Diversification of Cropping Systems for Different Integrated Farming System Models under Irrigated Situation of Southern Telangana Zone, Telangana, India

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Authors’ contributions

This work was carried out in collaboration among all authors. Author CPK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MG and GKR managed the analyses of the study. Authors KN, SHKS, AAQ, MA and KC managed the literature searches. All authors read and approved the final manuscript.

ABSTRACT

A long-term field experiment was undertaken during the year 2019-20 (third year of the experiment) at college farm, AICRP on Integrated Farming Systems unit, PJTSAU, Hyderabad to evaluate productivity and profitability of cropping systems for different farming systems under irrigated situation on a sandy loam soil of Southern Telangana Zone (STZ), Telangana. Among the ten cropping systems evaluated, sweet corn – vegetable system (tomato) was found to be more remunerative with B:C ratio 3.30 followed by okra – marigold – beetroot system with B:C ratio 3.0. Among the ecological cropping systems for improving soil health, pigeonpea + greengram (1:7) –
systems to solve the problem of fodder scarcity. Fodder sorghum and fodder maize in cropping systems are practiced more than crops alone. Income is far higher when integrated farming systems are adopted on a farm, which is supposed to increase food production. It involves interaction with farm resources, other farm enterprises and available technology, which determine their make-up [1]. The sustainability of Indian agriculture is being threatened by sharp declining factor productivity due to deteriorating soil quality, imbalanced use of fertilizers and escalating cost of production [2]. The food production must keep pace with the country’s increasing population, demanding not only the food security but also nutritional security. Therefore, to achieve sustainability and productivity, efforts must be focused on reversing the trend in monoculture by adopting efficient cropping systems. Hence, sustainable increase in crop yields is needed to ensure food security in India. Increasing population and shrinking land resources are exerting considerable pressure on land resource due to intensive cultivation. Over exploitation of land resources is leading to degradation of soil rapidly. It is also a fact that highly productive lands have been diverted from agriculture to infrastructural development, urbanization, and other related activities. Under these circumstances, the only viable option is to enhance the productivity vertically to meet the production goals [3]. Therefore, there is an urgency to adopt crop diversification and different inter-cropping systems is the fastest way of sustaining productivity, yet ever increasing energy costs, limit input availability and enhance farmers income. Several workers [4] and [5] in the recent past reported that the productivity and income is far higher when integrated farming systems are practiced than crops alone. About 91.1 million tonnes of green fodder is required to meet the basic demand of 40 kg green fodder per adult animal per day [6]. So, there is need of inclusion of crops like fodder cowpea, sunhemp, fodder sorghum and fodder maize in cropping systems to solve the problem of fodder scarcity. sesame cropping system recorded higher BC ratio (2.02) compared to Bt cotton + green gram (1:3) – groundnut cropping system (1.78). Out of the two systems evaluated to meet the household nutritional security, pigeon pea + groundnut (1.7) – finger millet system recorded higher BC ratio (1.85) compared to pigeon pea + maize (1:3) – groundnut. Within the two fodder crops/cropping systems, fodder maize – Lucerne system resulted in higher B:C ratio (1.65).

Keywords: Cropping systems; rice grain equivalent yield (RGEY); system productivity and system profitability.

1. INTRODUCTION

Cropping system is an important component of a farming system representing a cropping pattern adopted on a farm, which is supposed to increase food production. It involves interaction with farm resources, other farm enterprises and available technology, which determine their make-up [1]. The sustainability of Indian agriculture is being threatened by sharp declining factor productivity due to deteriorating soil quality, imbalanced use of fertilizers and escalating cost of production [2]. The food production must keep pace with the country’s increasing population, demanding not only the food security but also nutritional security. Therefore, to achieve sustainability and productivity, efforts must be focused on reversing the trend in monoculture by adopting efficient cropping systems. Hence, sustainable increase in crop yields is needed to ensure food security in India. Increasing population and shrinking land resources are exerting considerable pressure on land resource due to intensive cultivation. Over exploitation of land resources is leading to degradation of soil rapidly. It is also a fact that highly productive lands have been diverted from agriculture to infrastructural development, urbanization, and other related activities. Under these circumstances, the only viable option is to enhance the productivity vertically to meet the production goals [3]. Therefore, there is an urgency to adopt crop diversification and different inter-cropping systems is the fastest way of sustaining productivity, yet ever increasing energy costs, limit input availability and enhance farmers income. Several workers [4] and [5] in the recent past reported that the productivity and income is far higher when integrated farming systems are practiced than crops alone. About 91.1 million tonnes of green fodder is required to meet the basic demand of 40 kg green fodder per adult animal per day [6]. So, there is need of inclusion of crops like fodder cowpea, sunhemp, fodder sorghum and fodder maize in cropping systems to solve the problem of fodder scarcity. In view of this farming system perspective, inclusion of ecological cropping system for improving soil health, cropping systems to meet the household nutritional security, cropping systems for round the year green / dry fodder production and cropping systems involving vegetables and other high value crops are to be studied for their productivity and sustainability. Hence, the present study was undertaken.

