



Economic Analysis of Rice Cultivation System under Different Establishment Methods

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2019/v32i630034

Editor(s):

(1) Dr. Teresa De Pilli, Assistant Professor, Department of Science of Agriculture of Food of Environment (SAFE), University of Foggia, Via Napoli, Italy.

Reviewers:

(1) Bilal Ahmad Lone, Sher-e-Kashmir University of Agricultural Sciences and Technology, India.

(2) Venkata Sanyasi Seshendra Kumar Karri, GITAM University, India.

(3) A. Ashok Kumar, Dr. NTR College of Agricultural Engineering, Acharya NG Ranga Agricultural University, India.

Complete Peer review History: <http://www.sdiarticle3.com/review-history/47110>

Original Research Article

Received 03 November 2018

Accepted 28 January 2019

Published 15 February 2019

ABSTRACT

Energy utilization efficiency depends on different factor of cropping systems such as physiochemical properties of soil, land preparing operation, plant protection, fertilizer application, threshing, harvesting operation and grain and straw yield. India is developing county and rice crops are one of the most energy intensive crop and its major component are irrigation, land development (tillage), FYM (Farmyard manure) and fertilizers. The importance of Mechanization in cultivation system involves higher input cost but at the same time, it can reduce operation cost of cultivation, increases grain yield and can reduce operational time. Cost of cultivation of rice in different treatment was calculated by adding the cost of all input parameter such as seeds, fertilizers, pesticides, fuel, and labourer. Grain output was observed considerably higher in mechanized transplanting seedling compare to direct sowing. Direct sowing and zero till mechanical transplanting methods produced the low grain yield because of poor crop growth as compare to transplanting seedling of rice in a standing water table. The grain yield in mechanical transplanting varied from 29.5 to 32.6 q/h where as in direct sowing treatment 31.2 to 32.1 q/ha.

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Keywords: Rice transplanting; zero till drill; energy utilization etc.

1. INTRODUCTION

The cost of energy in agriculture have increased day by day and it is one of the most important input parameter in the practice of crop cultivation and it is required at each step of crop production from initial phase (tillage) to final (harvesting). In each operation of crop production there is application of input that depends on energy base fossil fuel (mechanical machinery) consumption which emits carbon-di-oxide and other greenhouse gases. Energy utilization efficiency depends on different factor of cropping systems such as physiochemical properties of soil, land preparing operation, plant protection, fertilizer application, harvesting, threshing operation and grain and straw yield [1]. India is developing county and here the rate of energy consumption is rising day by day with the involvement of new technology in the field of agriculture [2]. However, there are advantages of the use of new technology and machineries in agriculture that can reduce the energy need by 18–83% in tillage operation with different cultivation system [3].

Rice crops is one of the most energy intensive crop and its major component are irrigation, land development (tillage), FYM (Farmyard manure) and fertilizers. In India per capita energy availability is 1.84 kW/ha (Department of agriculture cooperation and farmers welfare) and

in Haryana is 2 kw/ha. Therefore, there is a need to classify energy-efficient rice cultivation system, [4]. The cost of cultivation is equally important for developing county like India where resources are limited and farmers are poor. Initial cost input for rice cultivation is higher and its output from rice cultivation is a major concern among the rice cultivators [5]. The importance of Mechanization in cultivation system involves higher input cost but at the same time it can reduces operation cost of cultivation, increase in grain yield and can reduce operational time [6]. Therefore, there is a need to analyse an efficient rice cultivation system in terms of benefit cost ratio. The present study was taken on rice cultivation with the objective to analyse economics and energy efficiency in the state of Haryana.

2. METHODOLOGY

2.1 Experimental Site

2.1.1 Transplanting/sowing field preparation according to treatments

The study was conducted in flatland of Agricultural Engineering farms of the Choudhary Charan Singh Agricultural University at Hisar, Haryana State of India. The data were obtained from field experiments conducted in Kharif seasons.

