) and ascorbic acid (7.41 mg100g $^{-1}$) followed by composted coir pith applied at the rate of 12.5 t ha$^{-1}$ ($A_2$), which registered number of branches (8.22), number of fruits (2.10), fruit yield (50.43 t ha$^{-1}$), total soluble solid (9.78%) and ascorbic acid (7.29 mg100g $^{-1}$) next to $A_1$. Tank silt contains all nutrients which are responsible for the enhanced growth and yield attributes in watermelon. Annadurai *et al.* (2005) noticed similar results that tank silt amendment enhanced the productivity of crops such as sunflower, groundnut, cotton, sugarcane, soybean, gingili, tomato, cotton, onion, brinjal, turnip, cucumber, chillies, etc.

### Effect of nutrients

The growth and yield attributes of watermelon *viz.,* number of branches, vine length, number of fruits and fruit weight were significantly influenced by the application of recommended dose of NPK as 200:100:100 kg ha$^{-1}$ through fertigation at 7 days interval ($N_5$) (Table 1) which registered maximum number of branches (10.0), longest vine (347.89 cm), highest number of fruits plant$^{-1}$ (2.38), more weight of fruit (5.33 kg), higher fruit yield (63.32 t ha$^{-1}$), more total soluble solid (10.75%) and ascorbic acid (8.05 mg100g$^{-1}$) followed by the application of 75 per cent NPK through fertigation at seven days interval ($N_3$). However, among the two levels of NPK without fertigation, the minimum number of branches (6.78), shortest vein length (268.44 cm), minimum number of fruits per plant (1.75), lowest fruit weight (4.29 kg), minimum fruit yield (38.36 t ha$^{-1}$), lower contentment of total soluble solid (8.30%) and ascorbic acid (6.08 mg 100 g$^{-1}$) were found in treatment applied with 75 per cent NPK ha$^{-1}$ through soil application ($N_1$). This finding was supported by Kadam *et al.* (2009). The levels of tank silt at the rate of 20 t ha$^{-1}$ recorded the higher number of pods, pod yield, haulm yield and shelling percentage in case of groundnut crop (Binitha, 2006).

**The combined effect of amendment and nutrients**

The interaction of amendments with fertilizers played an important role in increasing the production of watermelon. Though the interaction effect was non-significant for all parameters except fruit yield, more number of branches (10.67), longer vine (362 cm), maximum number of fruits plant$^{-1}$ (2.57), maximum weight of fruit (5.27 kg), maximum fruit yield (68.77 t ha$^{-1}$), maximum content of total soluble solid (10.94%) and ascorbic acid (8.07 mg 100g$^{-1}$) were registered by the application of tank silt @ 100 t ha$^{-1}$ along with 100 per cent NPK as 200:100:100 kg ha$^{-1}$ through fertigation at 7 days interval ($A_1N_5$) followed by the application of composted coir pith @ 12.5 t ha$^{-1}$ with 100 per cent NPK through fertigation at 7 days interval ($A_2N_5$). Among the two levels of NPK without fertigation, the less number of branches (6.33), short vein length (259.33 cm), low number of fruits plant$^{-1}$ (1.67), low fruit weight (4.26 kg), minimum fruit yield (36.11 t ha$^{-1}$), low content of total soluble solid (8.17%) and ascorbic acid (6.08 mg 100 g$^{-1}$) were found in treatment applied with FYM @ 20 t ha$^{-1}$ with 75 per cent NPK ha$^{-1}$ through soil application ($A_3N_1$). The results indicated that only inorganic nutrients cannot alone maintain an instant flow of nutrients for increasing the crop yield. There is a need to use organic and chemical fertilizers in combination with drip fertigation to increase crop productivity. The increase in the fruit yield might be due to the application of organic amendments in combination with inorganic fertilizers. This result is supported by the earlier findings of Andrade Junior *et al.* (2009) and Kadam *et al.* (2009).

**Nutrient uptake**

**Effect of amendments**

The uptake of N and K in watermelon was also significantly influenced by the amendments. The highest values of N and K uptake (32.90 kg ha$^{-1}$ and 24.09 kg ha$^{-1}$, respectively) by watermelon were recorded with the application of tank silt @ 100 t ha$^{-1}$($A_1$) followed by the treatment applied with composted coir pith @ 12.5 t ha$^{-1}$ ($A_2$) which recorded the values of 31.69 kg ha$^{-1}$ and 21.88 kg ha$^{-1}$, whereas, the highest phosphorus uptake (3.17 kg ha$^{-1}$) was recorded in treatment applied with composted coir pith @ 12.5 t ($A_2$) ha$^{-1}$ followed by the treatment with tank silt @100 t ha$^{-1}$ ($A_1$) by recording the value of 2.96 kg ha$^{-1}$. The minimum uptake of N, P and K (26.32 kg ha$^{-1}$, 2.78 kg ha$^{-1}$ and 19.49 kg ha$^{-1}$,

**Table 1. Effect of organic amendment with inorganic fertilizers on growth, yield and quality of hybrid watermelon**

| Treatments | No. of branches plant$^{-1}$ | Vine length (cm) | No. of fruits plant$^{-1}$ | Average fruit wt. (kg) | Fruit yield (t ha$^{-1}$) | TSS (%) | Ascorbic acid (mg100g $^{-1}$) |
|---|---|---|---|---|---|---|---|
| **Main factor (Amendments)** | | | | | | | |
| $A_1$-Tank silt @ 100 t ha$^{-1}$ | 8.7 | 308.2 | 2.2 | 4.7 | 55.5 | 9.8 | 7.4 |
| $A_2$ -Composted coir pith @ 12.5 t ha$^{-1}$ | 8.2 | 312.1 | 2.0 | 4.7 | 50.4 | 9.8 | 7.3 |
| $A_3$-Farm yard manure (FYM) @ 20 t ha$^{-1}$ | 7.5 | 300.9 | 2.0 | 4.9 | 49.4 | 9.4 | 7.2 |
| Mean | 8.2 | 307.1 | 2.1 | 4.8 | 51.8 | 9.7 | 7.3 |
| SEd | 0.2 | 11.4 | 0.1 | 0.1 | 0.3 | 0.1 | 0.1 |
| CD (P=0.05) | 0.6 | NS | 0.1 | NS | 0.8 | 0.1 | 0.1 |
| **Main factor (Nutrients)** | | | | | | | |
| $N_1$ - 75 % RDF (Soil application) | 6.8 | 268.4 | 1.7 | 4.3 | 38.4 | 8.3 | 6.2 |
| $N_2$ -100 % RDF (Soil application) | 7.2 | 297.1 | 2.0 | 4.5 | 45.5 | 9.3 | 6.6 |
| $N_3$ -75 % RDE at 7 days interval (Fertigation) | 9.0 | 339.2 | 2.3 | 5.1 | 58.4 | 10.6 | 7.9 |
| $N_4$ -75 % RDF at 15 days interval (Fertigation) | 7.7 | 279.3 | 2.1 | 4.7 | 50.8 | 9.4 | 7.3 |
| $N_5$ -100 % RDF at 7 days interval (Fertigation) | 10.0 | 347.9 | 2.4 | 5.3 | 63.3 | 10.7 | 8.1 |
| $N_6$ -100 % RDF at 15 days interval (Fertigation) | 8.3 | 310.3 | 2.2 | 4.8 | 54.2 | 9.7 | 7.6 |
| Mean | 8.2 | 307.1 | 2.1 | 4.8 | 51.8 | 9.7 | 7.3 |
| SEd | 0.3 | 20.2 | 0.1 | 0.1 | 0.2 | 0.1 | 0.1 |
| CD (P=0.05) | 0.6 | 41.2 | 0.2 | 0.2 | 0.5 | 0.2 | 0.1 |
| **Interaction** | | | | | | | |
| $A_1N_1$ | 7.3 | 275.7 | 1.8 | 4.4 | 41.1 | 8.4 | 6.3 |
| $A_1N_2$ | 8.0 | 305.0 | 2.0 | 4.5 | 47.8 | 9.2 | 6.8 |
| $A_1N_3$ | 9.3 | 351.0 | 2.4 | 4.9 | 62.8 | 10.8 | 8.1 |
| $A_1N_4$ | 8.3 | 228.7 | 2.2 | 4.7 | 54.2 | 9.5 | 7.4 |
| $A_1N_5$ | 10.7 | 362.0 | 2.6 | 5.3 | 68.8 | 10.9 | 8.1 |
| $A_1N_6$ | 8.7 | 326.7 | 2.3 | 4.8 | 58.2 | 9.8 | 7.7 |
| $A_2N_1$ | 6.7 | 270.3 | 1.8 | 4.2 | 37.8 | 8.3 | 6.1 |
| $A_2N_2$ | 7.3 | 298.3 | 2.0 | 4.5 | 44.4 | 9.4 | 6.6 |
| $A_2N_3$ | 9.0 | 338.3 | 2.3 | 5.1 | 56.5 | 10.6 | 7.9 |

Table 1 Contd..

| Treatments | No. of branches plant$^{-1}$ | Vine length (cm) | No. of fruits plant$^{-1}$ | Average fruit wt. (kg) | Fruit yield (t ha$^{-1}$) | TSS (%) | Ascorbic acid (mg100g $^{-1}$) |
|---|---|---|---|---|---|---|---|
| $A_2N_4$ | 7.7 | 308.0 | 2.1 | 4.5 | 49.3 | 9.7 | 7.4 |
| $A_2N_5$ | 10.3 | 350.0 | 2.3 | 5.3 | 61.7 | 10.8 | 8.1 |
| $A_2N_6$ | 8.3 | 307.7 | 2.1 | 4.7 | 52.8 | 10.0 | 7.6 |
| $A_3N_1$ | 6.3 | 259.3 | 1.7 | 4.3 | 36.1 | 8.2 | 6.1 |
| $A_3N_2$ | 6.3 | 288.0 | 1.9 | 4.6 | 44.4 | 9.2 | 6.4 |
| $A_3N_3$ | 8.7 | 328.3 | 2.2 | 5.2 | 55.9 | 10.5 | 7.9 |
| $A_3N_4$ | 7.0 | 301.3 | 2.0 | 4.9 | 48.8 | 9.1 | 7.2 |
| $A_3N_5$ | 9.0 | 331.7 | 2.3 | 5.4 | 59.5 | 10.5 | 8.0 |
| $A_3N_6$ | 8.0 | 296.7 | 2.1 | 4.8 | 51.7 | 9.3 | 7.5 |
| Mean | 8.2 | 307.5 | 2.1 | 4.8 | 51.8 | 9.7 | 7.3 |
| A@N | | | | | | | |
| SEd | 0.5 | 33.9 | 0.1 | 0.2 | 0.5 | 0.1 | 0.1 |
| CD (P=0.05) | NS | NS | NS | NS | 1.1 | 0.3 | 0.2 |
| N@A | | | | | | | |
| SEd | 0.5 | 34.9 | 0.1 | 0.1 | 0.4 | 0.2 | 0.1 |
| CD (P=0.05) | NS | NS | NS | NS | 0.9 | 0.3 | 0.2 |

**Table 2. Effect of organic amendment with inorganic fertilizers on nutrient uptake of hybrid watermelon and soil fertility**

| Treatments | Nutrient uptake (kg ha$^{-1}$) | | | Organic carbon | Available nutrients (kg ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|
| | N | P | K | (%) | N | P | K |
| **Main factor (Amendments)** | | | | | | | |
| $A_1$-Tank silt @ 100 t ha$^{-1}$ | 32.9 | 3.0 | 24.1 | 0.4 | 196 | 13.4 | 193 |
| $A_2$-Composted coir pith @ 12.5 t ha$^{-1}$ | 31.7 | 3.2 | 21.9 | 0.3 | 189 | 13.0 | 174 |
| $A_3$-Farm yard manure (FYM) @ 20 t ha$^{-1}$ | 26.3 | 2.8 | 19.5 | 0.2 | 179 | 12.5 | 165 |
| Mean | 30.5 | 3.0 | 21.8 | 0.3 | 188 | 13.0 | 178 |
| SEd | 0.2 | 0.1 | 0.1 | 0.1 | 0.4 | 0.1 | 0.1 |
| CD (P=0.05) | 0.4 | NS | 0.2 | 0.1 | 1.1 | 0.1 | 0.3 |
| **Main factor (Nutrients)** | | | | | | | |
| $N_1$ - 75 % RDF (Soil application) | 20.1 | 1.9 | 12.0 | 0.2 | 140 | 9.7 | 149 |
| $N_2$ -100 % RDF (Soil application) | 25.6 | 2.6 | 17.6 | 0.3 | 158 | 12.0 | 170 |
| $N_3$ -75 % RDE at 7 days interval (Fertigation) | 36.7 | 3.7 | 28.3 | 0.3 | 216 | 14.3 | 186 |
| $N_4$ -75 % RDF at 15 days interval | | | | | | | |

Table 2 Contd..

| Treatments | Nutrient uptake (kg/ha) | | | Organic carbon (%) | Available nutrients (kg/ha) | | |
|---|---|---|---|---|---|---|---|
| | N | P | K | | N | P | K |
| (Fertigation) | 28.5 | 2.7 | 20.6 | 0.3 | 182 | 12.5 | 176 |
| $N_5$-100 % RDF at 7 days interval (Fertigation) | 39.8 | 4.0 | 30.5 | 0.4 | 242 | 16.5 | 203 |
| $N_6$-100 % RDF at 15 days interval (Fertigation) | 32.1 | 3.0 | 21.9 | 0.2 | 188 | 12.8 | 180 |
| Mean | 30.5 | 3.0 | 21.8 | 0.3 | 188 | 13.0 | 178 |
| SEd | 0.2 | 0.1 | 0.1 | 0.1 | 0.7 | 0.1 | 0.1 |
| CD (P=0.05) | 0.4 | 0.2 | 0.2 | 0.1 | 1.4 | 0.2 | 0.2 |
| **Interaction** | | | | | | | |
| $A_1N_1$ | 22.6 | 1.5 | 15.3 | 0.3 | 146 | 10.5 | 165 |
| $A_1N_2$ | 27.3 | 2.8 | 20.6 | 0.3 | 175 | 12.3 | 182 |
| $A_1N_3$ | 39.3 | 3.8 | 29.9 | 0.4 | 209 | 14.8 | 202 |
| $A_1N_4$ | 31.5 | 2.9 | 23.5 | 0.4 | 199 | 12.5 | 194 |
| $A_1N_5$ | 41.5 | 3.9 | 31.9 | 0.5 | 253 | 16.4 | 218 |
| $A_1N_6$ | 35.2 | 2.9 | 23.2 | 0.3 | 193 | 13.6 | 196 |
| $A_2N_1$ | 19.4 | 2.1 | 10.9 | 0.2 | 140 | 9.4 | 142 |
| $A_2N_2$ | 26.2 | 2.7 | 17.6 | 0.2 | 155 | 11.9 | 168 |
| $A_2N_3$ | 38.3 | 3.9 | 29.3 | 0.3 | 222 | 14.3 | 184 |
| $A_2N_4$ | 30.2 | 2.8 | 20.0 | 0.2 | 183 | 12.5 | 172 |
| $A_2N_5$ | 40.4 | 4.3 | 30.0 | 0.3 | 243 | 17.4 | 203 |
| $A_2N_6$ | 35.6 | 3.2 | 23.4 | 0.2 | 188 | 12.4 | 176 |
| $A_3N_1$ | 18.3 | 1.9 | 9.6 | 0.2 | 132 | 9.2 | 141 |
| $A_3N_2$ | 23.3 | 2.3 | 14.7 | 0.2 | 143 | 11.6 | 158 |
| $A_3N_3$ | 32.4 | 3.5 | 25.7 | 0.3 | 218 | 13.7 | 173 |
| $A_3N_4$ | 23.9 | 2.3 | 18.2 | 0.3 | 165 | 12.4 | 161 |
| $A_3N_5$ | 37.5 | 3.9 | 29.5 | 0.3 | 230 | 15.7 | 189 |
| $A_3N_6$ | 25.5 | 2.9 | 19.2 | 0.2 | 182 | 12.6 | 168 |
| Mean | 30.5 | 3.0 | 21.8 | 0.3 | 188 | 13.0 | 178 |
| A@N | | | | | | | |
| SEd | 0.4 | 0.2 | 0.2 | 0.1 | 1.1 | 0.1 | 0.2 |
| **CD (P=0.05)** | 0.8 | 0.4 | 0.4 | 0.1 | 2.4 | 0.3 | 0.5 |
| N@A | | | | | | | |
| SEd | 0.3 | 0.1 | 0.1 | 0.1 | 1.2 | 0.1 | 0.2 |
| **CD (P=0.05)** | 0.7 | 0.3 | 0.3 | 0.2 | 2.4 | 0.3 | 0.4 |

**Table 3. Effect of organic amendment with inorganic fertilizers on economics of hybrid watermelon**

| Treatments | Cost of cultivation (Rs./ha) | Gross returns (Rs./ha) | Net returns (Rs./ha) | Benefit: cost ratio |
|---|---|---|---|---|
| **Main factor (Amendments)** | | | | |
| ($A_1$) Tank silt @ 100 t ha$^{-1}$ | 1,01,729 | 3,00,417 | 1,98,795 | 1.88 |
| ($A_2$) Composted coir pith @ 12.5 t ha$^{-1}$ | 1,21,618 | 2,74,307 | 1,52,688 | 2.20 |
| ($A_3$) Farm yard manure (FYM) @ 20 t ha$^{-1}$ | 1,11,618 | 2,66,973 | 1,55,355 | 2.33 |
| Mean | 1,11,655 | 2,80,565 | 1,68,946 | 2.14 |
| SEd | 90.72 | 10.88 | 8.16 | 0.004 |
| **CD (P=0.05)** | 251.88 | 30.23 | 22.67 | 0.010 |
| **Main factor (Nutrients)** | | | | |
| $N_1$ - 75 % RDF (Soil application) | 82,820 | 1,51,300 | 68,493 | 1.52 |
| $N_2$ -100 % RDF (Soil application) | 93,972 | 1,81,053 | 87,303 | 1.62 |
| $N_3$ -75 % RDE at 7 days interval (Fertigation) | 1,22,820 | 3,48,680 | 2,25,860 | 2.52 |
| $N_4$ -75 % RDF at 15 days interval (Fertigation) | 1,17,820 | 3,02,760 | 1,84,940 | 2.26 |
| $N_5$ -100 % RDF at 7 days interval (Fertigation) | 1,28,750 | 3,76,860 | 2,48,090 | 2.61 |
| $N_6$ -100 % RDF at 15 days interval (Fertigation) | 1,23,750 | 3,22,740 | 1,98,990 | 2.29 |
| Mean | 1,11,655 | 2,80,565 | 1,68,946 | 2.14 |
| SEd | 128.30 | 11.41 | 11.55 | 0.003 |
| **CD (P=0.05)** | 262.04 | 23.32 | 23.58 | 0.006 |
| **Interaction** | | | | |
| $A_1N_1$ | 72,820 | 1,62,640 | 89,820 | 1.23 |
| $A_1N_2$ | 83,750 | 1,88,560 | 1,04,810 | 1.25 |
| $A_1N_3$ | 1,12,820 | 3,73,380 | 2,60,560 | 2.31 |
| $A_1N_4$ | 1,07,820 | 3,22,440 | 2,14,620 | 1.99 |
| $A_1N_5$ | 1,18,750 | 4,09,320 | 2,90,570 | 2.45 |
| $A_1N_6$ | 1,13,750 | 3,46,080 | 2,32,330 | 2.04 |
| $A_2N_1$ | 92,820 | 1,48,200 | 55,380 | 1.60 |
| $A_2N_2$ | 1,03,750 | 1,79,200 | 75,450 | 1.73 |

Table 3 Contd..

| Treatments | Cost of cultivation (Rs./ha) | Gross returns (Rs./ha) | Net returns (Rs./ha) | Benefit: cost ratio |
|---|---|---|---|---|
| $A_2N_3$ | 1,32,820 | 3,41,580 | 2,08,760 | 2.57 |
| $A_2N_4$ | 1,27,820 | 2,95,140 | 1,67,320 | 2.31 |
| $A_2N_5$ | 1,38,750 | 3,69,540 | 2,30,790 | 2.66 |
| $A_2N_6$ | 1,33,750 | 3,12,180 | 1,78,430 | 2.33 |
| $A_3N_1$ | 82,820 | 1,43,040 | 60,220 | 1.73 |
| $A_3N_2$ | 93,750 | 1,75,400 | 81,650 | 1.87 |
| $A_3N_3$ | 1,22,820 | 3,31,080 | 2,08,260 | 2.69 |
| $A_3N_4$ | 1,17,820 | 2,90,700 | 1,72,880 | 2.47 |
| $A_3N_5$ | 1,28,750 | 3,51,660 | 2,22,910 | 2.73 |
| $A_3N_6$ | 1,23,750 | 3,09,960 | 1,86,210 | 2.50 |
| Mean | 1,11,655 | 2,80,565 | 2,80,565 | 2.14 |
| A@N | | | | |
| SEd | 222.22 | 21.08 | 20.00 | 0.01 |
| **CD (P=0.05)** | NS | 47.18 | 43.29 | 0.01 |
| N@A | | | | |
| SEd | 222.00 | 19.78 | 20.00 | 0.01 |
| **CD (P=0.05)** | NS | 40.39 | 40.84 | 0.01 |

respectively) were recorded in the treatment applied with FYM @ 20 t $ha^{-1}$($A_3$). The organic amendments contain all macro and micronutrients, which enhanced the steady supply of nutrient at all critical stages of the crop resulted in higher nutrient uptake by the crop. The result confirms the findings of Annadurai *et al.* (2005).