2. MATERIALS AND METHODS

The study was conducted at college farm of All India Coordinated Research Project on Integrated Farming Systems, Professor Jayashankar Telangana Sate Agricultural University, Rajendranagar during 2019-2020. The soil of the experimental field was sandy loam soil. The experiment was laid out with ten cropping systems as treatments in Randomized Block Design (RBD) with three replications. The ten combinations of cropping sequence tested were T₁: Rice – Maize, T₂: Bt cotton – Fallow, T₃: Bt cotton + Greengram (1:3) – Groundnut, T₄: Pigeon pea + Greengram (1:3) – Sesame, T₅: Maize + Pigeon pea (1:3) – Groundnut, T₆: Pigeon pea + Groundnut (1:7) – Ragi, T₇: Fodder sorghum + Fodder cowpea (1:2) – Horsegram – Sunhemp, T₈: Fodder maize – Lucerne, T₉: Sweet corn – Vegetables (Tomato) and T₁₀: Bhendi – Marigold – Beetroot during kharif and rabi seasons respectively. Each treatment was allocated randomly initially and replicated three times. All the crops in different cropping systems were raised in accordance with recommended package of practices. Crop sequences during rabi were taken up as and when the preceding kharif crops were harvested in the respective plots. Economic yield and stover/straw/stalk yield were recorded individually for all the crops in cropping systems. For comparison of different crop sequences, the yields of all the crops were converted to rice grain equivalent yield on price basis.
Rice equivalent yield (REY) was calculated as follows:

\[
\text{REY (kg ha}^{-1}\text{)} = \frac{\text{Economical yield of a crop}}{x \text{ Price (Rs kg}^{-1}\text{) of same crop \text{ e.g. wheat/Price (Rs kg}^{-1}\text{) of rice}}}
\]

The economic analysis of the experiment was carried out by taking into consideration the prevailing prices of inputs used and the outputs realized. The cost of cultivation of different crops individually has been calculated. The yields of different crops in various cropping systems were converted into gross returns in rupees. Net returns for each cropping system were calculated by deducing cost of cultivation from gross returns. B: C ratio was also calculated for each cropping system. The various formulae used are given below:

\[
\text{Net returns (Rs ha}^{-1}\text{)} = \text{Gross returns (Rs ha}^{-1}\text{)} - \text{Cost of cultivation of crop (Rs ha}^{-1}\text{)}
\]

\[
\text{B:C ratio} = \frac{\text{Net return (Rs ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs ha}^{-1}\text{)}}
\]

### 2.1 Data Analysis and Statistics

The experimental data was analysed by adopting RBD statistical tool and analysis of variance was worked out as suggested by Rao [7].

