Productivity and profitability as influenced by rice based cropping systems in Tunga Bhadra project area of Karnataka

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Abstract
A field experiment under All India Coordinated Research Project was conducted for four years (2015-16 to 2018-19) in irrigated condition at Agricultural Research Station, Siruguppa, University of Agricultural Sciences (UAS), Raichur, Karnataka, India, to study the productivity and profitability of cropping system as influenced by rice based cropping system in Tunga Bhadra Project area of Karnataka on deep black soil. The experiment consisted of ten cropping systems and laid out in completely randomized block design with three replications. The results showed that, growing of rice followed by ridge gourd (Kharif-summer) recorded significantly higher rice equivalent yield (11338 kg/ha), gross return (Rs.213355/ha), net return (Rs.142691/ha), BC ratio (3.08), system productivity (31.07 kg/ha/day) and system profitability (537.54 Rs/ha/day) compared to other cropping systems. Whereas rice followed by beans cropping system registered significantly lowest rice equivalent yield, gross returns, net returns, BC ratio, system productivity and system profitability when compared to other cropping systems tested under the study.

Keywords: Cropping system, rice equivalent yield, gross returns, net returns, BC ratio

Introduction
Rice followed by rice is the most predominant cropping system in the deep and shallow black soil of Tungabhadra Project Area of Karnataka, India. Continuous cultivation of rice for longer periods with low system productivity, and often with poor crop management practices, led to loss in soil fertility due to emergence of multiple nutrient deficiency (Dwivedi et al., 2001) [2] and deterioration of soil physical properties, and decline in factor productivity and crop yields in high productivity areas (Yadav, 2002) [12].

Diversification and intensification of rice-based system to increase productivity per unit resource is very pertinent. Crop diversification shows lot of promises in alleviating these problems besides, fulfilling basic needs for cereals, pulses, oilseeds and vegetables and, regulating farm income, withstanding weather aberrations, controlling price fluctuation, ensuring balanced food security, preservation of natural resources, minimise the chemical fertilizer and pesticide loads, ensuring environmental safety and creating employment opportunity (Gill and Ahlawat, 2006) [3]. Crop diversification has been recognized as an effective strategy for achieving the objectives of food security, nutrition security, income growth, poverty alleviation, creation of employment opportunities, and judicious use of land and water resources, sustainable agricultural development and environmental improvement (Hedge et al., 2003) [5]. The crop diversification may enhance profitability, reduce pests, spread out labour more uniformly, reduce risks from aberrant weather by different planting and harvesting times and source of high value products from new crops (Reddy and Suresh, 2009) [8]. Rice being the staple food of people, hence, rice cannot be replaced with other crops during kharif season. The only option left is to identify suitable crops for rabi/summer seasons for non availability/scarcity of water due to less storage capacity in the reservoirs coupled with low water availability for the tail end farmers in the command area it is more so with TBP. Growing of crops such as vegetables, pulses and oilseeds during summer is an alternative approach for realizing higher productivity and profitability. Moreover, growing non paddy crops during summer has a special reference for efficient utilization of irrigation water, labour and other resources for higher productivity, profitability and food security.
There is need to evaluate the possibilities of replacing summer rice with other suitable upland crops and include summer season crops for higher productivity. Similarly, there are opportunities to include grain legumes and vegetables during summer season. The demand for vegetable crops has increased enormously leading to sharp increase in their prices and it has been the dominant factor for high inflationary pressure in Indian economy during recent years. Inclusion of crops like oilseeds, pulses, vegetables and fodder crops will improve the economic condition of small and marginal farmers owing to higher price and/or higher volume of their main and by-products (Sharma et al., 2007)\(^{[9]}\). Hence, efforts are being made to promote diversification of rice-based cropping sequence in this area of country with vegetable crops for sustaining the productivity and to meet out demand for vegetables. Therefore, the present investigation was carried out to find out most productive, resource-use-efficient and remunerative cropping system for this region.