**Effect of nutrients**

The uptake of N, P and K in watermelon was also significantly influenced by the various nutrient level and application methods. The highest values of N, P and K uptake (39.79 kg $ha^{-1}$, 4.04, and 30.49 kg $ha^{-1}$, respectively) by watermelon were recorded with the application of 100 per cent NPK as 200:100:100 kg $ha^{-1}$ through fertigation at seven days interval ($N_5$) followed by 75 per cent NPK through fertigation at 7 days interval ($N_3$) with the N, P and K uptake values of 36.68 kg $ha^{-1}$, 3.71 kg $ha^{-1}$ and 28.30 kg $ha^{-1}$, respectively. The lowest uptake of N, P and K (20.13 kg $ha^{-1}$, 1.86 kg $ha^{-1}$ and 11.97 kg $ha^{-1}$, respectively) were observed in the treatment with soil application of 75% recommended dose of NPK ($N_1$). This could be ascribed to the increase in the available N, P and K contents in soil resulting from the increasing availability of nutrients which ultimately increased nutrient content in the plant tissue and also greater biomass production at the higher rate of fertilizer application. Since the uptake of the nutrient is a function of dry matter and nutrient content, the increased growth and yield attributes together with higher NPK content resulted in greater uptake of these elements. The result confirms the findings of Sajitha *et al.* (2016).

**The combined effect of amendments and nutrients**

The interaction of organic amendments with fertilizers played an important role in increasing the nutrient uptake of watermelon. Significantly maximum uptake of N and K (41.51 kg ha$^{-1}$ and 31.94 kg ha$^{-1}$) was recorded in treatment applied with tank silt @ 100 t ha$^{-1}$ with 100 per cent NPK as 200:100:100 kg ha$^{-1}$ through fertigation at 7 days interval ($A_1N_5$), whereas, the maximum P uptake (4.27 kg ha$^{-1}$) and higher uptake of N and K (40.37 kg ha$^{-1}$ and 30.00 kg ha$^{-1}$) were registered for the treatment applied with composted coir pith @ 12.5 t ha$^{-1}$ with 100 per cent NPK through fertigation at seven days interval ($A_2N_5$). The minimum values of N, P and K uptake (18.35 kg ha$^{-1}$, 1.92 kg ha$^{-1}$ and 9.65 kg ha$^{-1}$) were recorded in the treatment applied with FYM @ 20 t ha$^{-1}$ with 75 per cent NPK ha$^{-1}$ through soil application ($A_3N_1$). The increased uptake of nutrients can be attributed to good growth and fruit yield of watermelon and may be due to application of tank silt with inorganic fertilizers. The increased uptake of N, P and K in watermelon may be ascribed to more availability of these nutrients from the added tank silt, fertilizer sources and the solubility action of organic acids produced during the decomposition of organic materials. Similar results were also reported by Tanwar *et al.* (2003).

**Fertility status**

**Effect of amendments**

Highest organic carbon (0.38 %), available N, P and K (196.07 kg ha$^{-1}$,13.41 kg ha$^{-1}$and 193.17 kg ha$^{-1}$, respectively) were recorded with the application of tank silt @ 100 t ha$^{-1}$ ($A_1$) followed by application of composted coir pith @ 12.5 t ha$^{-1}$ ($A_2$) which recorded the 0.27 % of organic carbon with available N, P and K (188.79 kg ha$^{-1}$,12.98 kg ha$^{-1}$ and 174.30 kg ha$^{-1}$, respectively) (Table 2). The tank silt and composted coir pith contain high level of organic carbon and all nutrients, which helped in sustaining the organic carbon and available N, P and K in the soil. Similar findings has been reported earlier by Gonsalves *et al.* (2011).

**Effect of Nutrients**

The soil organic carbon and available NPK were significantly influenced by different levels and methods of nutrient application. The highest organic carbon (0.39 %), available N, P and K (242 kg ha$^{-1}$, 16.5 and 204 kg ha$^{-1}$, respectively) were recorded with the application of 100 per cent NPK through fertigation at 7 days interval ($N_5$) followed by 75 per cent NPK as 150:75:75 kg ha$^{-1}$ through fertigation at 7 days interval ($N_3$) organic carbon (0.34%), available N, P and K (217 kg ha$^{-1}$, 14.3 and 187 kg ha$^{-1}$, respectively). The lowest values of organic carbon (0.24%) and available N, P and K (140, 9.7 and 150 kg ha$^{-1}$, respectively) were noticed in the treatment received 75 per cent NPK as 150:75:75 kg ha$^{-1}$ through soil application ($N_1$) (Table 2). The decline in the available N status of the soil might be attributed to the utilization of N, P and K for growth of watermelon. These results are in agreement with the findings of Castellanos *et al.* (2013).

**Combined effect of amendments and nutrients**

Combined application of amendments with fertilizers was significantly influenced the organic carbon and available nutrients (Table 2). The highest organic carbon (0.52%), available N, P and K (253 kg ha$^{-1}$, 16.4 kg ha$^{-1}$ and 218 kg ha$^{-1}$, respectively) were recorded with the treatment received tank silt @ 100 t ha$^{-1}$ with 100 per cent NPK as 200:100:100 kg ha$^{-1}$ through fertigation at seven days interval ($A_1N_5$) followed by the treatment applied with composted coir pith @ 12.5 t ha$^{-1}$ with 100 per cent NPK through fertigation at 7 days interval ($A_2N_5$), which recorded the next highest content of organic carbon (0.35%) and available N, P and K (243 kg ha$^{-1}$, 17.4 kg ha$^{-1}$ and 203 kg ha$^{-1}$, respectively). The higher content of organic carbon in soil might be due highly fertile tank silt and composted coir pith combined with inorganic nutrients that favoured the needed nutrient transformation besides providing favourable physico-chemical properties and mineralization of soil nutrients leading to higher availability of N, P and K in soil. These results are in agreement with the findings of Kadam and Karthikeyan (2006) and Kacha *et al.* (2017). The lowest organic carbon content (0.21%) and available N, P and K (132 kg ha$^{-1}$, 9.2 and 141 kg ha$^{-1}$, respectively) were observed for the treatment applied with FYM @ 20 t ha$^{-1}$ with 75 per cent NPK ha$^{-1}$ through soil application ($A_3N_1$). The decline in the available N status of the soil can be attributed to the utilization of N, P and K for growth of watermelon. These results are in agreement with the findings of Vasanth Kumar *et al.* (2012).

**Economics**

Details on economics and benefit-cost ratio in watermelon $F_1$ hybrid Suprit in relation to various organic amendments with inorganic fertilizers with and without fertigation treatments tested are presented in Table 3.

**Effect of amendments**

The application of tank silt @ 100 t ha$^{-1}$($A_1$) resulted in significantly higher returns (Rs.1,98,795) and benefit-cost ratio (1.88) followed by application of FYM @ 20 t ha$^{-1}$ ($A_3$) which recorded the net returns of Rs.1,55,355 and benefit-cost ratio of 2.33. This might be due low cost of manures that reduced the cost of cultivation and increased the net return.

**Effect of nutrients**

The highest net return (Rs.2,48,090) with the benefit-cost ratio of 2.61 were obtained with the application of 100 per cent NPK through fertigation at seven days interval ($N_5$). The next highest net return (Rs. 2,25,860) with the benefit-cost ratio of 2.52 were recorded for the treatment received 75 per cent NPK as 150:75:75 kg $ha^{-1}$ through fertigation at seven days interval ($N_3$). The lowest net return (Rs. 68,493) with the benefit-cost ratio (1.52) were recorded in the treatment received 75 per cent NPK as 150:75:75 kg $ha^{-1}$ through soil application ($N_1$).

**Combined effect of amendments and nutrients**

The application of tank silt @ 100 t $ha^{-1}$ with 100 per cent NPK as 200:100:100 kg $ha^{-1}$ through fertigation at 7 days interval ($A_1N_5$) fetched significantly the highest net returns (Rs. 2,90,570 and benefit-cost ratio (2.45) over the rest of the treatments. The application of CCP@ 12.5 t $ha^{-1}$ with 100 per cent NPK as 200:100:100 kg $ha^{-1}$ through fertigation at 7days interval ($A_2N_5$) recorded the net return of Rs.2,30, 790 and benefit : cost ratio of 2.66 which was higher than the application of FYM @ 20 t $ha^{-1}$ with 100 per cent NPK as 200:100:100 kg $ha^{-1}$ through fertigation at 7 days interval ($A_3N_5$) which fetched the net return of Rs.2,22, 910 but with a better benefit-cost ratio of 2.73. This might be due to increased higher productivity and lower cost of cultivation. The variation in the cost of cultivation under different treatments were due to variable costs of fertilizers. Fruit yield was the major factor, which caused differences in net return. These results are in close conformity with the findings of Kumar *et al.* (2007) and Sajitha (2013).

**CONCLUSION**

Application of tank silt @ 100 t $ha^{-1}$ with 100 per cent NPK as 200:100:100 kg $ha^{-1}$ through fertigation at seven days interval ($A_1N_5$) could be recommended for higher fruit yield of hybrid watermelon, better net return and sustaining soil fertility in *Theri* land (Red sand dune) of Thoothukudi district of Tamil Nadu.

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# EFFECT OF BIOGAS DIGEST ON THE MICROBIAL POPULATION AND ENZYMATIC ACTIVITY OF SOIL UNDER CHICKPEA CULTIVATION

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## ABSTRACT

The experiment was conducted during *Rabi*, 2018 on black clayey soils to study the 'Effect of biogas digest on biological properties of chickpea grown soil'using chickpea variety 'JG-11' in randomized block design and replicated thrice. The results revealed that application of 100% Recommended dose of Phosphorus (RDP) through BGD + microbial consortium recorded highest biological activity (bacteria, fungi, actinomycetes population and enzymatic activity) which was on par with treatment that received 100% RDP through biogas digest.

**Key words:** Biogas Digest (BGD), Microbial population, Enzymatic activity, Chickpea soil

## INTRODUCTION

Usage of chemical fertilizers in today's agriculture had gone beyond the recommended levels. It is high time to go for the balanced and integrated use of plant nutrients which promotes the soil health and a direct contributor to the soil productivity. A large, diverse and active population of soil organisms is the most important indicator of healthy soil. Enzymes in soils are biologically significant as they are involved in the transformation, cycling of mineral elements and influence their availability to plants. The soil enzyme activity an index of microbial activity is influenced by nature, age of crop and addition of fertilizers and manures. Interest in soil enzyme activity has increased recently since it is believed to reflect the potential capacity of a soil to perform nutrient transformations (Singaram and Kamala Kumari, 1995).

Enzyme activities are very much influenced by the addition of organic manures due to an increase in soil microbial activity. Among the various sources of manures and fertilizers,biogas digest is one of the best alternatives which helps in increasing the soil health directly by providing nutrients, required carbon source for soil microbial populations and indirectly by making unavailable forms of soil nutrients into available forms (Sandeep Kumar *et al*., 2015).The addition of organic manures to soil could be a promising technology for reducing the usage of synthetic fertilizers (Parmar *et al*., 2018).Hence, the investigation was carried out to study the 'Effect of biogas digest on the population of microorganisms and activity of enzymes in chickpea grown soil' using chickpea variety 'JG-11' during *Rabi* 2018-19.

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## MATERIAL AND METHODS

The experimental field was moderately alkaline in soil reaction (8.26), medium in organic carbon (0.53%), low in available nitrogen (172 kg $ha^{-1}$), high in available $P_2O_5$ (26.5 kg $ha^{-1}$) and $K_2O$ (321 kg $ha^{-1}$) and sufficient in sulphur and micronutrients. The soil was clayey in texture with a bulk density and water holding capacity of 1.87Mg $m^{-3}$ and 56.86 per cent, respectively. The biological activities of initial soil viz., population of bacteria (16×$10^5$ CFU $g^{-1}$ soil), fungi (6×$10^3$ CFU $g^{-1}$ soil) and actinomycetes (36×$10^4$ CFU $g^{-1}$ soil) and activity of urease (63.64µg $NH4^+$ $g^{-1}$ 2 $h^{-1}$), dehydrogenase (21.32µg TPF $g^{-1}$ $d^{-1}$) and acid and alkaline phosphatase (18.64 & 35.32 µg PNP $g^{-1}$ $h^{-1}$). The experiment comprised of 10 treatments *viz.*, $T_1$ – Control (without P fertilizer); $T_2$ – 100% RDP through inorganic sources; $T_3$ – 75% RDP through inorganic sources; $T_4$ – 75% RDP (through inorganic) + 25% P through BGD (Biogas digest); $T_5$ – 50% RDP (through inorganic) + 50% P through BGD (Biogas digest); $T_6$ – 100% RDP (through inorganic) + Microbial Consortium; $T_7$ – 75% RDP (through inorganic) + Microbial Consortium; $T_8$ – 50% RDP (through inorganic) + Microbial Consortium; $T_9$ – 100% RDP through BGD; $T_{10}$– 100% RDP through BGD + Microbial Consortium laid out in randomized block design (RBD) and were replicated thrice.

Biogas Digest was applied to plots depending on phosphorus content of BGD and recommendation to crop. Nitrogen and Sulphur contributed by BGD was deducted and the remaining N and S were applied through inorganic sources. N in the form of urea for inorganic treatments applied in two splits, whereas, complete P and S was applied as a basal dose. Microbial Consortium in the respective plots included Rhizobium, phosphate solubilizing bacteria (PSB) and potassium solubilizing bacteria (KSB). Rhizobium was given as seed treatment @ 5-6 ml per kg of chickpea seed. PSB and KSB were applied in the plots by mixing with the soil of the same plot and evenly distributed it in the plot.

The soil samples were collected before sowing, at vegetative, reproductive and harvest stages up to a depth of 30cm processed and stored in polythene bags at $2^0$C to $4^0$C for an as short time as possible until examination for the assessment of soil biological activity.Bacteria, fungi and actinomycetes were estimated as per the procedures outlined by Paroda (2007).Urease activity was estimated by quantifying the rate of release of $NH_4^+$ - N from the hydrolysis of urea.Phosphatase activity was measured by estimating the concentration of paranitrophenol (PNP) produced due to hydrolysis of the substrate p-nitrophenol phosphate by phosphatase enzyme as described by Tatabai and Bremner (1972). Dehydrogenase activity in the soil sample was determined by following the procedure as described by Klein *et al.* (1971).

## RESULTS AND DISCUSSION

### Soil microbial activity

### Bacteria (×$10^5$ CFU $g^{-1}$ soil)

Data indicated that there was a significant difference among treatments at all the growth stages of crop. The bacterial population showed a declining trend with the advancement of the crop stage (Table 1).

The maximum colony forming units (37.00 & 30.67) were observed in treatment $T_{10}$ (100% RDP through BGD + Microbial Consortium) and it was on par with $T_9$ (34.00 & 27.99) which received 100% RDP through BGD, while lowest count of bacterial population (17.67 & 16.33) was observed in $T_1$ treatment (controlwith no P fertilizer) at vegetative and harvest stages. The treatment $T_9$ which received 100% RDP through BGD was on par with $T_5$ treatment which received 50% RDP through BGD+50% RDP through inorganic source in both vegetative and harvest stages.

At the reproductive stage, significantly highest colony-forming units of bacterial

**Table 1. Effect of organic manures and inorganic phosphorus fertilizers on soil bacterial population (×$10^5$ CFU $g^{-1}$ soil) at different crop growth stages of chickpea**

| TREATMENTS | Vegetative | Reproductive | Harvest |
|---|---|---|---|
| T-$_1$ – Control (without P fertilizer) | 17.67 | 17.00 | 16.33 |
| $T_2$ – 100% RDP through inorganic sources | 22.99 | 21.67 | 19.00 |
| $T_3$ – 75% RDP through inorganic sources | 21.33 | 19.00 | 18.33 |
| $T_4$ – 75% RDP (through inorganic) + 25% P through BGD (Biogas digest) | 28.33 | 26.67 | 24.00 |
| $T_5$ – 50% RDP (through inorganic) + 50% P through BGD (Biogas digest) | 31.01 | 29.01 | 26.33 |
| $T_6$ – 100% RDP (through inorganic) + Microbial Consortium | 25.00 | 23.00 | 20.00 |
| $T_7$ – 75% RDP (through inorganic) + Microbial Consortium | 22.65 | 20.00 | 18.33 |
| $T_8$ – 50% RDP (through inorganic) + Microbial Consortium | 18.00 | 17.67 | 16.67 |
| $T_9$ – 100% RDP through BGD | 34.00 | 29.00 | 27.99 |
| $T_{10}$– 100% RDP through BGD + Microbial Consortium | 37.00 | 33.33 | 30.67 |
| **SEm±** | 1.38 | 1.10 | 1.13 |
| **CD(0.05)** | 4.12 | 3.28 | 3.36 |
| **CV(%)** | 9.31 | 8.09 | 9.00 |

population was observed in $T_{10}$ treatment which received 100% RDP through BGD + Microbial Consortium, while lowest count was observed in treatment $T_1$(17.00) which received no P fertilizer. However, the treatment $T_9$ which received 100% RDP through BGD recorded 29.00 and it was on par with $T_5$ which received 50% RDP through inorganic + 50% P through BGD (29.01) & $T_4$ which received 75% RDP through inorganic + 25% P through BGD (26.67).

Among completely inorganic treatments ($T_2$ -100% RDP through inorganic & $T_3$-75% RDP through the inorganic), the treatment $T_2$ recorded higher value (22.99, 21.67 & 19.00) for bacterial population than the $T_3$ treatment (21.33, 19.00 & 18.33).

The population was significantly improved when organics were supplied as BGD. Manure application is known to stimulate and improve fungal and bacterial population and biological activity (Chaoui *et al.*, 2003).

**Actinomycetes (×$10^4$ CFU $g^{-1}$ soil)**

The effect of BGD and inorganic phosphorus fertilizer application either as sole or as a combination showed a significant difference among the treatments regarding actinomycetes population (Table 2).

At vegetative stage, significantly highest population of actinomycetes (64.00) was found in the treatment $T_{10}$ which was supplied with 100% RDP through BGD + received 50% RDP through inorganic + 50% RDP through BGD. Among the combined treatments, treatment $T_5$ which received 50% RDP through inorganic + 50% P through BGD recorded higher value (52.99) and $T_8$ which received 50%RDP through inorganic + microbial consortium recorded the lowest value for actinomycetes population.

At the reproductive stage, significantly highest population (58.33) was observed in $T_{10}$ treatment (100% RDP through BGD + Microbial Consortium) and it was on par with $T_9$ treatment (53.98) which received 100% RDP through BGD while the lowest actinomycetes population (39.33) was recorded in $T_1$ treatment *i.e.*, control. But, the treatment $T_9$ which is completely organic was on par with treatments $T_5$ (51.00) that was supplied with 50% RDP through inorganic + 50% RDP through BGD & $T_4$ (49.32) which received 75% RDP through inorganic + 25% P through BGD.