### 3. RESULTS AND DISCUSSION

#### 3.1 Productivity and Economics of Crops and Cropping Systems

The performance of different high value crops in terms of rice grain equivalent yield during kharif 2019 indicated that sweet corn recorded significantly higher rice grain equivalent yield (9005 kg ha\(^{-1}\)) over other field and vegetable crops evaluated in different cropping systems (Table 1). Sweet corn and okra were tested under cropping systems involving high value crops and sweet corn (9005 kg ha\(^{-1}\) and Rs.1,09,727 net returns) was found to be more remunerative than okra (6884 kg ha\(^{-1}\) with 82,420 Rs ha\(^{-1}\) net returns). Among the ecological cropping systems for improving soil health, Bt cotton + Greengram (1:3) cropping system recorded significantly higher rice grain equivalent yield (7676 kg ha\(^{-1}\)) than Pigeon pea + Greengram (1:3) (6133 kg ha\(^{-1}\)) cropping system. However, because of lower cost of cultivation, Pigeon pea + Greengram (1:3) (6133 kg ha\(^{-1}\)) cropping system recorded higher net returns (Rs. 82,798) compared to Bt cotton + Greengram (Rs. 88,804). However, Bt cotton and pigeonpea yields were not influenced by different intercropping systems. This might be due the fact that after the harvest of inter crops, competition reduced thereby water and nutrient availability was not affected. Kumawat et al. [8] and Singh et al. [9] reported the similar results with different intercropping systems. Out of the two systems tested to meet the household nutritional security, both Pigeon pea + Maize (1:3) and Pigeon pea + Groundnut (1:7) systems were on par with each other and recorded almost similar rice grain equivalent yields of 7833 and 8801 kg ha\(^{-1}\) respectively. This might be due to the absence of competition between pigeonpea and intercrops for growth resources such as nutrients, moisture, solar radiation because maize and groundnut crops were harvested before flowering period of pigeonpea and groundnut being leguminous crop show no competition of resources. These results are close conformity with the findings of Kumar et al. [10]. Out of the two fodder crops, fodder sorghum + fodder cowpea (1:2) (4512 kg ha\(^{-1}\)) and fodder maize (4241 kg ha\(^{-1}\)) systems were on par with each other. Rice and Bt cotton were tested as pre-dominant cropping systems of the region and recorded almost similar rice grain equivalent yields with 5728 and 5885 kg ha\(^{-1}\) respectively. These results were supported by Pragathi Kumari et al. [11].

The performance of different crops in terms of rice grain equivalent yield during rabi and summer 2019-20 indicated that marigold followed by beetroot crop (T\(_{10}\)) recorded significantly higher rice grain equivalent yield (33934 kg ha\(^{-1}\)) over other crops evaluated in different cropping systems (Table 2). However, because of low cost of cultivation, tomato crop (T\(_{10}\)) recorded (14957 kg ha\(^{-1}\) with 227139 Rs ha\(^{-1}\) net returns and 4.80 BC ratio) and was found to be more remunerative than marigold followed by beetroot crop. These results are in line with that of Kharub et al. [12] who evaluated the relative productivity of six rice-based crop sequences at Karnal (Haryana) taking wheat as a cereal crop and observed that wheat equivalent yield was maximum (197.1-200.3 q ha\(^{-1}\)), with rice - potato - wheat system followed by rice - vegetable pea-wheat system (173.5-173.8 q ha\(^{-1}\)). They have also reported that these systems resulted in additional wheat equivalent yield of 48-71 q/ha over the rice-wheat system.

Among the ecological cropping systems involving pulses/green manures and other crops for
improving soil health, groundnut crop recorded significantly higher rice grain equivalent yield (6251 kg ha\(^{-1}\)) and net returns (74620 Rsha\(^{-1}\)) than sesame (2696 kg ha\(^{-1}\)) with net returns of 24523 Rs ha\(^{-1}\) crop. Out of the two systems tested to meet the household nutritional security, groundnut crop recorded significantly higher rice grain equivalent yield (7113 kg ha\(^{-1}\)) and net returns (90425 Rsha\(^{-1}\)) than ragi. Out of the two fodder crops, lucerne crop (2990 kg ha\(^{-1}\)) resulted in comparatively higher rice grain equivalent yield over horsegram followed by sunhemp crops, though both the systems were on par with each other. Rice – Maize was tested as pre-dominant cropping systems of the region and recorded rice grain equivalent yield of 5557 kg ha\(^{-1}\) with net returns of 66,235 Rsha\(^{-1}\). Pragathi Kumari et al. [13] have reported similar results on the study which was conducted with the same cropping systems.