Material and Methods

An AICRP experiment was conducted for four years (2015-16 to 2018-19) under irrigated condition during 2016-17 to find out alternative cropping system for existing rice – rice system in TBP area at Agricultural Research Station, Siruguppa. The experiment consists of 10 treatments with rice grown in the kharif followed by different crops in the rabi and treatments were replicated thrice in the randomized complete block design. The experimental soil was deep black having slightly alkaline in pH (8.18) and low in soluble salt concentration (0.38 dS/m), medium in soil organic carbon content (0.65%) and available phosphorus (11.3 kg/ha), low in available nitrogen (177 kg/ha) and rich in available Potassium (348 kg/ha). The treatments details, fertilizer dosage and varieties used in the experiment were given in Table 1 and 2. The fertilizers were applied in the form of urea, Diammonium phosphate (DAP) and muriate potash as per the recommended package of practice for each crop tested during both the seasons. The data on the yield parameters were recorded at harvest. The cost of inputs prevailing in the market at the time of their use was considered for calculation of the economics of different treatments. Net return per hectare was calculated by deducting the cost of cultivation from gross returns per hectare, gross returns was calculated by using the total income obtained from grain and straw yields and the benefit cost ratio was worked out as follows. Benefit cost ratio = Gross returns/Cost of cultivation. The rice equivalent yield was calculated by using the following formula (Verma and Mudgal, 1983)\(^{[11]}\).

\[
YRC (kg/ha) \times MPCC(Rs./kg)+Yield of main crop(kg/ha)
\]

\[
Price of rice (Rs./kg)
\]

Whereas, \(YRC= \text{Yield of rabi crop (kg ha}^{-1}\), \(MPCC=\text{Market price of rabi crop (Rs. kg}^{-1}\)). The System Productivity (SP) for the cropping system was calculated as dividing the REY by number of days in a year and expressed in kg/ha/day and System profitability was calculated by dividing the Net Returns by number of days in a year i.e. 365 days. The plant samples were collected and subjected to chemical analysis. The grain and stover samples were analyzed for N by digesting sample with concentrated H\(_2\)SO\(_4\) and the acid digested was distilled for NH\(_3\) by using 40% NaOH and was estimated by titration against standard acid and phosphorus and potassium in the plant sample extracted by diacid were determined by vanadomolybic yellow colour and flame photometry method, respectively (Jaiswal, 2004). MSTAT was used for statistical analysis of data and means were separated using critical difference (CD) at p=0.05 (Gomez and Gomez, 1984)\(^{[8]}\).

| Treatments | Kharif | Rabi | Summer | Pre-monsoon |
|------------|--------|------|--------|-------------|
| 1          | Rice (BPT-5204) | -    | Rice    | Existing system |
| 2          | Rice (SIRI-1253) | -    | Ridge gourd (ZT and DS) | |
| 3          | Rice (SIRI-1253) + Sesbania (Incorporation after 55 days) | -    | Mustard | Green gram (Residue incorporation) |
| 4          | Rice (SIRI-1253) | -    | Beans | Sesbania incorporation |
| 5          | Rice (SIRI-1253) | -    | Siyazeera | Sesbania incorporation |
| 6          | Rice (SIRI-1253) | -    | Coriander | - |
| 7          | Rice (GNV 10-89) | Spinach | Black gram (Residue incorporation) | - |
| 8          | Rice (GNV 10-89) | Methi | Green gram (Residue incorporation) | - |
| 9          | Rice (GNV 10-89) | -    | Rice (RASI) | Sesbania incorporation |
| 10         | Rice (GNV 10-89) | Sesbania incorporation | Rice (RASI) | - |

| Treatments | Crops | Varieties | Fertilizer doses (N, P, K kg/ha) |
|------------|-------|----------|-------------------------------|
| 1          | Paddy | BPT-5204, SIRI-1253 and GNV 10-89 | 150:75:75 |
| 2          | Ridge gourd | Jaipur long | 50:50:00 |
| 3          | Mustard | Varuna | 100:60:40 |
| 4          | Beans | Local | 60:20:20 |
| 5          | Siyazeera | Local | 50:20:20 |
| 6          | Coriander | Local | 75:30:30 |
| 7          | Blackgram | T9 | 12.5:25:00 |
| 8          | Green gram | Chinamung | 12.5:25:00 |
| 9          | Spinach | Local | 25:00:00 |
| 10         | Methi | Local | 100:00:00 |
Results and Discussion