At harvest stage, the treatment $T_{10}$ (100% RDP through BGD + Microbial Consortium) recorded significantly higher actinomycetes population (53.33) and it was on par with treatment $T_9$ (51.67) which received 100% RDP through BGD, treatment $T_4$ (46.67) which received 75% RDP through inorganic + 25% P through BGD & treatment $T_5$ (47.99) which received 50% RDP through inorganic + 50% P through BGD, while the lowest population of actinomycetes (38.00) was recorded in $T_1$ treatment which received no P fertilizer. However, $T_9$ was on par with $T_4$ (75% RDP through inorganic + 25% P through BGD), $T_5$ (50% RDP through inorganic + 50% P through BGD) & $T_6$ (100% RDP through inorganic +

Microbial Consortium).

The supply of readily metabolizable carbon in the biogas slurry is likely to have been the most influential factor contributing to the higher microbial population. Soil microbial biomass responds rapidly to the addition of readily available C (Tejada *et al.*, 2006). The positive effect on microbial biomass observed in the soils amended with organic wastes is due to improvement in microbial growth and thereby plant growth (Pascual *et al.,* 1998).

Somasundaram *et al.* (2003) also reported that liquid organic sources of nutrients not only enhance the microbes in the environment but also act as catalysts with a synergistic effect to promote all the useful microbes of the environment by secreting proteins, organic acids and antioxidants in the presence of organic matter and convert them into energy thereby improving actinomycetes population in soil.

**Table 2. Effect of organic manures and inorganic phosphorus fertilizers on soil actinomycetes populationa (×$10^4$ CFU $g^{-1}$ soil) at different crop growth stages of chickpea**

| TREATMENTS | Vegetative | Reproductive | Harvest |
|---|---|---|---|
| $T_{-1}$ – Control (without P fertilizer) | 41.00 | 39.33 | 38.00 |
| $T_2$ – 100% RDP through inorganic sources | 47.67 | 45.33 | 42.00 |
| $T_3$ – 75% RDP through inorganic sources | 43.33 | 41.00 | 39.00 |
| $T_4$ – 75% RDP (through inorganic) + 25% P through BGD (Biogas digest) | 50.00 | 49.32 | 46.67 |
| $T_5$ – 50% RDP (through inorganic) + 50% P through BGD (Biogas digest) | 52.99 | 51.00 | 47.99 |
| $T_6$ – 100% RDP (through inorganic) + Microbial Consortium | 47.69 | 46.03 | 44.67 |
| $T_7$ – 75% RDP (through inorganic) + Microbial Consortium | 44.00 | 42.33 | 41.03 |
| $T_8$ – 50% RDP (through inorganic) + Microbial Consortium | 42.65 | 40.68 | 38.33 |
| $T_9$ – 100% RDP through BGD | 59.00 | 53.98 | 51.67 |
| $T_{10}$– 100% RDP through BGD + | 64.00 | 58.33 | 53.33 |
| Microbial Consortium | | | |
| **SEm±** | 2.64 | 2.09 | 2.45 |
| **CD(0.05)** | 7.85 | 6.22 | 7.30 |
| **CV(%)** | 9.29 | 7.76 | 9.62 |

**Fungi ($\times 10^3$ CFU $g^{-1}$ soil)**

The study revealed that fungal population at different growth stages of chickpea was significantly influenced by the application of P through BGD, inorganic source and combined application of organics and inorganics. Fungal population count was decreasing with the age of the crop *i.e.*, from vegetative to harvest stage (Table 3).

At all growth stages, significantly higher fungal population was observed in $T_{10}$ (100% RDP through BGD + Microbial Consortium) treatment (28.00, 27.00 & 24.33) and this was significantly superior over all other treatments, while lowest values were recorded in $T_1$ treatment *i.e.* control plot with no P fertilizer (11.33, 10.00 & 8.00) at vegetative, reproductive and harvest stages, respectively. Among the

**Table 3. Effect of organic manures and inorganic phosphorus fertilizers on soil fungi population ($\times 10^3$ CFU $g^{-1}$ soil) at different crop growth stages of chickpea**

| TREATMENTS | Vegetative | Reproductive | Harvest |
|---|---|---|---|
| T-$_1$ – Control (without P fertilizer) | 11.33 | 10.00 | 8.00 |
| $T_2$ – 100% RDP through inorganic sources | 14.67 | 13.67 | 13.33 |
| $T_3$ – 75% RDP through inorganic sources | 13.67 | 13.33 | 11.67 |
| $T_4$ – 75% RDP (through inorganic) + 25% P through BGD (Biogas digest) | 18.67 | 17.00 | 15.33 |
| $T_5$ – 50% RDP (through inorganic) + 50% P through BGD (Biogas digest) | 20.99 | 19.32 | 18.33 |
| $T_6$ – 100% RDP (through inorganic) + Microbial Consortium | 16.00 | 15.00 | 14.00 |
| $T_7$ – 75% RDP (through inorganic) + Microbial Consortium | 14.00 | 13.67 | 12.00 |
| $T_8$ – 50% RDP (through inorganic) + Microbial Consortium | 11.67 | 11.00 | 10.33 |
| $T_9$ – 100% RDP through BGD | 25.00 | 23.63 | 22.00 |
| $T_{10}$– 100% RDP through BGD + Microbial Consortium | 28.00 | 27.00 | 24.33 |
| **SEm±** | 0.84 | 0.79 | 0.73 |
| **CD(0.05)** | 2.51 | 2.35 | 2.19 |
| **CV(%)** | 8.42 | 8.38 | 8.57 |

treatments that received the combined application of organics and inorganics, the treatment $T_5$ which received 50% RDP through inorganic + 50% P through BGD recorded higher values of 20.99, 19.32 & 18.33 at vegetative, reproductive and harvest stages, respectively.

The lowest population was reported in control and chemical fertilizer applied plots. This might be due to reduction in OC content of the soil, compaction, reduced porosity, reduced WHC and reduced micronutrients (Scott *et al*., 1996).The higher fungal population was recorded in organics applied treatments and this may also be beneficial for increasing the crop yield because they help in increasing the nutrient mobility from the soil.

**Table 4. Effect of organic manures and inorganic phosphorus fertilizers on soil urease activity (μg $NH4^+$ $g^{-1}$ 2 $h^{-1}$)at different crop growth stages of chickpea**

| TREATMENTS | Vegetative | Reproductive | Harvest |
|---|---|---|---|
| $T_{-1}$ – Control (without P fertilizer) | 65.10 | 64.65 | 64.12 |
| $T_2$ – 100% RDP through inorganic sources | 68.60 | 66.88 | 66.21 |
| $T_3$ – 75% RDP through inorganic sources | 66.27 | 65.63 | 65.20 |
| $T_4$ – 75% RDP (through inorganic) + 25% P through BGD (Biogas digest) | 70.31 | 69.90 | 69.40 |
| $T_5$ – 50% RDP (through inorganic) + 50% P through BGD (Biogas digest) | 71.80 | 70.90 | 70.80 |
| $T_6$ – 100% RDP (through inorganic) + Microbial Consortium | 69.90 | 67.92 | 67.80 |
| $T_7$ – 75% RDP (through inorganic) + Microbial Consortium | 66.97 | 66.37 | 65.85 |
| $T_8$ – 50% RDP (through inorganic) + Microbial Consortium | 65.36 | 64.92 | 64.50 |
| $T_9$ – 100% RDP through BGD | 74.70 | 72.40 | 71.09 |
| $T_{10}$– 100% RDP through BGD + Microbial Consortium | 75.30 | 73.40 | 72.80 |
| **SEm±** | 2.01 | 1.96 | 1.92 |
| **CD(0.05)** | 5.98 | 5.85 | 5.72 |
| **CV(%)** | 7.31 | 6.92 | 6.64 |

**Table 5. Effect of organic manures and inorganic phosphorus fertilizers on soil hydrogenase activity (μg TPF $g^{-1}$ $d^{-1}$)**

| TREATMENTS | Vegetative | Reproductive | Harvest |
|---|---|---|---|
| $T_{-1}$ – Control (without P fertilizer) | 26.00 | 24.33 | 23.00 |
| $T_2$ – 100% RDP through inorganic sources | 31.33 | 29.00 | 28.33 |
| $T_3$ – 75% RDP through inorganic sources | 29.33 | 27.00 | 26.00 |
| $T_4$ – 75% RDP (through inorganic) + 25% P through BGD (Biogas digest) | 36.00 | 33.98 | 32.31 |
| $T_5$ – 50% RDP (through inorganic) + 50% P through BGD (Biogas digest) | 37.35 | 34.00 | 32.67 |
| $T_6$ – 100% RDP (through inorganic) + Microbial Consortium | 32.00 | 30.99 | 30.00 |
| $T_7$ – 75% RDP (through inorganic) + Microbial Consortium | 31.00 | 28.67 | 26.36 |
| $T_8$ – 50% RDP (through inorganic) + Microbial Consortium | 27.69 | 26.67 | 24.33 |
| $T_9$ – 100% RDP through BGD | 37.33 | 35.00 | 34.00 |
| $T_{10}$– 100% RDP through BGD + Microbial Consortium | 41.00 | 38.67 | 36.00 |
| **SEm±** | 1.84 | 1.71 | 1.59 |
| **CD(0.05)** | 5.48 | 5.08 | 4.74 |
| **CV(%)** | 9.70 | 9.61 | 9.44 |

**Enzymatic Activity**

**Urease activity**

Data indicated significant differences among treatments at all stages of crop growth period of chickpea (Table 4). The data showed that urease activity was significantly higher in treatment $T_{10}$ (75.30, 73.40 & 72.80 μg $NH_4^+$ $g^{-1}$ 2 $h^{-1}$) which received 100% RDP through BGD + microbial consortium during vegetative, reproductive and harvest stages respectively and this was on par with treatment $T_9$ (74.70, 72.40 & 71.09 μg $NH_4^+$ $g^{-1}$ 2 $h^{-1}$) which received 100% RDP through BGD, while lowest urease activity was observed in control treatment ($T_1$) which received no P fertilizer (65.10, 64.65 & 64.12 μg $NH_4^+$ $g^{-1}$ 2 $h^{-1}$) during all growth stages of chickpea.

Urease activity was decreased from vegetative to harvest stage of the crop and the treatments which received organics recorded higher values compared to inorganics and combined application of organics and inorganics. Similar results of highest enzymatic activity of urease were reported by Tejada *et al.* (2006) in poultry manure amended soils followed by crushed cotton gin compost over control. Similar findings were reported by Rai and Yadav (2011).

**Dehydrogenase activity**

The data on the influence of the organic and inorganic source of P and their combined application on dehydrogenase activity (Table5) indicated that there was a significant difference among the treatments.

Dehydrogenase activity was significantly higher in treatment $T_{10}$ (41.00μg TPF $g^{-1}$ $d^{-1}$, 38.67 & 36.00 μg TPF $g^{-1}$ $d^{-1}$) which received 100% RDP through BGD + microbial consortium and it was on par with treatment $T_9$ (37.33μgTPF $g^{-1}$ $d^{-1}$, 35.00 & 34.00 μgTPF $g^{-1}$ $d^{-1}$) which received 100% RDP through BGD.

Dehydrogenase activity was recorded highest in the treatments which received organics and this might be due to the enhanced level of soil enzyme activity due to addition of organic manures promotes the recycling of nutrients in the soil ecosystem (Ramesh *et al.,* 2006). Increased nutrient availability in organic-manure treatment could also be due to increased dehydrogenase and phosphatase activity (Gunapala *et al.*, 1998).

The effect of organic manures was found superior in improving DHA as it stimulated microbial population. Being chief carbon source, it provided energy to soil microorganisms, and increased the number of pores and maintained good soil structure accompanied by better dehydrogenase activity (Marinari *et al*., 2000). The dehydrogenase activity of soil after harvest of chickpea was significantly increased with the organic application (farmyard manure and green leaf manure). Similar findings were reported by Verma *et al*. (2010). This might be due to an increase in microbial growth with the addition of organic carbon substrate.

**Acid phosphatase activity**

The results pertaining to acid phosphatase activity were presented in Table6. revealed that supply of P to chickpea crop through BGD, inorganic P fertilizer and their combined application significantly influenced the acid phosphatase activity at vegetative, reproductive and harvest stages of the crop growth period.

Significantly higher acid phosphatase activity was recorded in treatment $T_{10}$ which received 100% RDP through BGD + microbial consortium (27.71 μg PNP $g^{-1}$ $h^{-1}$, 26.20 and 25.40 μg PNP $g^{-1}$ $h^{-1}$), while lowest was recorded in treatment $T_1$ which received no P fertilizer (21.65 μg PNP $g^{-1}$ $h^{-1}$, 21.12 & 20.64 μg PNP $g^{-1}$ $h^{-1}$) during vegetative, reproductive and harvest stages, respectively. Data indicated that treatments which received organics recorded higher acid phosphatase activity and acid phosphatase activity was found to be decreasing from vegetative to harvest. Similar results of high acid and alkaline phosphatase activity in manure amended plots was reported by Masto *et al.* (2006).

**Alkaline phosphatase activity**

Data pertaining to the activity of alkaline phosphatase in soil revealed that there was a

**Table 6. Effect of organic manures and inorganic phosphorus fertilizer on Acid and Alkaline phosphatase Activity (µg PNP $g^{-1}$ $h^{-1}$)**

| Treatments | Acid Phosphatase | | | Alkaline Phosphatase | | |
|---|---|---|---|---|---|---|
| | Vegetative | Reproductive | Harvest | Vegetative | Reproductive | Harvest |
| $T_{-1}$ – Control (No P fertilizer) | 21.65 | 21.12 | 20.64 | 36.98 | 36.46 | 35.64 |
| $T_2$ – 100% RDP through inorganic sources | 24.00 | 23.78 | 23.32 | 38.56 | 37.99 | 37.15 |
| $T_3$ – 75% RDP through inorganic sources | 23.36 | 22.45 | 22.10 | 37.58 | 37.07 | 36.43 |
| $T_4$ – 75% RDP (through inorganic) + 25% P through BGD (Biogas digest) | 25.30 | 24.80 | 24.00 | 39.75 | 38.97 | 37.90 |
| $T_5$ – 50% RDP (through inorganic) + 50% P through BGD (Biogas digest) | 25.98 | 25.60 | 24.20 | 40.11 | 39.01 | 38.57 |
| $T_6$ – 100% RDP (through inorganic) + Microbial Consortium | 24.90 | 24.50 | 23.52 | 39.40 | 38.78 | 37.64 |
| $T_7$ – 75% RDP (through inorganic) + Microbial Consortium | 23.89 | 23.47 | 22.93 | 37.87 | 37.64 | 36.90 |
| $T_8$ – 50% RDP (through inorganic) + Microbial Consortium | 22.65 | 21.98 | 21.33 | 37.26 | 36.66 | 35.94 |
| $T_9$ – 100% RDP through BGD | 26.40 | 25.80 | 24.90 | 40.98 | 40.23 | 39.87 |
| $T_{10}$– 100% RDP through BGD + Microbial Consortium | 27.71 | 26.20 | 25.40 | 43.37 | 41.65 | 40.89 |
| **SEm±** | 0.91 | 0.90 | 0.88 | 1.21 | 1.03 | 0.99 |
| **CD(0.05)** | 2.72 | 2.68 | 2.64 | 3.61 | 3.07 | 2.96 |
| **CV(%)** | 6.46 | 6.52 | 6.62 | 5.37 | 5.21 | 5.17 |

significant difference among treatments at various stages of chickpea crop (Table 6). However,a gradual decrease in enzymatic activity was observed with the advancement of the crop stage.

At vegetative, reproductive and harvest stages, higher alkaline phosphatase activity (43.37, 41.65 & 40.89 µg PNP $g^{-1}$ $h^{-1}$) was observed in treatment $T_{10}$ which received 100% RDP through BGD + microbial consortium and lowest enzymatic activity was observed in treatment $T_1$ (36.98, 36.46 & 35.64 µg PNP $g^{-1}$ $h^{-1}$) which received no P fertilizer, respectively.

Alkaline phosphatase activity was decreasing from vegetative to harvest stage of the crop. Higher alkaline phosphatase activity was observed in treatments which received organics compared to treatments which received inorganics and combination of organics and inorganics. Similar results of higher alkaline phosphatase activity in organics amended plots was reported by Masto *et al.* (2006).

## CONCLUSION

The study revealed that application of biogas digest along with microbial consortia increased soil biological activity in terms of microbial population (bacteria, fungi and actinomycetes) and enzymatic activity(urease, dehydrogenase, acid and alkaline phosphatase)compared to application of sole inorganics and combination of organics and inorganics.

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# PRODUCTIVITY OF RICE-GROUNDNUT CROPPING SYSTEM UNDER INTEGRATED NUTRIENT MANAGEMENT

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## ABSTRACT

The experiment was conducted during *Kharif* and *Rabi* seasons of 2016 - 18 to record the performance of rice under integrated nutrient management and residual effect on succeeding groundnut crop and productivity of the system.The experiment was laid out in RBD during *Kharif* with rice variety 'BPT-5204' and sown with six treatments *viz.,* $T_1$ - 50 % RDF + 50 % N vermicompost; $T_2$ - 75 % RDF + 25 % N vermicompost; $T_3$ - 100 % RDF, $T_4$ - 100 % RDF + 25 % N vermicompost; $T_5$ - 100 % RDF + 50 % N vermicompost; and $T_6$ - 150-60-40 kg NPK ha$^{-1}$. Residual effect on succeeding groundnut crop was studied by dividing each rice plot into four plots.Groundnut variety 'Dharani' was sown in December with four treatments *viz.,* $F_1$ - No fertilizers; F2 - 50 % RDF; $F_3$ - 75 % RDF and $F_4$ - 100 % RDF. Pooled data of *Kharif* rice indicated higher grain yield (5103 kg ha$^{-1}$) with the application of 150-60-40 kg NPK ha$^{-1}$ which was on par with 100% RDF + 25 % N through vermicompost (4513 kg ha$^{-1}$) and 100% RDF + 50 % N through vermin compost (4579 kg ha$^{-1}$).Higher pod yield of succeeding *rabi* groundnut (2891 kg ha$^{-1}$) was obtained with the application of 100% RDF+50 % N through vermicompost. Higher system productivity was recorded (10,127 kg ha$^{-1}$) with the application of 150-60-40 kg ha$^{-1}$ followed by the application of 100% RDF+ 50% N through vermicompost (10,020 kg ha$^{-1}$) to preceding rice.

**Key Words**: Integrated nutrient management, rice, groundnut, productivity, rice - groundnut cropping system.

## INTRODUCTION

The recommended dose of NPK fertilizers alone does not sustain soil productivity under continuous intensive cropping (Yaduvanshi and Sharma, 2010). Integrated Nutrient Management plays an important role in sustaining the production and productivity of crops under these conditions. The inclusion of organic manures improves physical-biological properties, soil fertility and crop yields (Yaduvanshi *et al*., 2013). It is well known that the organic manures cannot substitute chemical fertilizers entirely because of the low content of plant nutrients.The extent of substitution of chemical fertilizers with organic sources of nutrients needs to be worked out without sacrificing yield. Because of long term release of nutrients by organic sources, nutrient requirements of the succeeding crop also can be met by which there is a possibility of reducing nutrients to the succeeding crop. The nutrient needs of the crops in a cropping system depend

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on the fertilizers applied to the previous crop.Systematic approach of nutrient supply to the cropping system as a whole increases the fertilizer use efficiency and economizes the use of costly mineral fertilizers by accounting residual effect of nutrient sources applied to previous crops.

Rice-based cropping system in India involving rotation of rice with pulses, oilseeds and other crops is widely followed. Hence, the study was conducted to assess the productivity and extent of economization of fertilizers in rice-groundnut crop sequence under integrated nutrient supply system in a system-based approach.