Fig. 1. Intercropping of Bt cotton (1) with greengram (3)

Fig. 2. Identification of different cropping systems module for different farming systems experiment at AICRP on IFS unit

Fig. 3. Pigeonpea (1)+ greengran (6) intercropping at AICRP on IFS

Fig. 4. Pigeonpea (1)+Groundnut(7) intercropping
Table 1. Performance of crops in various cropping systems during *kharif*, 2019

| Treatments | Grain yield | Straw/ Stover yield | Productivity (Rice grain Equivalent Yield kg ha\(^{-1}\)) | Profitability (Rs ha\(^{-1}\)) |
|------------|-------------|---------------------|----------------------------------------------------------|-----------------------------|
|            | Grain       | Straw               | Total          | Cost of cultivation (Rs. ha\(^{-1}\)) | Gross returns (Rs. ha\(^{-1}\)) | Net returns (Rs. ha\(^{-1}\); Rs. Re\(^{-1}\)) |
| A1         | T1          | Rice                | 5390          | 6197            | 5390           | 338           | 5728           | 47158 | 105104 | 57946 | 1.23 |
|            | T2          | Bt cotton           | 1943          | 4444            | 5825           | 61            | 5885           | 46923 | 107994 | 61071 | 1.30 |
| A2         | T1          | Bt cotton + Greengram (1:3) | 1910      | 4406            | 7512           | 163           | 7676           | 52043 | 140847 | 88804 | 1.71 |
|            | T2          | Pigeon pea + Greengram (1:6) | 1192      | 3775            | 5951           | 182           | 6133           | 29747 | 112545 | 82798 | 2.78 |
| A3         | T1          | Pigeon pea + Maize (1:3) | 564          | 5858            | 1787           | 7478          | 432            | 7402   | 7833   | 53957 | 143743 | 89786 | 1.66 |
|            | T2          | Pigeon pea + Groundnut (1:7) | 1240     | 3996            | 2383           | 8097          | 704            | 8801   | 53025  | 161489 | 108464 | 2.05 |
| A4         | T1          | Fodder sorghum + Fodder Cow pea (1:2) | 0       | 12648           | 19166          | 0             | 4512           | 4512   | 28519  | 82796  | 54277 | 1.90 |
|            | T2          | Fodder maize        | 0            | 38911           | 0              | 4241          | 4241           | 26367  | 77822  | 51455  | 1.95 |
| A5         | T1          | Sweet corn          | 15253        | 18642           | 0              | 7481          | 1524           | 9005   | 55513  | 165240 | 109727 | 1.98 |
|            | T2          | Bhendi              | 6296         | 1588            | 0              | 6862          | 22             | 6884   | 43897  | 126317 | 82420 | 1.88 |
| S Em+      |             |                     |                |                 |                |               |                |        |        | 374.0  |          |         |           |
| CD (0.05)  |             |                     |                |                 |                |               |                |        |        | 1120.0 |          |         |           |
| CV (%)     |             |                     |                |                 |                |               |                |        |        | 9.7    |          |         |           |

Sale price for Grain (kg\(^{-1}\)): Rice = Rs 18.35, Maize = Rs 17.6, Groundnut = Rs 50.9, Bhendi = Rs 20.00, Bt Cotton = Rs 55.0, Greengram = Rs 70.5, Pigeonpea = Rs 58.0, Sweet corn = Rs 9.00
Sale price for stover (kg\(^{-1}\)): Rice = Rs 1.00 Maize = Rs 1.00, Bhendi = Rs 0.25, Groundnut = Rs 5.00, Greengram = Rs 2.00, Sweet corn = Rs 1.5, Bt cotton = 0.25, Pigeonpea = Rs 0.25, Fodder sorghum = Rs 2.00,
Fodder cowpea = 3.00, Fodder maize = 2.00
Table 2. Performance of crops in various cropping systems during rabi and summer, 2019-20

| Trt  | Cropping sequence | Economic yield (kg ha\(^{-1}\)) | Straw yield (kg ha\(^{-1}\)) | Rice grain equivalent yield (kg ha\(^{-1}\)) | Total |
|------|-------------------|---------------------------------|-----------------------------|-----------------------------------------------|-------|
|      | Rabi Summer       | Rabi Summer                     | Grain Rabi Summer           | Straw Rabi Summer                             |       |
| T1   | Maize             | 5395                            | 7020                        | 5174                                          | 383   | 5557 |
| T2   | Fallow            | 0                               | 0                           | 0                                             | 0     | 0    |
| T3   | Groundnut         | 2016                            | 2420                        | 5592                                          | 659   | 6251 |
| T4   | Sesame            | 756                             | 1658                        | 2673                                          | 23    | 2696 |
| T5   | Groundnut         | 2144                            | 4281                        | 5946                                          | 1167  | 7113 |
| T6   | Ragi              | 1832                            | 3845                        | 3145                                          | 52    | 3197 |
| T7   | Horsegram - Sunhemp | 8973 | 15467 | 0 | 978 | 1264 | 2242 |
| T8   | Lucerne           | 27430                           | 14882                       | 75                                            | 14957 |
| T9   | Tomato            | 27309                           | 5528                        | 24433                                         | 9331  |       |
| T10  | Marigold - Beetroot | 14945 | 17122 | 7911 | 4554 | 108 | 62 | 33934 |