Grain and straw yield

The pooled data over four years on grain yield were presented in Table 3. The grain yield of different crops during kharif/summer were significantly influenced by different cropping systems. Among the three rice varieties tested, SIR-1253 recorded higher yield (6188 kg/ha) followed by GNV 10-89 (5960 kg/ha). Similar results were also reported by Bastia et al. (2008). However, BPT 5204 recorded least grain yield (5122 kg/ha). During summer season the pooled data on yield indicated that ridge guard has recorded significantly higher pooled yield (5244 kg/ha) compared to rest of the summer crops. In case of summer crops tested under study revealed that among the different crops Siyazzeera (420 kg/ha) recorded significantly lower grain yield compared to rest of the crops.

Rice equivalent yield

The pooled rice equivalent yield was worked out to identify the best cropping system among the different cropping systems evaluated and are presented in Table 4. The findings of Singh et al. (2007) [10] who reported rice-pea-okra followed by rice-pea-onion as the most productive cropping sequence for eastern Uttar Pradesh, India. Mishra et al. (2007) [7] also reported higher productivity and profitability through inclusion of vegetables and pulses in rice-based cropping system. Walia et al. (2014) [14] who reported that productivity in terms of REY and system productivity was highest for rice-green pea summer moongbean as compared to rice-wheat and all other crop sequences. In another study conducted at Australia reported that the choice of cropping systems had a significant impact on total grain production over a 3-year cropping cycle (i.e., grains produced by Year-1 plus Year-2

| Treatments | 2015-16 | 2016-17 | 2017-18 | 2018-19 | Pooled |
|------------|---------|---------|---------|---------|--------|
|            | Kharif  | Summer  | Kharif  | Summer  | Kharif  | Summer  | Kharif  | Summer  | Kharif  | Summer  |
| T1         | 5176    | 3670    | 5109    | 3818    | 5208    | 3948    | 4993    | 4099    | 5122    | 3884    |
| T2         | 5594    | 5788*   | 5886    | 5606    | 6035    | 4945    | 5415    | 4638    | 5732    | 5244    |
| T3         | 6141    | 536     | 5473    | 495     | 5291    | 494     | 5374    | 471     | 5570    | 499     |
| T4         | 6501    | 1546    | 5952    | 1483    | 5026    | 1393    | 5291    | 1400    | 5692    | 1455    |
| T5         | 5652    | 485     | 6299    | 395     | 5671    | 390     | 5415    | 410     | 5759    | 420     |
| T6         | 5112    | 746     | 7159    | 755     | 6531    | 680     | 5952    | 744     | 6188    | 731     |
| T7         | 4867    | 1052    | 6200    | 1070    | 6696    | 955     | 6275    | 1056    | 6010    | 1033    |
| T8         | 4726    | 744     | 6961    | 852     | 6805    | 807     | 6118    | 805     | 5960    | 802     |
| T9         | 4469    | 3799    | 5374    | 3923    | 6031    | 4134    | 5787    | 4237    | 5416    | 4023    |
| T10        | 4643    | 3901    | 5704    | 4048    | 6283    | 4070    | 5704    | 4232    | 5583    | 4063    |
| S.Em±      | 172     | 87      | 185     | 86      | 256     | 53      | 231     | 76      | 211     | 69      |
| CD (0.05)  | 509     | 258     | 550     | 256     | 760     | 157     | 326     | 159     | 595     | 195     |

Table 3: Pooled grain yield (kg/ha) of crops as influenced by rice based Cropping system