## MATERIAL AND METHODS

The field experiment was conducted at Agricultural Research Station, Utukur,Kadapa during *Kharif* and *Rabi* seasons of 2016-2018 to study the performance of rice under integrated nutrient management and its residual effect on succeeding groundnut supplied with varying levels of NPK fertilizers.The experimental field was sandy loam in texture with pH 7.9, low nitrogen (139 kg $ha^{-1}$), high in available phosphorus (87 kg $ha^{-1}$) and potash (590 kg $ha^{-1}$).The experiment was laid out in RBD during *Kharif* for rice and split-plot during *Rabi* by taking residual effect of rice as main plots and direct effect of fertilizers to groundnut as subplots by dividing each rice plot into four subplots. Rice variety 'BPT 5204' was sown in July with six treatments *viz.,* $T_1$ - 50 % RDF + 50 % N vermicompost; $T_2$ - 75 % RDF + 25 % N vermicompost; $T_3$ - 100 % RDF( 80-60-40 kg NPK $ha^{-1}$); $T_4$ - 100 % RDF + 25 % N vermicompost; $T_5$ - 100 % RDF + 50 % N vermicompost; and $T_6$ - Farmers Practice (150-60-40 kg NPK $ha^{-1}$). After harvesting of *Kharif* rice,each rice plot was divided into four plots and groundnut variety'Dharani'was sown in Decemberwith four treatments *viz.,* $F_1$ - No fertilizers $F_2$ - 50 % RDF, $F_3$ - 75 % RDF and $F_4$ - 100 % RDF. The recommended dose of fertilizers was 80-60-40 kg NPK $ha^{-1}$ for rice and 30-40-50 kg NPK $ha^{-1}$ for groundnut. All other agronomic practices were followed as per the recommendation. Data on growth and yield parameters were taken at harvest on five randomly selected plants in each plot and averaged to get replicated data. Rice equivalent yield of groundnut was calculated as:

$$\text{Rice equivalent yield (kg ha}^{-1}\text{)} = \frac{\text{Yield of groundnut x Sale price of groundnut}}{\text{Sale price of rice}}$$

The total productivity of the system was calculated in terms of rice equivalent yield.The productivity $ha^{-1}$ $day^{-1}$ was worked out as total productivity / 365. The data obtained were subjected to statistical analysis by adopting Fisher's method of analysis of variance as outlined by Gomez and Gomez (1984). The level of significance used in 'F' test was at 5% level of significance.

## RESULTS AND DISCUSSION

### Effect of INM on rice

Taller plants of rice were recorded with application of 150-60-40 kg NPK ha$^{-1}$ with mean height of 88.8 cm. Similarly total and productive tillers were more with the application of 150-60-40 kg NPK ha$^{-1}$ with mean of 11.4 and 10.6, respectively (Table 1). Significantly lengthier panicles were recorded with application of 150-60-40 kg NPK ha$^{-1}$ in two years with mean panicle length of 21.7 cm. Panicle length of rice was not significantly influenced by integrated nutrient management in 2018. The number of grains per panicle (Table 2) was not significantly influenced by integrated nutrient management during 2016. Whereas,significantly higher number of grains per panicle was recorded with the application of 150-60-40 kg NPK ha$^{-1}$ during two years 2017 and 2018 with mean number of grains of 191.9 per panicle. Thousand grain weight of rice was not significantly influenced by the nutrient management. Significantly higher grain (4954 kg ha$^{-1}$) and straw yield (7603 kg ha$^{-1}$) of rice was recorded with the application of 150-60-40 kg NPK ha$^{-1}$in 2018 (Table 2). In 2016 and 2017, though higher grain and straw yield was recorded with the application of 150-60-40 kg NPK ha$^{-1}$,it was on par with other treatments-100% RDF, 100% RDF + 50% N through vermicompost and 100% RDF + 25 % N through vermicompost. Pooled analysis of yield data (Table 2) revealed higher rice grain yield (5103 kg ha$^{-1}$) with the application of 150-60-40 kg NPK ha$^{-1}$which was on par with 100% RDF + 25 % N through vermicompost (4513 kg ha$^{-1}$) and 100% RDF + 50 % N through vermicompost (4579 kg ha$^{-1}$) . Higher yields with organic nutrient substitution @ 25% or 50% might bedue to slow release and continuous supply of nutrients in balanced quantity throughout growth stages which enabled the rice plants to assimilate sufficient photosynthetic products resulting in increased dry matter production, panicles with more number of fertile grains, higher test weight, grain and straw yield. Similarly, Pandey *et al*. (2007) observed better plant growth and improved yield components of rice with substitution of 25% or 50% organic in combination with 50-75% RDF. Biashya *et al.* (2015) reported improved yield attributes and yield (6.03 t ha$^{-1}$) with crop receiving 2.5 t poultry manure ha$^{-1}$ along with 75 kg N +16.5 kg P + 31.3 kg K ha$^{-1}$.

**Residual effect of INM to rice on succeeding groundnut**

Plant height of groundnut was not influenced by the residual effect of integrated nutrient management practices applied to preceding rice in two years (2016 and 2018). The number of branches per plant,number of pods per plant, shelling percentage(Table 3) and 100 kernel weight of groundnutwerenot significantly influenced by the INM to preceding rice.Higher pod yield of groundnut (Table 4) was observed with the application of 50% RDF+ 50% vermicompost to preceding rice which was on par with 100% RDF + 50% N through vermicompost in two years. Pooled analysis revealed significantly higher pod yield with 100%

RDF +50% N through vermicompost (2891 kg ha$^{-1}$) to the preceding rice which was on par with 50% RDF+ 50% N through vermicompost (2735 kg ha$^{-1}$ ) and 75 % RDF+ 25 % N through vermicompost(2769 kg ha$^{-1}$). Talathi *et al*. (2009) reported the beneficial effects of integrated nutrient management when 50% N was substituted either through glyricidia or FYM to rice on succeeding cropswhich might be attributed to sustained nutrient supply and better utilization of applied nutrients through improved micro - environmental conditions. Bharat *et al*.(2017) also reported significant effect on most of the yield components and yield of groundnut through residual 50% RDF+50% RDN through urban compost to preceding crop and 100% RDF to the succeeding crop of groundnut .

**The direct effect of fertilizers on groundnut**

Plant height and number of branches (Table3) per plant were not significantly influenced by the direct effect of fertilizers applied to groundnut. The number of pods per plant was more with the application of 100% RDF which was on par with 75% RDF.Shelling percentage and 100 kernel weight were not significantly influenced by the fertilizers applied to groundnut. Pod yield of groundnut (Table 4) was more with the application of 100% RDF, but, it was on par with 75% RDF which is superior to control *i.e.* no fertilizers application (Table 4). Application of 100% RDF to *rabi* groundnut recorded on par yield (2865 kg ha$^{-1}$) with 75 %(2789kg ha$^{-1}$) or 50% RDF(2763kg ha$^{-1}$) which revealed the benefit of substituting either 25 % or 50 % N through vermicompost to the *Kharif* rice on succeeding groundnut Higher system yield of 9.07t ha$^{-1}$ year$^{-1}$ and 8.75 tha$^{-1}$year$^{-1}$, respectively with the application of 50% recommended dose of chemical fertilizers (RDF) coupled with 50% recommended N through green manuring of Azolla or through FYM to rainy season (*Kharif*) rice followed by supply of 100% RDF through chemical fertilizers to summer rice was also reported by Mishra *et al*. (2017).Similarly total productivity of rice - maize crop sequence was higher when 50% recommended NPK through fertilizers + 50% N through glyricidia was given to rice and 75 % recommended dose of fertilizer to succeeding maize crop (Talathi *et al.,* 2009).

Rice equivalent yield of groundnut (Table 4) was more (5441 kg ha$^{-1}$) with the application of 100% RDF+ 50% N through vermicompost to the preceding rice. The integrated nutrient management to rice might have influenced the production of groundnut through residual effect.The system productivity was more (10,127 kg ha$^{-1}$) with the application of 150-60-40 kg NPK ha$^{-1}$ to the preceding riceand it was closely followed by the application of 100% RDF + 50 % N through vermicompost to rice(10,020 kg ha$^{-1}$). These treatments also recorded higher system productivity of 27.74 kg ha$^{-1}$and 27.45 kg ha$^{-1}$ per day, respectively.

**Table 1. Growth and yield parameters of *Kharif r*ice (BPT-5204) as influenced by integrated nutrient management (2016-2018)**

| Treatment | Plant Height (cm) | | | | Number of tillers plant$^{-1}$ | | | | Productive tillersplant$^{-1}$ | | | | Panicle Length (cm) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2016** | **2017** | **2018** | **mean** | **2016** | **2017** | **2018** | **mean** | **2016** | **2017** | **2018** | **mean** | **2016** | **2017** | **2018** | **mean** |
| T1:50 % RDF + 50 % N vermicompost | 73.0 | 91.0 | 80.9 | 81.6 | 8.6 | 11.0 | 8.7 | 9.4 | 8.4 | 9.8 | 8.5 | 8.9 | 20.5 | 20.8 | 20.2 | 20.5 |
| T2:75 % RDF + 25 % N vermicompost | 76.7 | 87.4 | 83.9 | 82.7 | 8.7 | 12.1 | 8.8 | 9.8 | 8.6 | 11.0 | 8.6 | 9.4 | 20.6 | 21.3 | 20.4 | 20.8 |
| T3:100 % RDF(80-60-40 kg NPK ha$^{-1}$) | 77.0 | 91.8 | 84.3 | 84.3 | 8.4 | 12.1 | 9.6 | 10.0 | 8.5 | 10.5 | 8.6 | 9.2 | 21.4 | 21.0 | 20.0 | 20.8 |
| T4:100 % RDF + 25 % N vermicompost | 77.8 | 91.5 | 83.8 | 84.4 | 8.4 | 11.8 | 8.8 | 9.6 | 8.5 | 10.3 | 8.9 | 9.2 | 20.7 | 21.6 | 20.2 | 20.8 |
| T5:100 % RDF + 50 % N vermicompost | 79.3 | 94.0 | 83.9 | 85.7 | 9.80 | 12.3 | 9.30 | 10.4 | 9.5 | 10.5 | 9.2 | 9.7 | 20.9 | 21.6 | 20.6 | 21.0 |
| T6:150-60-40 kg NPK ha$^{-1}$ | 79.9 | 95.0 | 91.5 | 88.8 | 10.6 | 13.6 | 10.1 | 11.4 | 10.2 | 11.7 | 10.0 | 10.6 | 22.7 | 22.3 | 20.3 | 21.7 |
| **SE $_{m}\pm$** | 1.8 | 2.3 | 1.3 | | 0.3 | 0.4 | 0.4 | | 0.5 | 0.5 | 0.4 | | 0.1 | 0.5 | 0.1 | |
| **CD at 5%** | 5.6 | 6.3 | 5.7 | | 1.2 | 1.4 | 1.2 | | 1.6 | 1.7 | 1.4 | | 0.5 | 0.8 | NS | |

**Table2. Yieldparameters and yield of rice (BPT-5204) as influenced by integrated nutrient management(2016-2018)**

| Treatment | No. of grains panicle$^{-1}$ | | | | 1000 grain weight(g) | | | | Grain Yield (kg ha$^{-1}$) | | | | Straw Yield (kg ha$^{-1}$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2018 | mean | 2016 | 2017 | 2018 | mean | 2016 | 2017 | 2018 | mean | 2016 | 2017 | 2018 | mean |
| $T_1$:50 % RDF + 50 % N vermicompost | 139.6 | 168.8 | 199.6 | 169.3 | 14.3 | 14.6 | 12.0 | 13.6 | 3379 | 4426 | 3699 | 3823 | 7797 | 6650 | 5333 | 6593 |
| $T_2$:75 % RDF + 25 % N vermicompost | 140.2 | 189.4 | 207.2 | 178.9 | 14.7 | 14.6 | 12.9 | 14.0 | 3848 | 4395 | 4028 | 4176 | 8285 | 7344 | 5498 | 7042 |
| $T_3$: 100 % RDF(80-60-40 kg NPK ha$^{-1}$) | 169.3 | 181.4 | 206.0 | 185.5 | 14.2 | 14.4 | 13.4 | 14.0 | 4287 | 4604 | 4249 | 4478 | 9413 | 7468 | 5950 | 7610 |
| $T_4$: 100 % RDF + 25 % N vermicompost | 144.2 | 184.6 | 206.4 | 178.4 | 14.4 | 14.7 | 13.0 | 14.0 | 4318 | 4940 | 4252 | 4513 | 9229 | 7766 | 5994 | 7663 |
| $T_5$:100 % RDF + 50 % N vermicompost | 158.2 | 187.6 | 213.3 | 186.3 | 14.8 | 14.7 | 13.4 | 14.3 | 4516 | 4901 | 4312 | 4579 | 8569 | 7944 | 6137 | 7550 |
| $T_6$: 150-60-40 kg NPK ha$^{-1}$ | 151.4 | 204.9 | 219.4 | 191.9 | 14.3 | 14.7 | 13.7 | 14.2 | 4756 | 5056 | 4954 | 5103 | 9618 | 7988 | 7603 | 8403 |
| **SE $_m\pm$** | 9.4 | 4.9 | 3.6 | | 0.3 | 0.2 | 0.20 | | 234 | 166 | 183 | 176 | 332 | 260 | 265 | |
| **CD at 5%** | NS | 15.5 | 13.2 | | NS | NS | NS | | 740 | 525 | 640 | 590 | 1049 | 821 | 853 | |

**Table 3.Growth and yield of succeeding*rabi*groundnut as influenced by integrated nutrient management under rice –groundnut sequence (2016-2018)**

| Treatments | Plant Height (cm) | | | | Number of branches Plant$^{-1}$ | | | | No. of PodsPlant$^{-1}$ | | | | Shelling Percentage (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Main plots** | **2016** | **2017** | **2018** | **mean** | **2016** | **2017** | **2018** | **mean** | **2016** | **2017** | **2018** | **mean** | **2016** | **2017** | **2018** | **mean** |
| $T_1$: 50% RDF+ 50% N vermicompost | 24.7 | 27.6 | 20.5 | 24.2 | 3.9 | 3.8 | 3.4 | 3.7 | 20.4 | 15.2 | 9.2 | 14.9 | 70.3 | 67.1 | 70.2 | 69.2 |
| $T_2$:75% RDF+25%N vermicompost | 22.7 | 26.8 | 20.4 | 23.3 | 3.9 | 3.8 | 3.4 | 3.7 | 19.1 | 13.8 | 9.9 | 14.2 | 69.9 | 69.3 | 69.3 | 69.5 |
| $T_3$:100% RDF(80-60-40 kg NPK ha$^{-1}$) | 24.4 | 28.9 | 18.6 | 23.9 | 3.9 | 3.9 | 3.7 | 3.8 | 13.2 | 14.7 | 9.6 | 12.5 | 69.8 | 66.0 | 68.8 | 68.2 |
| $T_4$:100%RDF +25%N vermicompost | 23.9 | 29.1 | 19.0 | 24.0 | 3.8 | 3.8 | 3.4 | 3.6 | 15.3 | 13.6 | 8.3 | 12.4 | 68.5 | 67.8 | 70.6 | 68.9 |
| $T_5$:100%RDF +50%N vermicompost | 23.7 | 29.5 | 20.0 | 24.4 | 3.9 | 3.8 | 3.5 | 3.7 | 15.4 | 13.9 | 9.1 | 12.8 | 70.5 | 69.9 | 70.8 | 70.4 |
| $T_6$:150-60-40 kg NPK ha$^{-1}$ | 24.6 | 27.8 | 18.9 | 23.7 | 3.9 | 3.8 | 3.3 | 3.6 | 17.1 | 11.8 | 8.6 | 12.5 | 71.2 | 66.8 | 70.3 | 69.4 |
| **SE $_m\pm$** | 0.6 | 0.5 | 0.2 | | 0.0 | 0.1 | 0.1 | | 1.1 | 1.2 | 0.1 | | 0.8 | 1.37 | 1.3 | |
| **CD at 5%** | NS | 1.6 | NS | | NS | NS | NS | | NS | NS | NS | | NS | NS | NS | |
| **Subplots** | | | | | | | | | | | | | | | | |
| $F_1$:Control | 23.5 | 28.1 | 19.7 | 23.7 | 3.9 | 3.7 | 3.2 | 3.6 | 14.5 | 12.7 | 8.4 | 11.8 | 70.2 | 67.8 | 67.3 | 68.4 |
| $F_2$:50%RDF | 24.2 | 28.2 | 19.2 | 23.8 | 3.9 | 3.7 | 3.5 | 3.7 | 15.4 | 13.7 | 8.9 | 12.6 | 69.5 | 66.9 | 68.3 | 68.2 |
| $F_3$:75 %RDF | 24.5 | 27.8 | 19.9 | 24.0 | 3.9 | 4.0 | 3.4 | 3.7 | 18.5 | 14.1 | 9.4 | 14.0 | 71.1 | 68.6 | 70.1 | 69.9 |
| $F_4$:100 % RDF(30-40-50 kg NPK ha$^{-1}$) | 23.8 | 28.4 | 19.4 | 23.8 | 3.9 | 3.8 | 3.6 | 3.7 | 18.6 | 14.9 | 9.7 | 14.4 | 69.3 | 67.3 | 70.3 | 68.9 |
| **SE $_m\pm$** | 0.7 | 0.6 | 0.8 | | 0.0 | 0.3 | 0.3 | | 0.7 | 0.6 | 0.0 | | 0.9 | 0.9 | 1.0 | |
| **CD at 5%** | NS | NS | NS | | NS | NS | NS | | 2.0 | 1.8 | NS | | NS | NS | NS | |

**Table 4. Yield of groundnut and system productivityas influenced by integrated nutrient management (2016-2018)**

| Treatments | 100 Kernel Weight (g) | | | | Pod Yield (kg ha$^{-1}$) | | | | Rice equivalent Yield (kg ha$^{-1}$) | System Productivity (kg ha$^{-1}$) | System Productivity kg ha$^{-1}$day$^{-1}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Main plots** | **2016** | **2017** | **2018** | **mean** | **2016** | **2017** | **2018** | **mean** | | | |
| $T_1$:50% RDF+ 50% N vermicompost | 43.0 | 43.4 | 43.4 | 43.2 | 3676 | 2918 | 2874 | 2735 | 5148 | 8971 | 24.57 |
| $T_2$:75% RDF+ 25%N vermicompost | 42.8 | 44.6 | 43.8 | 43.7 | 3297 | 2851 | 2545 | 2769 | 5212 | 9388 | 25.72 |
| $T_3$:100% RDF (80-60-40kg NPK ha$^{-1}$) | 42.9 | 43.6 | 42.9 | 43.1 | 3298 | 2774 | 2283 | 2652 | 4992 | 9470 | 25.94 |
| $T_4$:100%RDF + 25%N vermicompost | 44.4 | 43.5 | 43.4 | 43.7 | 3290 | 2850 | 2385 | 2712 | 5104 | 9617 | 26.34 |
| $T_5$:100%RDF + 50%N vermicompost | 42.4 | 43.2 | 42.9 | 42.8 | 3493 | 2956 | 2780 | 2891 | 5441 | 10,020 | 27.45 |
| $T_6$:150-60- 40 kg NPK ha$^{-1}$ | 42.2 | 42.4 | 41.6 | 42.0 | 3198 | 2855 | 2300 | 2669 | 5024 | 10,127 | 27.74 |
| **SE $_m\pm$** | 2.3 | 0.92 | 1.3 | | 98 | 123 | 102 | 59 | - | | |
| **CD at 5%** | NS | NS | NS | | 376 | NS | 473 | 156 | - | | |
| **Sub Plots** | | | | | | | | | | | |
| $F_1$:Control | 43.9 | 44.7 | 42.9 | 43.8 | 3086 | 2677 | 2380 | 2602 | | | |
| $F_2$:50%RDF | 42.1 | 43.3 | 43.7 | 43.0 | 3172 | 2907 | 2497 | 2763 | | | |
| $F_3$:75 %RDF | 42.3 | 43.5 | 43.7 | 43.1 | 3122 | 2941 | 2643 | 2789 | | | |
| $F_4$:100 % RDF(30-40-50) | 42.1 | 42.8 | 43.7 | 42.8 | 3230 | 2943 | 2795 | 2865 | | | |
| **SE $_m\pm$** | 1.4 | 1.0 | 1.0 | | 52 | 66 | 84 | 45 | | | |
| **CD at 5%** | NS | NS | NS | | 138 | 190 | 298 | 102 | | | |

## CONCLUSION

Application of 25 % or 50% recommended nitrogen through organic sources such as vermicompost to *Kharif* rice not only benefit the rice crop butalso has a significant residual effect on succeeding groundnut and to reduce the fertilizer dose of groundnut by 50% without sacrificing yield.