CD (at 5%) 2511  SEM + 838  CV (%) 11

Sale price for grain (kg\(^{-1}\)): Maize = Rs 17.6, Rice = Rs 18.35, Tomato = Rs 10.0, Groundnut = Rs 50.9, Sesame = Rs 64.85, Fingermillet = Rs 31.5, Marigold = Rs 30.00, Beetroot = Rs 10.00

Sale price for stover (kg\(^{-1}\)): Maize = Rs 1.00, Rice = Rs 1.00, Tomato = Rs 0.25, Groundnut = Rs 5.00, Sesame = Rs 0.25, Fingermillet = Rs 0.25, Horsegram = Rs 2.0, Sunhemp = Rs 1.5, Lucerne = Rs 2.0, Marigold = Rs 0.25, Beetroot = Rs 0.25

Table 3. Performance of crops in various cropping systems during 2019-20

| Treatments | Kharif (2019) | Rabi (2019-20) | Summer (2019-20) | Rice Grain Equivalent Yield (kg ha\(^{-1}\)) | Productivity |
|------------|---------------|----------------|-------------------|-----------------------------------------------|--------------|
|            | Grain yield (kg ha\(^{-1}\)) | Straw/Stover yield (kg ha\(^{-1}\)) | Grain yield | Straw/Stover yield (kg ha\(^{-1}\)) | Grain yield | Straw yield | Grain yield | Straw yield | Straw yield | Kharif yield | Rabi yield | Summer (RGYEY kg ha\(^{-1}\)) | System |
| T1 Rice-Maize | 5390          | 0               | 6197            | 0                  | 5395     | 0         | 7020        | 0            | 0            | 0            | 5390         | 338        | 5174          | 383         | 11284         |
| T2 Bt Cotton | 1943          | 0               | 4444            | 0                  | 0        | 0         | 0           | 0            | 0            | 0            | 0           | 0          | 0            | 0           | 5885          |
| T3 Bt cotton + Greengram (1:3) - Groundnut | 1910          | 466             | 4406            | 947                 | 2016     | 2420      | 7512        | 163          | 5592         | 659          | 7676        | 6251       | 0            | 14573       |
| T4 Pigeon pea + Greengram (1:6) - Sesame | 1192          | 568             | 3775            | 1199               | 756      | 1658      | 5951        | 182          | 2673         | 23           | 6133        | 2696       | 0            | 8829        |

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Treatments | Kharif (2019) | Rabi (2019-20) | Summer (2019-20) | Rice Grain Equivalent Yield (kg ha⁻¹) | Productivity
---|---|---|---|---|---
**Kharif-Rabi**

| | Grain yield (kg ha⁻¹) | Straw/ Stover yield (kg ha⁻¹) | Grain Yield | Straw/Stover yield (kg ha⁻¹) | Kharif | Rabi | Summer (RGGEY kg ha⁻¹) |
|---|---|---|---|---|---|---|---|
| T5 | 564 | 5858 | 1787 | 7478 | 2144 | 4281 | 432 | 7402 | 5946 | 1167 | 7833 | 7113 | 0 | 14946 |
| T6 | 124 | 0 | 1506 | 3996 | 2383 | 1832 | 3845 | 8097 | 704 | 3145 | 52 | 8801 | 3197 | 0 | 11998 |
| T7 | 0 | 0 | 12648 | 19166 | 8973 | 15467 | 0 | 4512 | 0 | 978 | 1264 | 4512 | 978 | 1264 | 6754 |
| T8 | 0 | 0 | 38911 | 0 | 27430 | 0 | 4241 | 0 | 2990 | 4241 | 2990 | 0 | 7231 |
| T9 | 152 | 53 | 18642 | 0 | 27309 | 5528 | 7481 | 1524 | 1488 | 2 | 75 | 9005 | 14957 | 0 | 23962 |
| T1 | 629 | 0 | 1588 | 0 | 14945 | 7911 | 17122 | 4554 | 6862 | 22 | 2443 | 3 | 108 | 933 | 62 | 6884 | 24541 | 9393 | 40817 |