**Table 4: Pooled rice equivalent, SP, GR, NR, B:C and S. Prof. as influenced by rice based cropping system**

| Treatments | REY (kg/ha) | SP (kg/ha/day) | GR (Rs./ha) | NR (Rs./ha) | B:C | S. Prof. (kg/ha/day) |
|------------|-------------|----------------|-------------|-------------|-----|---------------------|
| T1         | 8999        | 24.66          | 167881      | 90712       | 2.19| 406.12              |
| T2         | 11338       | 31.07          | 213355      | 142691      | 3.08| 537.54              |
| T3         | 6358        | 17.42          | 120483      | 62130       | 2.08| 289.72              |
| T4         | 7655        | 20.97          | 150469      | 86806       | 2.39| 368.29              |
| T5         | 6706        | 18.37          | 132938      | 71028       | 2.17| 321.08              |
| T6         | 7799        | 21.37          | 159064      | 97851       | 2.60| 393.33              |
| T7         | 7701        | 21.10          | 146605      | 87772       | 2.50| 361.05              |
| T8         | 7178        | 19.67          | 132980      | 73803       | 2.26| 323.70              |
| T9         | 9487        | 25.99          | 163674      | 89408       | 2.21| 397.12              |
| T10        | 9694        | 26.56          | 166998      | 92996       | 2.26| 406.22              |
| S.Em±      | 201         | 0.55           | 3541        | 3541        | 0.09| 9.79                |
| CD (0.05)  | 566         | 1.55           | 9965        | 9965        | 0.26| 27.99               |

System productivity and profitability

The pooled data on system productivity and profitability was presented in Table 4. Results indicated that, the system profitability and system productivity were significantly influenced by different cropping systems. Significantly higher system productivity (31.07 kg/ha/year) followed by T10 (26.56 kg/ha/year) and T5 (25.99 kg/ha/year) and lowest being was observed in T3 (17.42 kg/ha/year). Further, the significantly higher system profitability (537.54 Rs/ha/day) was observed in T2 followed by T10 (406.22 Rs/ha/day) and T1(406.12 Rs/ha/day). Whereas, least system profitability was recorded in T3 (289.72 Rs/ha/day). These results corroborates the findings of Singh et al. (2007) [10] who reported rice-pea-okra followed by rice-pea-onion as the most productive cropping sequence for eastern Uttar Pradesh, India. Mishra et al. (2007) [7] also reported higher productivity and profitability through inclusion of vegetables and pulses in rice-based cropping system. Walia et al. (2014) [14] who reported that productivity in terms of REY and system productivity was highest for rice-green pea summer moongbean as compared to rice-wheat and all other crop sequences. In another study conducted at Australia reported that the choice of cropping systems had a significant impact on total grain production over a 3-year cropping cycle (i.e., grains produced by Year-1 plus Year-2

**CD** (0.05) - Fresh weight
Economics of different systems
Significantly higher pooled gross returns (Rs. 213355/ha), net returns (Rs. 142691 /ha) and B:C ratio (3.08) were observed in T9 (rice followed by ridge gourd) compared to other cropping systems. The higher gross returns, net returns and B:C ratio were owing to higher yields in the T9. It was followed by T8 and T10. Although rice followed by BPT 5204 rice (T5) was not superior to rice followed by ridgeguard in terms of REY (Table 4), however, it recorded significantly higher GR, NR and B:C ratio of Rs. 167881/ha, Rs. 90712/ha and 2.19, respectively over all the three treatments of rice followed by other cropping systems with different rice varieties (T9 and T10) and other treatment also. This was might be due to higher yield rice and market price. The significantly lower GR, NR and BC ratio was observed in T1. Kumar Alok et al. (2008) also reported that inclusion of vegetable crops in rice- based crop sequences improved the net returns.

Conclusion
The results indicated that, farmers can grow rice during kharif followed by ridge gourd or beans during rabi/summer to get higher productivity and income in Tunga Bhadra Command Area of Karnataka.

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