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# STUDY ON THE PROCESSING AND PRESERVATION OF JACKFRUIT BISCUITS

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## ABSTRACT

The study on processing of jackfruit biscuit was carried out during the year 2018 in a Completely Randomized Design with four formulations (33%, 31%, 29% and 27% of wheat flour concentrations for 500g of jackfruit pulp). The effect of processing on the nutritional quality, sensory quality, shelf life and cost economics were calculated. The formulation, $T_3$ ( Jackfruit with 29% of wheat flour) was evaluated as the best treatment when compared to other formulations with moisture content of 12.87%, fat content of 2.87g and a protein content of 5.87g in 100g portion of the biscuits. The formulation $T_3$ was found to have a maximum shelf life period of five months. The average sensory scores for taste (8.6), colour (8.4), flavour (8.4) and overall acceptability (8.5) of jackfruit biscuits were initially maximum in the same treatment. Cost of production of one kg of the biscuits was Rs.72 with a benefit-cost ratio of 1.62.

**Key words:** Jackfruit Biscuits, Preservation, Processing

## INTRODUCTION

Fruits are the cheapest source of protective food supplied in fresh or processed or preserved form throughout the year for human consumption. Post-harvest losses of this fruit are very high due to lack of storage facilities and mishandling operations (Sreenivasa Murthy *et al.,* 2009). Proper handling, packaging, transportation and storage reduce the postharvest losses of fruits. Every 1% reduction in loss will save 5 million tons of fruits per year. Jackfruit belongs to the family Moraceae and is considered as the largest fruit among the edible fruits. Jackfruit is rich in dietary fibre. The fresh fruit has small but significant amounts of vitamin-A and flavonoid pigments. Together, these compounds play a vital role in antioxidant and vision functions. Jackfruit is a good source of antioxidant vitamin-C, provides about 13.7 mg or 23% of recommended dietary allowance. It is one of the rare fruits that is rich in B-complex group of vitamins.

Jackfruit seeds are very rich in digestible starch, protein, and minerals. However, the fruit is perishable and it is difficult to store for a long time because of its inherent compositional and textural characteristics. Tender jackfruits on storage without any processing or treatment were found to be deteriorating by browning (Ranasinghe *et al.,* 2019). Therefore, it is necessary to process this underutilized fruit into easily marketable products. Proper post-harvest technology for prolonging shelf - life is therefore necessary. Besides, alternate ways of using jackfruit in the flush season play a significant role in reducing the postharvest losses by proper processing. Hence, the study was conducted to

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process and preserve the jackfruit biscuits and to evaluate the nutritional, storage, sensory qualities and economic analysis of jackfruit biscuits.

**MATERIAL AND METHODS**

The study on the processing of jackfruit biscuits was carried out during the year 2018 in the Department of Horticulture, Faculty of Agriculture, Annamalai University in a Completely Randomized Design with four formulations of 33%, 31%, 29% and 27% of wheat flour concentration for 500g of jackfruit pulp and replicated five times. The effect of processing on the nutritional quality and sensory quality, storage life and cost economics were also calculated. The Sensory Score was obtained based on a nine point Hedonic scale [extremely like (9) to extremely dislike (1)] by 10 number of organoleptic panel members. The sensory parameters evaluated were taste, colour, flavour and overall acceptability. Moisture content of all the experimental samples was determined by controlled electric oven-dry method as suggested by Hossain and Siddique( 1982). Estimation of fat and protein was carried out by the method of AOAC (1990).

The oven was preheated to $325^0$ F. In a kitchen-aid mix bowl, all-purpose flour, confectionery sugar, cardamom and salt were added and mixed well. To this soft butter and vanilla extract were added and mixed until everything combined well. Chopped jackfruit pieces were also added to it and again mixed. Then it was removed from the bowl and made it into a log, wrapped with plastic wrap and frozen for about 15-20 minutes. Further, the dough was removed from the freezer when it was ready to bake, and it was cut into ½ inch thick slices. The slices were placed in cookie sheet about 2 inches apart and baked at $325^0$ F for 20 minutes or until it became brown. Afterwards, it was removed from the oven and set aside for 10 minutes in the cookie sheet and finally cooled completely and stored it in an airtight container.

**RESULTS AND DISCUSSION**

Jackfruit biscuits (Fig.1) that were prepared with 29% of wheat flour ($T_3$) were considered as the best treatment having a low moisture content of 12.87%, fat content of 2.87g and protein content of 5.87g in 100g of biscuits (Table 1) with a maximum shelf life period of five months. The sensory score was obtained based on nine-point hedonic scale by 10 number of organoleptic panel members and it was concluded that the taste (8.6), colour (8.4), flavour (8.4) and overall acceptability (8.5) were also higher in $T_3$ ( Table 2).

As the wheat flour concentration increases the protein content in processed products also get increased. Similarly, the maximum value for protein content(6.45 g) was recorded in $T_{1,}$ formulated with 33% of wheat flour concentration (6.45 g) followed by $T_2$ with 31% of wheat flour concentration (5.95 g). These results are in conformity with Hooda and Jood (2005) in wheat biscuits supplemented with fenugreek flour.

The different composition of jackfruit and wheat flour especially the gluten content of wheat flour could be responsible for the difference in the strength of the biscuits. The reduced amount of protein after processing might be due to their denaturation which might have occurred due to increase in moisture content and their involvement in maillard reactions to form brown pigment. Similarly, decreasing trend for protein content was noticed by Afoakwa *et al*. (2007) in a study conducted for analysing the textural qualities of chocolates.

A similar increasing trend of fat content has been reported by Ahmad *et al*. (2013) in weaning food prepared from multipurpose flour, papaya powder and milk powder; Sadaf *et al*. (2013) in instant baby food prepared from indigenous sources and Babita (2013) in weaning mix supplemented with pumpkin flour.

Benefit- cost ratio of jackfruit biscuit production was 1.62 with a net profit of Rs.72/-. Cost economics was calculated only for the best formulations. The results of the study are encouraging for value addition to Jack fruit and therefore, this processing can be recommended for commercial exploitation (Table 3).

**Table 1. Effect of variation in wheat concentration on nutritional quality of Jackfruit Biscuits**

| Treatment (Wheat flour content of the formulations) | Moisture Content (%) | Fat Content (g/ 100 g) | Protein Content (g/ 100 g) |
|---|---|---|---|
| $T_1$ (33%) | 14.86 | 1.47 | 6.45 |
| $T_2$ (31%) | 13.78 | 2.08 | 5.95 |
| $T_3$ (29%) | 12.87 | 2.87 | 5.87 |
| $T_4$ (27%) | 14.43 | 3.86 | 5.64 |
| **S.Ed** | 0.14 | 0.19 | 0.05 |
| **CD (P=0.05)** | 0.29 | 0.39 | 0.10 |

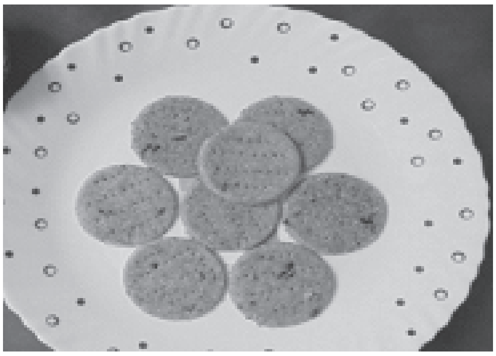

Fig. 1. Prepared Jackfruit Biscuits

**Table 2. Sensory scoring for jackfruit biscuits at 1st month of evaluation (July, 2018)**

| Taste Panel (TP) Member | $T_1$ (33% of wheat flour) | | | | $T_2$ (31% of wheat flour) | | | | $T_3$ (29% of wheat flour) | | | | $T_4$ (27% of wheat flour) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Taste | Colour | Flavour | Overall acceptability | Taste | Colour | Flavour | Overall acceptability | Taste | Colour | Flavour | Overall acceptability | Taste | Colour | Flavour | Overall acceptability |
| $TP_1$ | 9.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 9.0 | 8.0 | 9.0 | 9.0 | 9.0 | 7.0 | 7.0 | 7.0 |
| $TP_2$ | 9.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 9.0 | 8.0 | 8.0 | 9.0 | 8.0 | 9.0 | 7.0 | 9.0 | 7.0 | 7.0 |
| $TP_3$ | 7.0 | 9.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 9.0 | 8.0 | 8.0 | 8.0 | 9.0 | 7.0 | 8.0 | 7.0 |
| $TP_4$ | 7.0 | 9.0 | 9.0 | 8.0 | 8.0 | 8.0 | 9.0 | 8.0 | 8.0 | 8.0 | 9.0 | 8.0 | 9.0 | 8.0 | 8.0 | 8.0 |
| $TP_5$ | 7.0 | 9.0 | 8.0 | 8.0 | 8.0 | 9.0 | 8.0 | 8.0 | 8.0 | 9.0 | 8.0 | 7.0 | 8.0 | 7.0 | 8.0 | 8.0 |
| $TP_6$ | 8.0 | 9.0 | 8.0 | 8.0 | 8.0 | 9.0 | 9.0 | 8.0 | 9.0 | 8.0 | 9.0 | 9.0 | 9.0 | 8.0 | 8.0 | 7.0 |
| $TP_7$ | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 7.0 | 9.0 | 8.0 | 8.0 | 9.0 | 8.0 | 8.0 | 7.0 | 8.0 | 8.0 | 7.0 |
| $TP_8$ | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 7.0 | 9.0 | 7.0 | 9.0 | 8.0 | 8.0 | 9.0 | 9.0 | 7.0 | 8.0 | 7.0 |
| $TP_9$ | 8.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 8.0 | 8.0 | 8.0 | 8.0 | 9.0 | 9.0 | 7.0 | 8.0 | 8.0 | 8.0 |
| $TP_{10}$ | 7.0 | 9.0 | 8.0 | 8.0 | 8.0 | 8.0 | 9.0 | 8.0 | 8.0 | 9.0 | 8.0 | 9.0 | 9.0 | 7.0 | 8.0 | 8.0 |
| **Grand Total** | 78.0 | 83.0 | 79.0 | 78.0 | 78.0 | 78.0 | 85.0 | 78.0 | 86.0 | 84.0 | 84.0 | 85.0 | 83.0 | 76.0 | 78.0 | 74.0 |
| **Average** | 7.8 | 8.3 | 7.9 | 7.8 | 7.8 | 7.8 | 8.5 | 7.8 | 8.6 | 8.4 | 8.4 | 8.5 | 8.3 | 7.6 | 7.8 | 7.4 |

**Table 3. Cost economics of Jackfruit Biscuits**

| Descriptions | Quantity | Cost (Rs) |
|---|---|---|
| Wheat flour (g) | 300g | 15.60 |
| Confectioner's sugar (g) | 300g | 18.00 |
| Chopped jackfruit | 1kg | 100.00 |
| Butter (g) | 300g | 28.80 |
| Vanilla extract (g) | 2g | 1.60 |
| Salt (g) | 2g | 0.02 (2 paisa) |
| Total (Rs.) | | 164.02 |
| Cost of Packaging material (Rs.) | | 15.00 |
| Labour cost (Rs.) | | 187.50 |
| Total variable cost for 1 hr. (Rs.) | | 122.17 |
| Total fixed cost(Rs.) | | 0.63 |
| Total cost of production (Rs.) | | 122.80 |
| Sale of product/kg (Rs.) | | 200.00 |
| Net Profit (Rs.) | | 72.20 |
| Benefit-Cost Ratio | | 1.62 |

## CONCLUSION

Formulation $T_3$ (Jackfruit biscuit prepared with 29% of wheat flour) was adjudged as the best when compared to other formulations. Nutrient analysis revealed that the formulation $T_3$ had the moisture content of 12.87%, fat content of 2.87g and a protein content of 5.87g in 100g of the biscuits. $T_3$ was observed as a sample with maximum shelf life period of five months. The average sensory scores for taste (8.6), colour (8.4), flavour (8.4) and overall acceptability (8.5) of jackfruit biscuit were initially maximum in $T_3$ with 29% of wheat flour concentration. The same trend was maintained in all the months of evaluation with gradual reduction in scores.

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# FACTORS AFFECTING THE QUALITY OF POSTGRADUATE RESEARCH IN STATE AGRICULTURAL UNIVERSITIES (SAUs)

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## ABSTRACT

The study conducted on assessing the quality of postgraduate research revealed that the student research is being amply published and on an average two publications are being brought out from each thesis. From postgraduate research, more than 60 per cent of the publications were published in journals having NAAS rating <4.0 in both the universities *viz.,* Acharya N G Ranga Agricultural University (ANGRAU) and Tamilnadu Agricultural University (TNAU). The articles published during the last five years of research from 2011-2016 having NAAS rating above 6.0 are only 5.32% and 8.05% in ANGRAU and TNAU, respectively. Majority of the faculty opined that innovativeness and specialization are playing a major role in identifying research topic.Lack of participation in appropriate forums,lack of sufficient funding and infrastructure facilities are the main reasons affecting the quality of PG research.

**Key words:** Post Graduate Research, SAUs, ANGRAU, TNAU, Research Articles.

## INTRODUCTION

India is having one of the largest public agricultural research systems in the world, organized under the Indian Council of Agricultural Research (ICAR) and State Agricultural Universities (SAUs). One of the important limitations of the ICAR research system is the limited understanding of the local needs and requirements of the technologies by scientists. On the other hand,State Agricultural Universities (SAU's) research system is fairly strong enough with back stopping of state extension agencies who can showcase the requirements of the farmers. SAU system is having relatively more advantages, wherein,majority of the scientistsbelong to their native states, having strong extension units working in close coordination with farmers, strong linkages with state-level extension agencies.

State Agricultural Universities (SAUs) are playing a pivotal role in producing technical manpower for agricultural development and to provide solutions to the farmers through conducting need-based research. To develop highly qualified, competitive technical manpower, a well-established system of education is needed. During the process of development of qualified scientific manpower, they are trained intensively in the subject and research methodologies. The students at Postgraduate and Doctoral level are being involved in course work and research work to complete their degree. In all the SAUs in the country, the existing system at postgraduate level is course work for two semesters followed by research work for two semesters and at the doctoral level, the course work is for two semesters followed by research work for four semesters. The research exposure at the

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student level is foundation for their career, hence, they should be assigned research projects which should innate their talents.While large amounts of public resources are being invested for Postgraduate research, it is disheartening to note that the outputs do not commensurate with the investments and their outcomes do not go beyond laboratories and academic journals. Even for the published articles, quality of the publication is a major concern. NAAS rating is being adopted as criteria to assess the quality of publications in case of research in agricultural sciences and is being adopted in most of State and Central Agricultural Universities (Bishwapati *et al*., 2012). It is also observed that the work carried out in postgraduate research is not meeting the needs of farmers directly or indirectly which will result in wastage of resources (Srinivas *et al*., 2018). Moreover, due to non-documentation, plagiarism is polluting academic research globally (Bhanu *et al*., 2019). Keeping this in view, it is planned to conduct a study on the quality of academic research and factors affecting it.

## MATERIAL AND METHODS

The study was conducted during the year 2016 purposively in six colleges of two Agricultural Universities covering two states *viz.,* Andhra Pradesh and Tamil Nadu. The research studies pertaining to postgraduate research work during 2011-2016 was collected and tabulated. The data collected was categorised based on major areas of research. To find out the quality of the research, the data of the publications brought out from students research were collected for the said period (2011-16) and categorised based on NAAS rating and the pooled data is presented as Tables. The constraints faced in finalizing the topic for postgraduate research and factors affecting the quality of postgraduate research were also studied using a questionnaire and the responses were collected from the faculty offering PG programmes and as well from the students.

## RESULTS AND DISCUSSION

The results pertaining to publications brought out from the postgraduate academic research for the study period from ANGRAU (Andhra Pradesh) is presented in Table 1. The findings showed that 1935 publications are brought out from 755 theses *i.e.*, an average of 2.56 publications from each thesis. This might be due to the guidelines that are adopted by the SAU that a postgraduate student must submit two research articles at the time of submission of thesis for evaluation. From the data, it is observed that highest number of theses were submitted in Genetics and Plant Breeding (160) subject followed by Entomology (140) and Plant Pathology (55) during the study period. The average number of publications from each thesis is highest from Agricultural Extension discipline (3.27) followed by Crop Physiology (3.00). The average number of publications from Agronomy occupied third place (2.77) followed by Entomology and Genetics and Plant Breeding (2.53).

**Table 1. NAAS rating of publications of students research in ANGRAU**

| Department | Theses submitted (2011-16) | Publications brought out (2011-16) | Average number of publications | NAAS rating | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | <4 | % | 4 - 6 | % | > 6 | % |
| Agronomy | 90 | 250 | 2.77 | 202 | 80.80 | 35 | 14.00 | 13 | 5.20 |
| Soil Science | 80 | 180 | 2.25 | 118 | 65.56 | 53 | 29.44 | 9 | 5.00 |
| Entomology | 140 | 355 | 2.53 | 267 | 75.28 | 68 | 19.15 | 20 | 5.63 |
| Plant Pathology | 55 | 105 | 1.90 | 74 | 70.47 | 24 | 22.83 | 7 | 6.66 |
| Genetics and Plant Breeding | 160 | 405 | 2.53 | 298 | 73.58 | 83 | 20.47 | 24 | 5.96 |
| Crop Physiology | 70 | 210 | 3.00 | 114 | 54.24 | 92 | 43.80 | 4 | 1.92 |
| Agricultural Extension | 75 | 245 | 3.27 | 125 | 51.02 | 100 | 40.87 | 20 | 8.16 |
| Agricultural Economics | 85 | 185 | 2.18 | 130 | 70.27 | 49 | 26.48 | 6 | 3.24 |
| **Total** | 755 | 1935 | 2.56 | 1328 | 68.63 | 504 | 26.04 | 103 | 5.32 |

The number of publications published in journals with NAAS rating below 4 is highest (1328) *i.e.*, 68.63 per cent, while from NAAS rating 4-6 is 502 (25.94%) and > 6 is only 101 (5.21%). The data indicate that the quality of research should be improved to get published in journals with good NAAS rating. Among all the departments, Crop Physiology and Agricultural Extension have got highest number of publications in journals having NAAS rating > 4 and < 6 (43.80%; 40.87%), respectively. Agricultural Extension has recorded highest number of publications with NAAS rating >6 among all the departments (8.16) followed by Genetics and Plant Breeding (5.96) and Entomology (5.63%) while the least were recorded in Crop Physiology (1.92%). Among the departments, highest number of publications are recorded in Agronomy in journals with NAAS rating <4 (80.80%) while Entomology, Genetics and Plant Breeding, Plant pathology and Agricultural Economics recorded around 70 per cent and Agricultural Extension recorded least number of publications in journals with NAAS rating below 4 (51.02%).

The results about PG research of TNAU, Tamilnadu (Table 2) indicate that 475 students have submitted theses in different disciplinesduring the study period and 1130 scientific publications are brought out in different journals with an average of 2.38 publications from each thesis. The average number of publications from Entomology was highest (3.36%) followed by Agronomy (3.00%), Soil Science (2.75%) and least are in Agricultural Economics (1.75%). The number of publications published from Genetics and Plant

Breeding and Agricultural Economics are low in number.

The results pertaining to the quality of publications revealed that the research published in journals with NAAS rating <4 is highest (63.90%) followed by NAAS rating from 4 to 6 (28.05%) and NAAS rating >6 (8.05%). This shows that the quality of research should be improved to get more number of publications in journals with NAAS rating >6. The department wise results indicate that students of Agricultural Extension recorded highest percentage of publications with NAAS rating >6 (13.75%) among all the disciplines followed by Entomology (11.89%) and Crop Physiology (8.59%) while the least are with Genetics and Plant Breeding (6.04%). There are no publications from research output of Agricultural Economics with NAAS rating >6.