**S Ems + (0.05)**

| | | | | | | | |
| S Em+ | 363 | 762 | 0 | 1088 | 2282 | 2579 |

**CV (%)**

| | | |
| S Ems + | 9.8 | 17 | 19.0 |

*Sale price for Grain (kg⁻¹) : Rice = Rs 18.35, Maize = Rs 17.6, Groundnut = Rs 50.9, Bhendi = Rs 20.00, Bt Cotton = Rs 55.0, Greengram = Rs 70.5, Pigeonpea = Rs 58.0, Sweet corn = Rs 9.00, Sesame = Rs 64.85, Fingermillet = Rs 31.5, Marigold = Rs 30.00, Beetroot = Rs 10.00*

*Sale price for stover (kg⁻¹) : Rice = Rs 1.00, Maize = Rs 1.00, Bhendi = Rs 0.25, Groundnut = 5.00, Greengram = Rs 2.00, Sweet corn = Rs 1.5, Bt cotton = 0.25, Pigeonpea = Rs 0.25, Fodder sorghum = Rs 2.00, Fodder cowpea = 3.00, Fodder maize = 2.00, Tomato = Rs 0.25, Sesame =Rs 0.25, Fingermillet = Rs 0.25, Horsegram = Rs 2.0, Sunhemp = Rs 1.5, Lucerne = Rs 2.0, Marigold = Rs 0.25, and Beetroot = Rs 0.25*. 
## Table 4. Economics of crops in various cropping systems during 2019-20

| Treatment | Kharif (Rs. ha⁻¹) | Gross returns (Rs. ha⁻¹) | Net returns (Rs. ha⁻¹) | Rabi (Rs. ha⁻¹) | Gross returns (Rs. ha⁻¹) | Net returns (Rs. ha⁻¹) | Summer (Rs. ha⁻¹) | Gross returns (Rs. ha⁻¹) | Net returns (Rs. ha⁻¹) | System |
|-----------|------------------|--------------------------|------------------------|----------------|--------------------------|------------------------|------------------|--------------------------|------------------------|--------|
| T1 Rice-Maize | 47158            | 105104                   | 57946                  | 1.23           | 35731                    | 101966                 | 66235            | 1.85                     | 0                      | 120487  |
| T2 Bt Cotton | 46923            | 107994                   | 61071                  | 1.30           | 0                        | 0                      | 0                | 0                        | 0                      | 61071  |
| T3 Bt cotton+Greengram (1:3)-Groundnut | 52043            | 140847                   | 88804                  | 1.71           | 40094                    | 114714                 | 74620            | 1.86                     | 0                      | 160175  |
| T4 Pigeon pea + Greengram (1:6) - Sesame | 29747            | 112545                   | 82798                  | 2.78           | 24940                    | 49463                  | 24523            | 0.98                     | 0                      | 109112  |
| T5 Pigeon pea+Maize (1:3)-Groundnut | 53957            | 143743                   | 89786                  | 1.66           | 40094                    | 130519                 | 90425            | 2.26                     | 0                      | 162465  |
| T6 Pigeonpea + Groundnut (1:7) - Ragi | 53025            | 161489                   | 108464                 | 2.05           | 24468                    | 58669                  | 34201            | 1.40                     | 0                      | 140888  |
| T7 Fodder sorghum + Fodder cowpea (1:2) – Horsegram - Sunhemp | 28519            | 82796                    | 54277                  | 1.90           | 14994                    | 17946                  | 2952             | 0.19                     | 12334                  | 70588  |
| T8 Fodder maize - Lucerne | 26367            | 77822                    | 51455                  | 1.95           | 25920                    | 54859                  | 28939            | 1.12                     | 0                      | 83441  |
| T9 Sweetcorn-Vegetables (Tomato) | 55513            | 165240                   | 109727                 | 1.98           | 47330                    | 274469                 | 227139           | 4.80                     | 0                      | 331786  |
| T10 Okra – Marigold - Beetroot | 43897            | 126317                   | 82420                  | 1.88           | 75464                    | 450328                 | 291150           | 3.85                     | 44933                  | 484399  |

**Sale price for Grain (kg⁻¹):** Rice = Rs 17.7, Maize = Rs 17.0, Groundnut = Rs 48.9, Bhendi = Rs 20.00, Bt Cotton = Rs 54.5, Greengram = Rs 69.75, Pigeonpea = Rs 56.75, Sweet corn = Rs 9.0, Tomato = Rs 10.0, Sesame = Rs 62.49, Fingermillet = Rs 28.97, Marigold = Rs 50.00, Beetroot = Rs 10.00.