**Table 2. NAAS rating of publications of students research in TNAU**

| Department | Theses submitted (2011-16) | Publications brought out (2011-16) | Average number of publications | NAAS rating | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | <4 | % | 4 - 6 | % | > 6 | % |
| Agronomy | 50 | 150 | 3.00 | 95 | 63.33 | 44 | 29.33 | 11 | 7.33 |
| Soil Science | 60 | 165 | 2.75 | 117 | 70.90 | 37 | 22.42 | 11 | 6.67 |
| Entomology | 55 | 185 | 3.36 | 119 | 64.32 | 44 | 23.78 | 22 | 11.89 |
| Plant Pathology | 30 | 80 | 2.66 | 50 | 62.50 | 24 | 30.00 | 6 | 7.50 |
| Genetics and Plant Breeding | 120 | 215 | 1.81 | 150 | 69.76 | 52 | 24.17 | 13 | 6.04 |
| Crop Physiology | 30 | 70 | 2.33 | 41 | 58.59 | 23 | 32.83 | 6 | 8.59 |
| Agricultural Extension | 70 | 160 | 2.29 | 84 | 52.50 | 54 | 33.75 | 22 | 13.75 |
| Agricultural Economics | 60 | 105 | 1.75 | 66 | 62.85 | 39 | 37.17 | 0 | 0.00 |
| Total | 475 | 1130 | 2.38 | 722 | 63.90 | 317 | 28.05 | 91 | 8.05 |

The highest number of publications in journals with NAAS rating <4 is of Soil Science discipline (70.90%) followed by Genetics and Plant Breeding (69.76%) and Entomology (64.32%), while the least number is in Agricultural Extension (52.80%). Agricultural Economics students published highest number of publications in journals with NAAS rating ranging from 4 to 6 (37.17%) followed by Agricultural Extension (33.75%), Crop Physiology (32.83%), while the least number is in Soil Science (22.42%).

The results showed that most of the articles published out of P.G research are in journals having NAAS rating <4.0 which speaks about the quality of research. Further, only less than ten percent of the publications are being published in high NAAS rated journals. NAAS rating is the criteria in agricultural sciences which speak about the quality of the journal and quality of the publication. Though India ranks first as per the publications output is considered in Agriculture domain,the Indian research papers are cited only 3.2 times on an average, putting it in the 119$^{th}$ position out of 149 countries (Sundaram, 2012).

The results pertaining to factors affecting the quality of PG research are presented under the following headings.

**i. Selection of P.G research topic**

The results presented in Table 3 indicate that highest numberof the faculty in ANGRAU considered innovativeness (93.33 %), specialization (86.67%) and advice from the HoD (80.00)as the highest three factors while selecting the PG research topic. The need of stake holders (64.44%) is in fourth place in the order of priority and continuation of past research (62.22%) is in fifth place.The selection of research topic merely for publication of research papers by the faculty is the least priority in ANGRAU.

**Table 3. Factors affecting the selection of P.G research topic as perceived by the faculty**

| S.No. | Factors | ANGRAU (n=45) | | TNAU (n=38) | | TOTAL (n=83) | |
|---|---|---|---|---|---|---|---|
| | | % | f | % | f | % | |
| 1 | Own interest | 26 | 57.78 | 23 | 60.53 | 49 | 59.04 |
| 2 | Specialization | 39 | 86.67 | 38 | 100.00 | 77 | 92.77 |
| 3 | Continuation of past research | 28 | 62.22 | 15 | 39.47 | 43 | 51.81 |
| 4 | Advice from the HoDs | 36 | 80.00 | 23 | 60.53 | 59 | 71.08 |
| 5 | Innovativeness | 42 | 93.33 | 38 | 100.00 | 80 | 96.39 |
| 6 | Research papers | 8 | 17.78 | 4 | 10.53 | 12 | 14.46 |
| 7 | Need-based | 29 | 64.44 | 21 | 55.26 | 50 | 60.24 |

All the faculty (100%) from TNAU opined that specialization and innovativenessare foremost factors in selection of research topic followed by own interest (60.53 %) in third place and advice from HoD in fourth place (60.53 %). Majority of the faculty in both the universitieshave strongly agreed that the research topics are finalized based on the innovativeness (96.39 %) and specialization (92.77 %). Faculty members of both the universities agreed that research papers are not playing any role in the selection of research topic. Continuation of research topic is also given enough importance in both the universities in finalization of research topics for PG research. However, while finalizing the research topics for PG research, the needs of the stakeholder should be given top priority in State Agricultural Universities which is not being attended.

**ii. Constraints in planning the need-based research programmes**

The results presented in Table 4 reveal that majority of the faculty (54.22%) opined that non participation of teaching faculty in the zonal or state level research-extension advisory meetings or farmer- scientist interactions is the major constraint in planning need-based research programmes followed by weak research - extension-farmer linkages (27.71%). The other factors such as less experience of staff on insights and priorities of the farmers and less participation in the farmers training programmes also lead to poor planning.

**Table 4. Constraints in plannin g need-based studentsresearch programmes as perceived by the faculty (n=83)**

| S. No | Constraints | Frequency | Percentage |
|---|---|---|---|
| 1 | Week research - extension - farmer linkages | 23 | 27.71 |
| 2 | Experience on insights and priorities of the farmers | 7 | 8.43 |
| 3 | Lack of participation of teaching faculty in zonal or state level research extension meetings/ Farmer - Scientist Interactions | 45 | 54.22 |
| 4 | Limited hands- on training programmes with the farming communities | 8 | 9.63 |

### iii. Factors affecting the quality of P.G research

Majority of faculty opined that insufficient and delay in the release of funds (31.32%) is the main reason followed by lack of infrastructure facilities (19.27%) and insufficient staff (18.07 %). In-conclusive research results due to alteration in the programmes is the least influencing factor (2.40%) affecting the quality of PG research (Table 5). Other factors such as limited interdisciplinary and institutional linkages also affect the implementation of P.G programmes to a minor extent.These results are in agreement with the findings of Sundaram (2012).

**Table 5. Factors affecting the quality of P.G research as opined by the faculty (n=83)**

| S. No. | Factors | Frequency | Percentage |
|---|---|---|---|
| 1 | In-conclusive research results due to alteration of planned and ongoing research activities | 2 | 2.40 |
| 2 | Non availability of suitable laboratory equipment | 12 | 14.46 |
| 3 | Insufficient and delay in release of funds | 26 | 31.32 |
| 4 | Inter-disciplinary linkages are limited | 5 | 6.02 |
| 5 | Lack of expertise in staff | 3 | 3.61 |
| 6 | Limited infrastructure facilities | 16 | 19.27 |
| 7 | Lack of institutional linkages | 4 | 4.82 |
| 8 | Insufficient staff | 15 | 18.07 |

## CONCLUSION

Majority of the faculty opined that innovativeness and specialization are playing major role, while identifying the postgraduate research topic. Lack of participation in appropriate forums, lack of sufficient funding and infrastructure facilities are the main reasons affecting the quality of PG research.

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# TRAINING NEEDS ASSESSMENT OF AGRI-INPUT DEALERS

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## ABSTRACT

The sample of 120 Agri input dealers was studied for assessment of their training needs in Chittoor district of Andhra Pradesh during 2018-19. The results revealed that the major crops for which trainings requiredarerice, groundnut and mango. Germination tests for testing viability of seeds and seed materials,labeling and seed certification were among the top needed training areasunder the aspect of seeds and planting material. Types ofmanures and fertilizers available and dosage calculations of straight and complex fertilizers were the most needed training areas under manures and fertilizers aspect. Most important training needs related to agrochemicals aspect are pest and diseases identification in major crops,pesticides and their mode of action.Regarding farm machinery, latest farm implements and their maintenancewas identified as an important training need. Further, in addition to agricultural aspects, input dealers expressed the necessity of training requirement on business licensing, renewals,taxation and billing. Respondents preferred to have trainings of one-week duration, during the period of February to April with a periodicity once in every year for organising the trainings.

**Key words:** Training Needs Assessment, Agri- input dealers, Training duration and Periodicity of trainings

## INTRODUCTION

Technological advances in agriculture that were transferred to the farmers by various extension systems contributed to the current land mark of 283.37 million tons of food grain production in 2018-19 (GoI, 2018). Various extension systems included Government, NGO, and Private Sector Extension service providers are involved in the transfer of technology(ToT) and providing agri services.

Agri-input dealers became the important service providing partner to the farming communitynot only by supplying the agri inputs but by providing the needed agro-advisory services playing useful role in the agricultural production system. The input dealers are the bridge between farmers and agricultural developmental agencies, and often viewed by the farmers as a “friend, philosopher and guide” and is truly a change agent (Whagmode, 2014).

In India, the number of practising agri-input dealers is around 2,82,000 (GoI, 2014). For the farmers, agri-input dealer is the first contact person. During the purchase of different inputs,a farmer seeks advice on the type and usage of inputs from agri input dealers.The input dealers can be developed as Para-Extension professionals by organizing more training

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programmes on the identified areas for improving their agricultural knowledge and thereby their role performance in delivering the agri input services to the farmers.

Most of the pesticide retailers need training on various aspects being encountered in their day-to-day business such as pest and pesticides management and IPM techniques (Singh *et al.,* 2015).Training is a continuous process of acquiring the essential skills required for performing certain jobs.Training Needs Assessment (TNA) refers to the organizational process of collecting and analyzing data for deciding on when and on what trainings need to be conducted (Clarke, 2013). Hence, the study was conducted to assess the various training areas needed for the agri input dealers and also other aspects like duration, time and periodicity of the training programme.

## MATERIAL AND METHODS

The assessment study was conducted during 2018-19 in Chittoor district of Andhra Pradesh. A sample of 120 licensed agri-input dealers was selected randomly who were participatingin Diploma for Agricultural Extension Services for Input Dealers (DAESI) programme during 2018-19. After discussion with the agri-input dealers, subject matter specialistsof extension discipline and based on the activities and advices offered by the agri-input dealers, the training areas and topics were identified. The response from the agri-input dealers was sought using a pre-tested semi-structured interview schedule developed on a three-point rating scale namely, Most Needed, Needed and Not Needed and responses were quantified by assigning the scores of 3, 2 and 1, respectively. Training Need Index (TNI) was computed by using the formula:

$$\text{Training Need Index (TNI)} = \frac{\text{Score obtained}}{\text{Maximum obtainable score}} \times 100$$

Based on the TNI, the Need Hierarchy Rank was assigned for identification of most needed topics among the given category.

## RESULTS AND DISCUSSION

### Crop Specific Training needs

The results revealed that trainings were needed by agri input dealers on crops namely, rice (rank I), groundnut (rank II), mango (rank III), flower crops (rank IV) and sugarcane (rank V) followed by other crops namely,vegetable crops (Tomato, Brinjal, etc)(rank VI), maize (rank VII), oil seed crops (castor, gingerly, etc) (rank VIII), minor millets (rank IX), forage crops (rank X), jowar (rank XI) and sorghum (rank XII) (Table 1). The results emphasized that the agri input dealers need training mostly on the crops that were grown extensively in the Chittoor district *viz*., rice, groundnut, Mango and also some vegetable crops on which they lack the knowledge on cultivation. To address these training needs, a complete cultivation package along with the latest technologies on the crops should be made available to the agri-input dealers.

**Aspect-wise Training Needs**

**Training Needs on seeds and planting material**

Agri-input dealers required trainings on germination tests for seeds and viability (rank I), seed material and their labeling (rank II), seed certification, seed laws and regulations (rank III), seed storage management(rank IV) and seed rates for different methods of sowing(rank V) (Table 2).The results revealed that the dealers need more knowledge on seed viability and seed storage also as selling different types of seed material was their major business. The dealers are frequently encountering problems in renewal and registration during seeds certification and regulations, hence, they opined to receive more trainings on these aspects.

**Training Needs on manures and fertilizers**

Results revealed that when training on various types of manures and fertilizers (rank I), dosage calculations for nutrients from straight and complex fertilizers (rank II), micronutrients management(rank III), management of problematic soils (rank IV) and organic and natural nutrient formulations and their usage (rank V) were perceived as important by the agri input dealers (Table 3). Other priority aspects on which training required included fertilizer governing laws and regulations (rank VI),major nutrients management (rank VII), bio-fertilizers and their usage (rank VIII), soil health card based nutrient management (rank IX), usage of nutrient mixtures (rank X), bio formulations usage (rank XI), liquid fertilizers usage (rank XII) and compatibility of different manures and fertilizers with other agrochemicals (rank XIII) and safety issues manures and fertilizers (rank XIV).Similar results were reported by Shelake*etal.* (2015), that input dealers had expressed ‘high’ training needs on ‘micronutrient fertilizers’ followed by ‘integrated nutrient management’.

Agri-input dealers majorly involved in the business of manures and fertilizers. Farmers not only buy these inputs, but, also seek advice on what kind, how much and when to apply these manures and fertilizers. Because of this reason dealers need more updated information on crop nutrients for various crops and their usage so that they can in turn advise the farmers during input selling and gain their confidence. Specialized trainings on crop nutrition aspects periodically will ultimately help the agri input dealers to gain the latest knowledge.

**Training Needs on Agrochemicals**

Results of training needs assessed on aspects related to Agrochemicals (Table 4) revealed identification of pest and diseases on major crops (rank I), pesticides and their mode of action (rank II), usage of weed control chemicals and precautions (rank III), pesticides government laws and regulations (rank IV) and growth regulators and promoters for different crops (rank V) were perceived as most important areas for trainings. Other training aspects included pesticide residues and their management (rank VI), agro chemical formulations and their correct usage (rank VII), control of non-insect pests such as rats, birds, vertebrates, etc (rank VIII), harmful effects on crops, humans and environment (rank IX) and precaution and use of antidotes (rank X) were the other areas of training required. Ranked results revealed that compatibility of different agrochemicals (rank XI), use and maintenance of plant protection equipments (rank XII), protection measures and equipment for safe usage (rank XIII), ecological friendly insects and disease control products (XIV) and label claims (XV) were other aspects on which agri input dealers required training.

Sale of modern agrochemicals is always the most challenging task for any agri-input dealers as it involves high technicalities such aspest and diseases identification, recommending the suitable agro chemicals, their dosages, its efficacy, mode of action and application, compatibility and various other details. The acquired knowledge by receiving the training on identified new areas will help them to give more new technologicaladvice to the farmers and thereby they can win the trustworthiness of the farmers which will improve their business also.

**Table 1. Crop specific Training Needs required (n=120)**

| S.No. | Crop | TNI | Need Hierarchy Rank |
|---|---|---|---|
| 1 | Rice | 91.39 | I |
| 2 | Maize | 72.78 | VII |
| 3 | Jowar | 63.61 | XI |
| 4 | Sorghum | 63.06 | XII |
| 5 | Minor millets | 70.00 | IX |
| 6 | Groundnut | 89.44 | II |
| 7 | Sugarcane | 80.56 | V |
| 8 | Forage crops | 68.06 | X |
| 9 | Mango | 88.33 | III |
| 10 | Vegetable crops (Tomato, Brinjal,etc) | 79.44 | VI |
| 11 | Flower crops | 82.22 | IV |
| 12 | Oil seed crops (Castor, Gingelly, etc) | 70.56 | VIII |

**Table 2. Training Needs on seeds and planting material (n=120)**

| S.No. | Training Aspect | TNI | Need Hierarchy Rank |
|---|---|---|---|
| 1 | Seed material and their labeling | 81.40 | II |
| 2 | Germination tests for seeds and viability | 84.00 | I |
| 3 | Seed storage management | 79.20 | IV |
| 4 | Seed certification, seed laws and regulations | 79.70 | III |
| 5 | Seed rates for different methods of sowing | 74.70 | V |

**Table 3. Training Needs on manures and fertilizers (n=120)**

| S.No. | Training Aspect | TNI | Need Hierarchy Rank |
|---|---|---|---|
| 1 | Various types of manures and fertilizers available | 87.78 | I |
| 2 | Dosage calculations for nutrients from straight and complex fertilizers | 86.94 | II |
| 3 | Liquid fertilizers usage | 78.06 | XII |
| 4 | Safety management of manures and fertilizers | 79.17 | XIV |
| 5 | Compatibility of manures and fertilizers with other agrochemicals | 77.22 | XIII |
| 6 | Major nutrients management | 85.00 | VII |
| 7 | Management of problematic soils | 85.83 | IV |
| 8 | Micronutrients management | 86.39 | III |
| 9 | Bio formulations usage | 80.00 | XI |
| 10 | Organic and natural nutrient formulations and their usage | 85.56 | V |
| 11 | Fertilizers government laws and regulations | 85.28 | VI |
| 12 | Soil health card based nutrients management | 83.06 | IX |
| 13 | Bio fertilizers and their usage | 83.33 | VIII |
| 14 | Usage of nutrient mixtures | 81.11 | X |

The results are supported by the study of Mande and Darade (2011) who reported that majority of the farm input dealers had medium level of knowledge about advanced technology related to use of seeds, fertilizers and pesticides and most of the farm input dealers had needed training related to their sub-areas.

**Training Needs on farm implements and machinery**

Results revealed that input dealers need training on latest farm implements and machinery (rank I) and maintenance of implements and machinery (rank II) (Table 5). Agri- input dealers also sell small farm implements and tools for the farmers and also give advices for repair and maintenance, exclusive trainings on the farm machinery aspects will help to improve the competencies.

**Table 4. Training Needs on Agrochemicals (n=120)**

| S.No. | Training Aspect | TNI | Need Hierarchy Rank |
|---|---|---|---|
| 1 | Identification of pest and diseases on major crops | 92.50 | I |
| 2 | Pesticides and their mode of action | 91.11 | II |
| 3 | Weed control chemicals usage and precautions | 89.72 | III |
| 4 | Plant protection equipment | 76.39 | XII |
| 5 | Agro chemical formulations and their correct usage | 81.67 | VII |
| 6 | Precautions and use of antidotes | 79.72 | X |
| 7 | Control of non-insect pests such as rats, birds, vertebrates, etc | 81.39 | VIII |
| 8 | Harmful effects on crops, humans and environment | 80.28 | IX |
| 9 | Pesticides residues and their management | 83.06 | VI |
| 10 | Ecological friendly pest and disease control products | 73.89 | XIV |
| 11 | Human protection equipment | 75.28 | XIII |
| 12 | Label claims | 72.78 | XV |
| 13 | Compatibility of different agro chemicals | 79.44 | XI |
| 14 | Growth regulators and promoters | 84.17 | V |
| 15 | Pesticides governing laws and regulations | 85.28 | IV |

**Table 5. Training Needs on farm implements and machinery (n=120)**

| S.No. | Training Aspect | TNI | Need Hierarch Index |
|---|---|---|---|
| 1 | Latest farm implements and machinery | 86.67 | I |
| 2 | Maintenance of farm implements and machinery | 82.50 | II |

**Table 6. Training Needs on other aspects (n=120)**

| S.No. | Training Aspect | TNI | Need Hierarchy Rank |
|---|---|---|---|
| 1 | Usage of advanced ICT tools and equipment | 78.33 | IX |
| 2 | Managerial skills | 79.44 | VII |
| 3 | Communication skills | 84.72 | II |
| 4 | Documentation skills such as records keeping, reporting, etc | 80.00 | V |
| 5 | Modern information sources | 79.72 | VI |
| 6 | Digital agricultural systems such as web portals, kiosks, etc | 78.89 | VIII |
| 7 | Field Extension methods | 81.39 | IV |
| 8 | Business licensing, renewals, taxation and billing | 85.28 | I |
| 9 | Agro inputs related Legal aspects | 82.50 | III |

**Table 7. Training duration, preferred time and periodicity of training programmes (n=120)**

| S.No. | Aspect | Response Categories | Frequency (f) | Percentage (%) |
|---|---|---|---|---|
| 1 | Duration of the programme | Less than one week | 23 | 19.17 |
| | | One-week | 53 | 44.17 |
| | | Two-weeks | 7 | 05.83 |
| | | One month | 26 | 21.67 |
| | | > 1 month | 11 | 09.17 |
| 2 | Preferred time for undergoing trainings | January | 5 | 04.17 |
| | | February | 12 | 10.00 |
| | | March | 39 | 32.50 |
| | | April | 18 | 15.00 |
| | | May | 15 | 12.50 |
| | | September | 14 | 11.67 |
| | | October | 8 | 06.67 |
| | | November | 7 | 05.83 |
| | | December | 2 | 01.67 |
| 3 | Periodicity of the training programme required | Once in a season | 46 | 39.17 |
| | | Once in a year | 62 | 51.67 |
| | | for every two years | 11 | 9.17 |

**Training Needs on other aspects**

Apart from the technical agricultural aspects, training in other aspects which aid them in running business successfully and its development were also identified. These include business licensing, renewals, taxation and billing (rank I), communication skills (rank II), agro inputs related legal aspects (rank III), field extension methods (rank IV), documentation skills (rank V), modern information sources (rank VI), managerial skills (rank VII), digital agricultural techniques such as web portals, information kiosks, etc (rank VIII) and use of advanced ICT tools and devices (rank IX) (Table 6).