**Sale price for stover (kg⁻¹):** Rice = Rs 1.00, Maize = Rs 1.00, Bhendi = Rs 0.25, Groundnut = 5.00, Greengram = Rs 2.00, Bt cotton = 0.25, Pigeonpea = Rs 0.25, Fodder sorghum = Rs 2.00, Fodder cowpea = 3.00, Fodder maize = 2.00, Tomato = Rs 0.25 Sesame = Rs 0.25, Fingermillet = Rs 0.25, Horsegram = Rs 2.0, Sunhemp = Rs 1.5, Lucerne = Rs 2.0, Marigold = Rs 0.25, Beetroot = Rs 0.25
Regarding system productivity, Okra–Marigold–Beetroot system recorded significantly higher rice grain equivalent yield (40817 kg ha⁻¹) over other crops evaluated in different cropping systems (Tables 3 and 4). Among the cropping systems involving vegetables and other high value crops for income enhancement, Sweet corn – Tomato system was found to be more remunerative (36434 kg ha⁻¹ with 4,81,785 Rs ha⁻¹ net returns) than Okra – Marigold – Beetroot because of lower cost of cultivation though recorded higher rice grain equivalent yield. Among the ecological cropping systems, Bt cotton + Greengram (1:3)-Groundnut cropping system recorded significantly higher rice grain equivalent yield (14573 kg ha⁻¹) and net returns (160175 Rs ha⁻¹) than Pigeon pea + Greengram (1:6) - Sesame (8829 kg ha⁻¹) cropping system. However, due to lower cost of cultivation, Pigeonpea + Greengram (1:6) – Sesame system recorded higher BC ratio compared to Bt cotton + Greengram (1:3)- Groundnut cropping system. Out of the two systems tested to meet the household nutritional security involving cereals / pulses / oilseeds, Maize + Pigeon pea (1:3) – groundnut system reported to be more remunerative (11998 kg ha⁻¹ RGEY with 140888 Rs ha⁻¹ net returns and 1.85 B:C ratio) than Pigeon pea + Groundnut (1:7) - ragi system. Nagar et al. [14] also reported similar effect of intercropping on seed yield of pigeonpea. Out of the two fodder crops/cropping systems, Fodder maize – Lucerne (1.65 BC ratio) system resulted in higher rice grain equivalent yield (7231 kg ha⁻¹) and net returns (83441 Rs ha⁻¹) than fodder sorghum + fodder Cow pea (1:2) – Horsegram – Sunhemp system (6754 kg ha⁻¹ with 1.30 BC ratio). Rice and Bt cotton were tested as pre-dominant cropping systems of the region and rice – maize system recorded higher rice grain equivalent yield (11284 kg ha⁻¹) and net returns (120487 Rs ha⁻¹) than Bt cotton alone (5885 kg ha⁻¹). Cultivation involving sole crop or without intercropping results in decline in terms of productivity. In two years, cotton – legume – corn rotation, yield increase to the tune of 11 per cent was recorded as compared to continuous cotton grown without legumes [15]. Six Bt cotton based double cropping systems viz., two millets, two pulses and two oilseed crops were evaluated to identify the most profitable, productive and sustainable system. Amongst them, Bt cotton – maize recorded the highest seed cotton equivalent yield [16]. This indicate that in order to attain high productivity, intercropping plays a vital role.

4. CONCLUSION

Under high value crops, sweet corn - vegetable system (tomato) was more remunerative followed by okra – marigold – beetroot system. Among the ecological cropping systems, pigeonpea + greengram (1:6) – sesame, under the cropping systems for household nutritional security, pigeonpea + maize (1:3) - groundnut system, under two fodder crops/cropping systems, fodder maize – lucerne system and under predominant cropping systems, rice – maize systems were most profitable and can highly be recommended for different farming systems of Southern Telangana Zone of Telangana.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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