The results signify that updated knowledge on business licensing, renewals, taxation and billing were found to be highly required due to changing rules and regulations, taxation policies of the government. Communication skills were found important for effective communication with their clients *i.e.,* farmers for making their business more successful. Now-a-days, use of Information Technology with advanced communication tools such as web portals, blogs, web mails, online trading and business,etc in agri business is invariable, and this warrants to conduct trainings on these aspects.

**Duration, preferred time and periodicity of the trainings**

Results indicated that the agri -nput dealers opted for one-week training programmes (44.17%) followed by one-month duration (21.67%),less than one week (19.17%) and two weeks (05.83%) (Table 7). As the agri-input dealers are more engaged in their business activity, one-week duration programmes will be more suitable for them to attend.

Regarding preferred time for undergoing training programmes, more than one-fourth (32.50%) opined that the month of March is suitable for them to participate in the training programmes as it covers the lean period for crops, followed by April (15.00%), May (12.50%), September (11.67%) and February (10.00%) (Table 7).

Concerning periodicity of conducting training programmes,dealers preferred trainings once in a year (51.6%), once in a season (39.17%) and for every two years (9.17%) (Table 7). To update the knowledge of the agri-input dealers, trainings on various identified topics can be organized on yearly once basis at their suitable nearest locations.

## CONCLUSION

The results revealed the major crops for which training required are rice, groundnut and mango. The study identified many important training areas for agri input dealers that are required to be addressed on a priority basis in five major aspects of agriculture. Further, the study unearthed preferableduration as one week and preferred time of conducting training during the year is from February to April and periodicity for organizing trainings isonce in every year. The identified areas in the study will support the training organizing institutes to redesign their training programmes with the identified training areas in an effective way rather than to conduct trainingson routinetopics. To conclude, training the agri input dealers with right kind of training content at right time will strengthen the Para-Extension System.

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# PRODUCTION AND MARKETING OF SUGARCANE IN VISAKHAPATNAM DISTRICT OF ANDHRA PRADESH

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## ABSTRACT

The production and marketing of sugarcane cultivation have been studied in Visakhapatnam district of Andhra Pradesh during 2018-19. The results revealed that cost of cultivation was high for plant crop than the ratoon farming with the benefit-cost ratio of 1.10 for plant crop and 1.30 for ratoon crop. Net income for the plant crop was Rs.34735/- and Rs.41898/- for the ratoon. The coefficients human labour (0.73), manure (0.25) and seed rate (0.39) were showing positive significant effect on output and plant protection chemicals (-0.08) showing negative significant effect on output. The price spread analysis for the selected channel indicated that the producer received 70.83 per cent of consumer's price in channel 1 (sugar), 81.43% in channel 2 (jaggery). Total marketing cost was highest for channel 1 (34.30%) than the channel 2 (18.80%). The index of marketing efficiency was high for channel 2 *i.e.* 3.33 as compared to 1.06 for channel 1.

**Key words:** Sugarcane, cost concepts, input use efficiency, price spread

## INTRODUCTION

India ranks second in the world in sugarcane production after Brazil. In India sugarcane was cultivated in an area of 4.73 million ha with production of 376.90 million tonnes and with the productivity of 79.65 tonnes ha$^{-1}$ during 2017-18. Sugarcane is one of the important cash crops in Andhra Pradesh, constituting about 0.10 million ha of cultivated area with an overall production of 7.95 million tonnes and yield of 80.283 tonnes ha$^{-1}$ during the year 2017-18 (GoI, 2018). The major districts growing sugarcane in Andhra Pradesh, are Visakhapatnam, West Godavari and Krishna. Visakhapatnam ranks first in terms of area (0.5 lakh ha.) and production (2.0 MT) of sugarcane in Andhra Pradesh during the year 2017-18. Two major sugarcane-based industries in Visakhapatnam are sugar and jaggery with, both the industries having their own peculiar characters. The study was conducted to know the production and marketing situation with objectives, to work out costs and returns in cultivation of sugarcane, analyse the input use efficiency of sugarcane, and to identify the marketing margins and price spread of sugarcane cultivation. Rao (2017) studied about price spread of sugarcane jaggery farmers and the producers share in consumer's rupee and marketing efficiency in Value chain I and II reported as 67.94, 73.10 and 2.72 and 2.12, respectively. Peerzado *et al.* (2016) studied economic assessment of sugarcane production and its marketing constraints in

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Sindh, Pakistan. Production cost of Rs. 171631/- per ha and net returns of Rs. 368369 per ha. Krishnakant *et al.* (2015) studied cost of cultivation of sugarcane crop and the results revealed that the cost of cultivation of plant and ratoon sugarcane crop were found to be Rs. 172679/- per ha and Rs. 129753/- per ha respectively in the Meerut district of Uttar Pradesh. Ogwang (2009) used Cobb-Douglas production function to determine factors affecting sugarcane productivity. The results indicated that sugarcane acreage (farm size), amount of labour used and the fertilizer usage were positive and statistically significant.

## MATERIAL AND METHODS

The production and marketing of sugarcane cultivation was studied in Visakhapatnam district of Andhra Pradesh for the period of 2018-19 by collecting the data on costs and returns, marketing channels, etc. A multi-stage random sampling technique was adopted for selecting sampling units at various levels. In 1st stage, Andhra Pradesh is selected, in 2nd stage, Visakhapatnam district was selected as it is highest sugarcane producing district. In 3rd stage, three mandals were selected in Visakhapatnam district *viz.,* Madugula, Chodavaram and Anakapalle as sugarcane production was highest in these mandals. In 4th stage of sampling, 20 respondents were selected from each mandal and total 20 traders were also selected randomly from all the three mandals making total sample size 80 respondents.

**Cost of Cultivation:** The different cost concepts used are $A_1$, $A_2$, $B_1$, $B_2$ and $C_1$, $C_2$ & $C_3$ based on these cost concepts the production cost of sugarcane was calculated.

Cost $A_1$ = All actual expenses incurred in production by owner operator

Cost $A_2$ = Cost $A_1$ + rent paid for leased in land

Cost $B_1$ = Cost $A_2$ + interest on fixed capital (excluding land)

Cost $B_2$ = Cost $B_1$ + imputed rental value of owned land

Cost $C_1$ = Cost $B_1$ + imputed value of family labour

Cost $C_2$ = Cost $B_2$ + imputed value of family labour

Cost $C_3$ = Cost $C_2$ + 10per cent of Cost $C_2$ (As managerial cost)

**Cobb-Douglas production function:** This was fitted for the estimation of elasticities of important variables contributing to the yield of sugarcane.

$$Y = a\, X_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} X_5^{b5}$$

Where, Y - Yield (kg.)

$X_1$ - Human labour (human-days)

$X_2$ - Manure (kg.)

$X_3$ - Fertilizers (kg.)

$X_4$ - Plant protection chemicals (L)

$X_5$ - Seed rate (kg.)

**Producer's share in Consumer's Rupee:** It is the price received by the farmers expressed as a percentage to the retail price (*i.e.* price paid by consumer). If $P_r$ is the retail price and $P_f$ is the producer price then the producer's share in consumer rupee $P_s$ may be expressed as: $P_S = \frac{P_f}{P_r} * 100$

**Marketing Margin of Middlemen:** This is the difference between the total payment (cost + purchase price) and receipts (sale price) of middlemen (i^th^ agency).

Percentage margin of i^th^ middleman = $\frac{P_{R_i} - (P_{P_i} + C_{m_i})}{P_{R_i}} * 100$

Wherein, $P_{Ri}$ = Total Value of receipts per unit (sale price)

$P_{Pi}$ = Purchase value of goods per unit (purchase price)

$C_{mi}$ = Cost incurred on marketing per unit.

**Total Cost of Marketing:** The total cost incurred on marketing of sugarcane by the farmers and intermediaries involved in the process of marketing was computed as:

$C = C_F + C_{M1} + C_{M2} + C_{M3} + \ldots\ldots\ldots\ldots\ldots + C_{Mn}$

Wherein, C = Total cost of marketing

$C_F$ = Cost incurred by producer in the marketing of sugarcane

$C_{M1}$ = Cost incurred by the middlemen in the market of sugarcane

Marketing margin for the adopted marketing channel was worked out by comparing the prices prevailing at successive stages of marketing. The used prices were related to a particular point of time and the channels involved in the study are: Producer- Sugar factory- Wholesaler- Retailer- Consumer and Producer- Processor (Gur)- Wholesaler- Retailer- Consumer.

**Marketing Efficiency:** Shephard (1970) has suggested the ratio for calculating marketing efficiency. The decision rule was higher the ratio, higher the efficiency and vice-versa.

$M.E. = \frac{V}{I} - 1$

Wherein, V= value of goods sold (consumer's price)

I = Total marketing cost

M.E. = Index of marketing efficiency

## RESULTS AND DISCUSSION

### Costs and returns in cultivation of sugarcane

The operational cost has been presented for plant and for ratoon. The operational cost for ratoon crop (Rs. 83,302/-) found less when compared to plant crop (Rs. 1,42,945/-) because preparatory cultivation and planting charges are very less in the ratoon crop as compared to plant crop (Chinnappa, 1998).

Harvesting costs are higher for the sugarcane crop up to 18% to 20 per cent of the total operational cost are from harvesting operation only. The operational cost on the cultivation of sugarcane was increased over years due to increased labour wages and seed cost similar result for operational costs was recorded by Pusappa (2013). The total cost of cultivation was found to be Rs. 1,71,205/- for plant and Rs. 1,03,501/- for ratoon crop. Human labour contributes 28 per cent to total costs for planted, and for ratoon 26 per cent, seed cost contributes 16 per cent to total cost for planted 2.06 per cent for ratoon. Total fixed capital Rs.40669/- for plant and Rs.40,565/- for ratoon crop (Table 1).

**Table 1. Comparison of costs of cultivation of plant and ratoon sugarcane in 2018-19 (Rs. ha$^{-1}$)**

| | Particulars | Plant crop contribution | per cent crop | Ratoon contribution | per cent |
|---|---|---|---|---|---|
| 1. | Hired human labour | 37182 | 22 | 16844 | 16 |
| 2. | Imputed value of family labour | 11320 | 7 | 9800 | 9 |
| 3. | Seed cost | 27000 | 16 | 2140 | 2 |
| 4. | Animal power | 1800 | 1 | 4000 | 4 |
| 5. | Machine power | 7200 | 4 | 0 | 0 |
| 6. | Manures and fertilizers | 14381 | 8 | 9940 | 10 |
| 7. | Plant protection | 2715 | 2 | 2715 | 3 |
| 8. | Irrigation | 9750 | 6 | 6520 | 6 |
| 9. | Interest on working capital | 2922.89 | 2 | 1212 | 1 |
| 10. | Total operational cost | 114271 | 67 | 53171 | 51 |
| 11. | Rental value of owned land | 36000 | 21 | 36000 | 35 |
| 12. | Depreciation | 297 | 0.2 | 244 | 0.2 |
| 13. | Interest on fixed capital | 3697 | 2 | 3688 | 4 |
| 14. | Total fixed capital | 40669 | 24 | 40565 | 39 |
| 15. | Grand Total (Rs.) | 154940 | 90 | 93735 | 91 |
| 16. | Cost $A_1$ | 142648 | 83 | 83058 | 80 |
| 17. | Cost $A_2$ | 142648 | 83 | 83058 | 80 |
| 18. | Cost $B_1$ | 142945 | 83 | 83302 | 80 |
| 19. | Cost $B_2$ | 143620 | 84 | 83935 | 81 |
| 20. | Cost $C_1$ | 154265 | 90 | 93102 | 90 |
| 21. | Cost $C_2$ | 154940 | 90 | 93735 | 91 |
| 22. | Cost $C_3$ | 171205 | 100 | 103501 | 100 |
| | Yield (tonnes per ha.) | 70 | | 50 | |
| | Gross income (Rs.) | 189000 | | 135000 | |
| | Net income (Rs.) | 34735 | | 41898 | |
| | Benefit- cost ratio on operational cost | 1.32:1 | | 1.62:1 | |
| | Benefit- cost ratio on total cost | 1.10:1 | | 1.30:1 | |

The yields of sugarcane were stagnant for past two decades (hovering around 70-80 t $ha^{-1}$) (Rao, 2012). This has been mainly because a large area is under rainfed sugarcane wherein, the average yield is 50 t $ha^{-1}$. In the study area, the average yield of plant crop was 70 t $ha^{-1}$ and 50 t $ha^{-1}$ for ratoon. Total gross returns for sugarcane farmers was Rs. 1,89,000/-in plant crop and Rs. 1,35,000/- in ratoon crop per ha. The cost of production per tonne was Rs.2,446/- for plant and Rs.2,070/- for ratoon crop. Benefit cost ratio on operational cost for plant is 1.32 and for ratoon crop is 1.62. Benefit cost ratio on total cost for plant is 1.10 and for ratoon was 1.30. Total net income against total cost was Rs. 34,735/- and for ratoon crop was Rs. 41,898/- per ha.

**Input use efficiency of sugarcane**

The Cobb-Douglas production function was fitted For the estimation of elasticities of important variables contributing to the yield of sugarcane. (Table 2). The value of coefficient of multiple determinations ($R^2$) was found to be 0.78. Regression co-efficient associated with human labour, fertilizers, manures, seed rate and irrigation were positive and significant indicating that these resources contributed significantly to the output of this crop. However, plant protection chemicals did not enter as one of the significant variables in sugarcane cultivation. The negative and significant co-efficient of plant protection chemicals indicated that these farms are using this input in excess quantity.

**Table 2. The input use efficiency of sugarcane**

| Sl.No. | Particulars | Parameter | Coefficients |
|---|---|---|---|
| 1. | Intercept | A | 2.22 |
| 2. | human labour (human-days) | $X_1$ | $0.73^{**}$ (0.13) |
| 3. | Manure (kg.) | $X_2$ | $0.25^{*}$ (0.05) |
| 4. | Fertilizers (kg.) | $X_3$ | 0.269 (0.09) |
| 5. | plant protection chemicals (L) | $X_4$ | $-0.08^{**}$ (0.10) |
| 6. | Seed rate (kg.) | $X_5$ | $0.39^{*}$ (0.05) |
| 7. | Irrigation (no.) | $X_6$ | 0.43 (0.29) |
| 8. | R Square | | 0.78 |

**Note:** * and ** indicate significance at 1per cent and 5per cent, respectively; Figures within the parentheses are standard errors for the respective regression coefficients.

The results showed that for every unit increase in human labour, manure, fertilizers, seed rate and irrigation, the yield per ha increases by 0.73%, 0.25%, 0.269%, 0.39%, 0.43%, respectively and for a unit increase in plant protection chemicals the yield decreased by 0.08 %.

**Marketing margins and Price spread of Sugarcane cultivation**

In marketing of sugarcane two main products *viz.,* sugar and jaggery are involved. The marketing margins of producers and other marketing intermediaries are quantified along with the existing two marketing channels for sugarcane (Rao and Kumar, 2005). In the first channel (channel 1) the main players are producers, sugar factory, wholesalers, retailers and consumers. In the second channel (channel 2) the players are producers cum processor (gur), jaggery wholesalers, retailers and consumers.

**Table 3. Price spread per quintal of sugar in Visakhapatnam district for Channel-I**

| S. No. | Particulars | Cost (Rs.) | Per cent to Consumer's rupee |
|---|---|---|---|
| 1 | Cost incurred by producer | | |
| i. | Weighing, loading and unloading | 50 | 1.38 |
| ii. | Transportation | 100 | 2.77 |
| iii. | Miscellaneous charges | 30 | 0.83 |
| | Total | 180 | 4.98 |
| | **Net sale price to producers** | **2550** | **70.83** |
| 2. | Cost incurred by sugar factory | | |
| i. | Weighing, loading and unloading | 50 | 1.38 |
| ii. | Transportation | 150 | 4.00 |
| iii. | Production cost of sugar preparation | 400 | 22.20 |
| | Total | 600 | 16.66 |
| | **Net sale price to Sugar factory** | **2700** | **75.00** |
| 3. | Costs incurred by wholesaler: | | |
| i. | Weighing, loading and unloading | 50 | 1.38 |
| ii. | Transportation | 100 | 2.77 |
| iii. | Storage | 50 | 1.38 |
| iv. | Miscellaneous (packing material, GST and labour cost) | 25 | 0.69 |
| | Total | 225 | 6.25 |
| | Wholesaler's market margin | 275 | 7.64 |
| | **Wholesaler's sale price/retailer's purchase price** | **3200** | **88.88** |
| 4. | Costs incurred by retailer: | | |
| i. | Cost of packing | 50 | 1.38 |
| ii. | Transportation | 80 | 2.22 |
| iii. | Miscellaneous charges | 100 | 2.77 |
| | Total | 230 | 6.38 |
| | Retailer's margin | 170 | 4.72 |
| | **Retailer's sale price /Consumer's purchase price** | **3600** | **100** |
| | Total marketing cost | 1235 | 34.30 |

Producers share in consumer's rupee was found about 70.83 per cent in the channel-1 (Table 3). Producer incurred marketing cost of Rs. 180 for weighing, unloading and transportation. The total net sale price for producer was Rs. 2,550 per quintal of sugar. One tonne of sugarcane produces average one quintal of sugar. The cost incurred by sugar factory was Rs. 200 for transportation, loading and weighing and Rs. 400 for production cost of sugar which formed 16.66 per cent in consumer's rupee. The sugar factory sells sugar to wholesalers or brokers at Rs. 2700 per quintal sugar which formed 75 per cent in consumer's rupee. Wholesaler incurred marketing cost Rs.225 for weighing, loading and unloading, transportation, storage, taxes and packing which formed 6.25 per cent in consumer's rupee. Wholesaler sells produce to retailer at a cost of Rs.3200 including his margin Rs.275. Retailer incurred marketing cost Rs.230 which formed 6.38 per cent in consumer's rupee and his margin was Rs.170. The price paid by the consumer was Rs.3600 per quintal. In channel-1 total marketing cost for one quintal of sugar was Rs. 1235 which is 34.30 per cent in consumer's rupee.

Producer's share in consumer's rupee was 81.43 per cent in the channel-2 (Table 4). Producer incurred marketing cost of Rs. 424.5 per quintal for weighing, unloading, hamalies, commission to commission agents and transportation. The total net sale price for producer was Rs.3,420 per quintal of jaggery. One tonne of sugarcane produces on an average 100 kg to 130 kg of jaggery (Rao and Babu, 2012). The producer (farmer) sells jaggery to wholesalers in jaggery market yard in Anakapalle at price Rs. 3,420 per quintal. Wholesaler incurred marketing cost Rs.210 for weighing, loading and unloading, transportation, storage, which formed 5 per cent in consumer's rupee. Wholesaler sells jaggery to retailer at a cost Rs. 3,850 including his margin Rs.220. Retailer incurred marketing cost Rs.155 which formed 3.69 per cent in consumer's rupee and his margin was Rs. 195. The ultimate price received by the consumer was Rs. 4200. In case of channel-2 total marketing cost for per quintal of jaggery was Rs.789 which is 18.80 per cent in consumer's rupee.

**Table 4. Price spread per quintal of jaggery in Visakhapatnam district for Channel-2**

| S. No. | Particulars | Cost (Rs.) | Per cent to Consumer's rupee |
|---|---|---|---|
| 1. | Costs incurred by Producer | | |
| i. | i. Cost of gunny bags | 50 | 1.19 |
| ii. | ii. Weighing | 2.80 | 0.07 |
| iii. | iii. Hamalies | 9.30 | 0.22 |
| iv. | iv. Taxes if any | 73.6 | 1.75 |
| v. | v. Commission to commission agent | 138.8 | 3.30 |
| vi. | vi. Transportation | 150 | 3.57 |
| | Total | 424.5 | 10.11 |
| | **Producer's sale price** | **3420** | 81.43 |

Table 4 contd..

| S. No. | Particulars | Cost (Rs.) | Per cent to Consumer's rupee |
|---|---|---|---|
| 2. | Costs incurred by wholesaler | | |
| i. | Weighing, loading and unloading | 40 | 0.95 |
| ii. | Transportation | 70 | 1.67 |
| iii. | Storage | 50 | 1.19 |
| iv. | Miscellaneous (packing material and labour cost) | 50 | 1.19 |
| | Total | 210 | 5.00 |
| | Wholesaler's margin | 220 | 5.24 |
| | **Wholesaler's sale price/retailer's purchase price** | **3850** | 91.67 |
| 3. | Costs incurred by retailer | | |
| i. | Cost of gunny bags | 80 | 1.90 |
| ii. | Transportation | 50 | 1.19 |
| iii. | Miscellaneous charges | 25 | 0.60 |
| | Total | 155 | 3.69 |
| | Retailer's margin | 195 | 4.64 |
| | **Retailer's sale price /Consumer's purchase price** | **4200** | 100 |
| | Total marketing cost | 789.50 | 18.80 |

**Table 5. Indices of marketing efficiency in the selected channels**

| Particulars | Channel-1 | Channel-2 |
|---|---|---|
| 1. Value of goods sold (V)/ Net price received by farmer | 2550 | 3420 |
| 2. Consumers purchase price | 3600 | 4200 |
| 3. Marketing cost (I) | 1235 | 789.5 |
| 4. Index of marketing efficiency | 1.06 | 3.33 |

From the Table 5 it can be observed that channel-2 was efficient than channel-1. The low producers net price, higher marketing cost and margins in channel-1 to leads to inefficiency in marketing process. Similar results were recorded by Kavitha (2014) in her study on supply chain management of jaggery in Anakapalle region and observed that jaggery marketing channel had marketing efficiency of 3.33.

## CONCLUSION

The total cost of cultivation was found to be more for plant crop of sugarcane than ratoon crop. The reason might be due to high cost incurred on inputs such as seed material and fertilizers in the planted crop. Net income was more for ratoon crop. Plant protection chemicals had negative impact on the production. Channel-1 for sugar was less efficient with a value of marketing efficiency of 1.06 were as for channel-2 for jaggery it was 3.33. Producer's share in consumer's rupee for sugar producing farmer was 70.83 per cent and for jaggery farmer it was 81.43 per cent.

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**Research Note**
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# TYPES OF TENANCY FARMING IN ANDHRA PRADESH - AN INVENTORY

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In agricultural production system tenant farming is an agreement between the landowner and the tenant for farm production in a particular piece of landfor a fixed period of time for which the tenant will pay land lease rent. Based on the agreement, land owner contributes his land while the tenant contributes labour.The other resources required for farming namely, water, capital, inputs, etc are optional on the part of landowner to contribute as per the contract made between them. The land lease rent is paid in terms of cash or kind or both. However, there are several patterns of dynamics between the landowners and tenants. According to the CESS Report there are about 13,48,035 tenant farmers in A.P. (Revathi, 2014). To understand the dynamics of tenant farming it is important to know the type of tenancy. Tenancy is a binding contract between the land owner and the tenant which sets out the terms and conditions of tenancy and what type of tenancy it is; whether it is a fixed term or periodic (annual or seasonal). To reduce the chances of disputes or issues at a later stage, it is wise to closely discuss and scrutinize the tenancy agreement whether oral/documented before they come into contract. To make sure the obligations of tenancy, the rules and conditions the tenant must adhere to, need to be understood. At this juncture a study was conducted to know the existing tenancy types in Krishna district of Andhra Pradeshduring 2016-2018.

As a prelude of measure of tenancy types, a list of possible tenancy types that can go into the inventory was prepared consulting the literature, extension personnel and tenant farmers. These tenancy typeswere given to 40 judges who included land owners who leased-out their lands, tenant farmers and extension personnel working closely with tenant farmers to judge. The procedure followed by Jyothi *et al.* (2012) was adopted in developing the inventory on tenancy types. The judges were asked to rate the relevancy of tenancy types for the preparation of inventory based on their importance on a three point continuum *viz.,* most relevant, relevant and least relevant. They were requested to feel free to add some more tenancy type areas, if they feel important, and also delete unrelated tenancy types. After the responses were obtained, they were given scores as 3 for most relevant, 2 for relevant and 1 for least relevant tenancy type area.

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After giving scores to the tenancy types and coding the data, mean was calculated for each tenancy type. Finally, the weighted mean (2.345) of all tenancy types was obtained. The tenancy types, which were having a mean above the weighted mean, were retained in the inventory of tenancy types. The list of tenancy types selected with their mean values are given in Fig. 1.

The validity of the inventory on tenancy types was obtained through content validity method. The tenancy types selected for the inventory were evaluated individually and as a whole by the judges. These were again checked by experienced land owners who leased-out their lands and tenant farmers for their relevance and coverage. It was felt by them that all the items were relevant and covered entire tenancy types which are under implementation. Hence, it is reasonably assumed that the inventory on tenancy types has content validity.

For calculating the reliability, test-retest method was employed. The questionnaire covering thetenancy types were administered to 40 tenant farmers.After a lapse of 30 days, they were again administered in the form of questionnaire. The coefficient of reliability was calculated between the first and the second administered scores. The coefficient of reliability was fairly high (0.859) and was significant at 0.01 per cent level of probability thereby showing that the measurement was reliable.

The inventory developed consisted of different types of tenancy classified based on various criteria. Based on the agreement, there are two types of tenancy namely oral and documented. In most of the cases oral tenancy is observed but tenancy security is important hence, it need to be documentedas supported by Alarima *et al.* (2012);Damodaran (2011); Kiranmayi and Vijayabhinandana (2015).

Based on the duration of tenancy there are seven types namely seasonal, annual, biennial, short term (3 years), medium term (4-5 years), long term (5-8 years), very long term (> 8 years). The tenure of tenancy is very important.The duration of tenure determines whether the tenant need to invest on durable inputs or not [Kiranmayi and Vijayabhinandana (2015); Naveen and Hua (2019)].

Based on the size of the lease-in land there are five types of tenancy namely marginal (upto 1 ha), small (1-2 ha), medium (2-4 ha), large (4-6 ha) and very large (> 6 ha). The size of the lease-in land determines the capacity of the tenant to farm and inturn reflects his financial, needs.Based on availability of irrigation there are two types of tenancy namely rainfed (without bore) and irrigated (with bore). This in turn reflects on the returns that are expected from the lease-in land.

Based on inheritance there are two types of tenancy namely inherited tenancy and non-inherited tenancy.Endowment lands are taken on lease for long term, such lands are ploughed

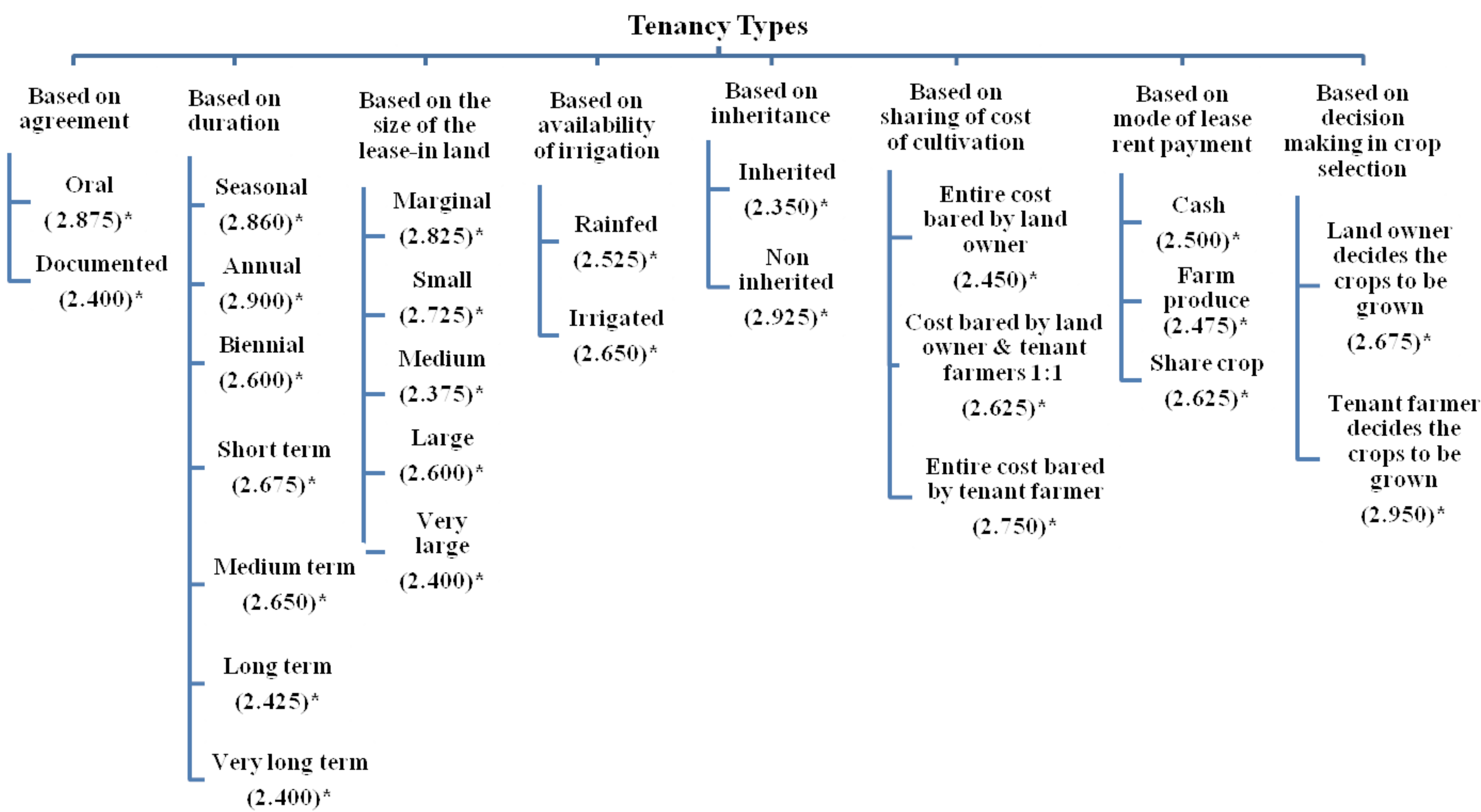


**Fig. 1. Schematic representation of tenancy type**

**Note:** *Figures in parenthesis indicate tenancy types whose mean is greater than the weighted mean by fore fathers, fathers and even their sons, hence, it is inherited. The lands leased for short term are non-inherited.

Based on sharing of cost of cultivation there are three types of tenancy namely entire cost of cultivation borne by land owner, cost of cultivation borne by land owner and tenant farmers in the ratio of 1:1 and entire cost of cultivation bared by tenant farmer. The mode of land lease rent payment is as per the requirement, convenience of land owner and capacity of tenant farmer. The findings are in line with Damodaran (2011).

Based on mode of lease rent payment tenancy is divided into cash payment, payment in the form of farm produce and as share crop. The findings are in line with that reported by Alarima *et al.* (2012) as cash and produce.Prasad *et al.* (2012) suggested as fixed rent, sharecrop and both.Kiranmayi and Vijayabhinandana (2015) reported as cash, kind and cash & kind.Islam and Maharjan (2014) found asshare cropping, leasing, mortgaging. Mahanakumar (2014) suggested as cash paid in two installments.

Cash payment is further divided into three types as entire land lease rent paid in advance, half cash paid in advance and remaining half paid after crop harvest and entire land lease rent paid after crop harvest.Land lease rents has to be paid in advance as reported by Vijayabhinandana *et al*. (2018).Fixed-rate rent is becoming more common in the regions with absentee landlordism, as it requires less supervision by the landlord, and sharecropping remains prevalent in areas where landlords are local as found by Sugden (2014). Share tenancy, fixed seasonal rent, lease arrangement and land on mortgage are suggested by Mahabub *et al.* (2014). In short, fixed-rent tenancy assumed risks to be borne solely by the tenant, who pay a fixed amount of rent, regardless of the quantity of harvest; but the tenants could make their own decisions and reduce risks through irrigation facilities, better seeds, improved pest control and better farming techniques. Thus, fixedrent tenancy, especially fixed-rent in cash equivalent, was found to becommon and more popular as reported by Phan and Akimi (2012). Share rent tenancy and fixed rent tenancy were reported by Suyanto (2001).

Sharecrop is further divided into three types as land lease rent paid in terms of cash and farm produce in 3:1 ratio, land lease rent paid in terms of cash and farm produce in 1:1 ratio and land lease rent paid in terms of cash and farm produce in 1:3 ratio. This arrangement could be accounted to the understanding between the land owner and tenant.Based on decision making in crop selection tenancy is divided into two types as land owner decides the crops to be grown on leased land and tenant farmer decides the crops to be grown on leased land. This could be accounted to the agreement between the land owner and tenant.

The types of tenancy need to be paid special and extra attention to study tenant farming. It tells about what a tenant can and can't do, what the land owner expects from the tenant, how long the tenancy would last for and whether or not any additional facilities like irrigation source, etc are given to the tenant on additional land rent. The tenancy type also tells us about the landlord preference to receive rental payments.

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**Research Note**
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# SCREENING OF GENOTYPES OF *Setaria italica (*L.*)* AGAINST RUST DISEASE UNDER FIELD CONDITIONS DURING *RABI* SEASON

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India is the world's largest producer of millets, harvesting about 11 million tons per year, nearly 40 percent of the world's output. Foxtail millet [*S. italica* (L.) P. Beauv] is the second-largest crop among the millets, cultivated for food in semi-arid tropics of Asia and as forage in Europe, North America, Australia, and North Africa (Austin, 2006). Millets are nutritious, non-glutinous, digestible, not acid-forming and compared to rice. Millets release a lesser percentage of glucose over a longer period which lowers the risk of diabetes. Millets are particularly high in minerals such as iron, magnesium, phosphorous and potassium (Michael Raj and Shanmugam, 2013).

Rust disease is common on foxtail millet and has also been reported in Europe, Asia and Africa. In India, it is known to be rampant in states such as Maharashtra, Madhya Pradesh, Tamil Nadu, Karnataka, Andhra Pradesh, Bihar, and Uttarakhand. In severe form, yield losses may vary from 30% - 40%. In case of susceptible variety or under epidemic conditions, yield loss would be still more. Recently, the cultivation of foxtail millet is also being extended to *rabi* and summer seasons. In both these conditions, rust occurs in severe form and more or less the only disease during *Rabi* and summer which is causing considerable yield and quality losses. It can occur in epiphytotic form during certain years and results in extensive losses in yield.Though rust can affect the crop at all the stages, the harm is more when disease occurs sooner than flowering. A large number of minute uredosori which are brown in colour are seen on upper as well as lower surface of the leaf. Spores repeatedly arranged in linear rows, but invade almost the entire leaf blade in seriously infected leaves. Spores can also be seen on the leaf sheath, culms and stem. Early drying of leaves and poor grain set occurs as a result of severe infection. Results of researchers indicated that rust incidence reduced the grain yield, ear head and grain weight per plant and 1000 grain weight and also affects the quality of forage. Sharma *et al.* (2014) reported a reduction in crude proteins, phosphorus and potassium in leaves owing to this disease. Therefore, the investigation was proposed to screen 15 genotypes of foxtail millet against rust.

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The field experiment was conducted to find out the resistance/susceptible sources against rust during *rabi* season, 2017 with 15 entries received from the PC unit of AICRP on Small Millets, Bengaluru. These entries were sown in Randomized Block Design and replicated thrice at Regional Agricultural Research Station, Nandyal. Each entry was sown in two rows of 3m length with a spacing of 22.5 cm X 7.5 cm. Each entry was sandwiched with the susceptible check (Prasad). Sowing of test entries was taken up during the 2$^{nd}$ fortnight of October, 2017. Observations were recorded at grain development stage for rust symptoms on leaves. The resistance or susceptibility of the test genotypes to rust disease was assessed using 1-9 rating scale (AICRP on Small Millets, 2018). Severity of rust was scored as per the 0-9 disease rating scale.

**Incidence of Rust: Standard evaluation system scale for rust**

| Score | Description | Reaction |
|---|---|---|
| 0-1 | Pinhead flecks with no sporulation | R |
| 1.1-3 | Small scattered erumpent pustules with little sporulation | MR |
| 3.1-5 | Clear many erumpent pustules containing numerous spores | MS |
| 5.1-7 | Many coalescing pustules covering < 50% leaves | S |
| 7.1-9 | Many coalescing pustules covering most (>50%) leaves | HS |

The study of rust incidence in the experiment revealed that none of the 15 entries were free of rust. All the test entries have been affected by the disease even under natural conditions. Genotypes exhibited rust which varied from grade 5.2 (SiA 326) to 8.6 (DHFT 2-5-3). Seven entries *viz.,* DHFT 5-6, DHFT 77-3, PKS 22, SiA 3212, SiA 3219, DHFT 35-3, DHFT 2-5-3 have more incidence of rust with highly susceptible reaction. Whereas, entries *viz.,* SiA 3179, PPSS-7, SIA 3220, TNSi 337, TNSi 345, IIMR FTM-1, SiA 326, SiA 3156 have shown susceptible reaction. Among all the highly susceptible genotypes, rust scored from 7.7 (PKS22) to 8.6 grade (IIMR FtM-1). Among the eight susceptible genotypes, rust ranged from 5.2 grade (SiA 326) to 6.6 grade (TNSi 345).

The genotypes of the study could not be considered as possible sources for disease resistance in breeding programme for development of rust resistant foxtail millet variety. Rajesh *et al.* (2019) also observed that SiA 3163 genotype has shown a highly susceptible reaction to rust with the grade of 7.67. Sharma *et al.*(2014) assessed 154 accessions of foxtail millet's for blast resistance under field conditions and reported 34 as resistant and 96 as moderately resistant during 2009 whereas, in 2010, the number of accessions in the resistant and moderately resistant categories was 46 and 65, respectively. Waqas *et al. (*2018) found 12 lines of wheat as moderately resistant to rust and 35 lines were in the range of resistant to moderately resistant. Arain *et al.* (2017) screened wheat genotypes and found that NIA-10/8 and ESW-9525 were resistant against all three rusts at different locations.

**Table 1. Disease rating scale and disease reaction for rust disease in *Setaria italica* genotypes during *rabi* season of 2017**

| S.No. | Entry | Score for rust( Grade) | Reaction |
|---|---|---|---|
| 1 | DHFT 5-6 | 8.4 | HS |
| 2 | SiA3179 | 5.8 | S |
| 3 | DHFT 77-3 | 8.4 | HS |
| 4 | PPSS-7 | 6.2 | S |
| 5 | PKS 22 | 7.7 | HS |
| 6 | SiA 3220 | 6.0 | S |
| 7 | TNSi 337 | 6.2 | S |
| 8 | SiA3212 | 7.8 | HS |
| 9 | SiA3219 | 8.4 | HS |
| 10 | TNSi 345 | 6.6 | S |
| 11 | DHFT 35-3 | 7.8 | HS |
| 12 | DHFT 2-5-3 | 8.6 | HS |
| 13 | IIMR FtM-1 | 6.0 | S |
| 14 | SiA326 | 5.2 | S |
| 15 | SiA3156 | 5.8 | S |

Among all the 15 test entries of the foxtail millet screened during *Rabi* season of 2017, none of the entries exhibited resistant reactions. All the entries were evaluated as susceptible to highly susceptible under high disease pressure occurred under natural screening. Hence, they cannot be recommended for rust liable fields and for breeding programme of rust resistant variety.

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