Table 1. Transplanting/sowing field preparation according to treatments

| Treatments | Methods | Description | Plot size(m ²) |
|----------------|---|--|----------------------------|
| T ₁ | Direct seeded rice (vattar) | One Plough + harrow + planking (with cultivator) + sowing by drill | 46.75 |
| T ₂ | Zero till-direct seeded rice without residues | Sowing by drill (no tillage) | 46.75 |
| T ₃ | Zero till-direct seeded rice with residues/Sesbania | Sowing by drill + residues (no tillage) | 46.75 |
| T ₄ | Zero till-mechanical transplanting | Self propelled rice transplanting (no tillage in standing water) | 46.75 |
| T ₅ | Unpuddle-mechanical transplanting | One Plough + harrow + planking (with cultivator) + Self propelled rice transplanting (standing water) | 46.75 |
| T ₆ | Puddle-mechanical transplanting | One Plough + harrow + planking (with cultivator) + puddling (with rotavator) + Self propelled rice transplanting | 46.75 |
| T ₇ | Puddle-manual transplanting | One Plough + harrow + planking (with cultivator) + puddling (with rotavator) + manual planting | 46.75 |

Experimental plan was conducted for analysis of yield for different rice cultivation practices. Seven treatment was selected as described in Table 1. These systems involved direct sowing rice (vattar) (T_1), Zero till-direct sowing rice without residues (T_2), Zero till-direct seeded rice with residues/Sesbania (T_3), Zero till-mechanical transplanting (T_4), Unpuddle-mechanical transplanting (T_5), Puddle-mechanical transplanting (T_6) and Puddle-manual transplanting (T_7).

The University is situated 30 km away from Kurukshetra city at latitude 29°51' N, longitude 76°41' E and altitude 241 meters above mean sea level. The field was selected for the study and it was uniform fertile. A composite soil sample from 0-30 cm soil depth was taken randomly at three places from the field before layout of experiment. The sample were mixed thoroughly, dried and were subjected to mechanical and chemical analysis. The physio-chemical analysis of the soil is presented in Table 2.

Table 2. Physio-chemical analysis of the soil of the experimental field

| Soil components | Content (%) |
|--------------------|-------------|
| Sand | 32.00 |
| Silt | 38.00 |
| Clay | 30.00 |
| Soil pH (1:2) | 8.20 |
| Organic carbon (%) | 0.32 |
| EC (ds/m) | 0.27 |

2.2 Experimental Management Practices

Seven different experimental management practices were followed and different inputs were used in seven rice cultivation systems which are summarized in Table 1. Plot size for each treatment was 46.75 m². In Direct sowing rice

land was prepared with single Mould Board Plough, one harrow, planking (with cultivator) operation were operated 10-15 days before sowing and seed was sown by seed drill. In T_2 treatment the seeds were sown with drill directly in the soil without any tillage operation. This treatment is zero till drill but in this treatment field was selected with no residue. In T_3 treatment which was similar to the T_2 treatment but the field was selected with residue for conserving moisture. In T_4 to T_7 treatments were done in standing water field and seedlings were grown for this treatment and transplanted into the field. For conventional and mechanized transplanting average 25 day-old seedlings with two to three seedlings per hill were transplanted at a spacing of 20 × 15 cm and 24 × 15 cm, respectively. Seedlings were grown on raised bed of 1 × 8 m area and 10 cm height. The seedbeds were sprinkled with water manually at regular interval. Taking care with transplanting seedlings, it was transplanted within 30 minutes after uprooting them from the nursery to avoid wilting and reduce transplanting shock. Transplanting in mechanized system was done by using 8-row self-propelled paddy transplanter.

In T_4 treatment no tillage operation was carried out and seedlings were transplanted with mechanical transplanter. And tillage operation is carried out in T_5 , T_6 and T_7 treatments. Seedlings were transplanted mechanically in T_5 and T_6 treatment and manual transplanting was done in T_7 treatment.

2.3 Energy Balance

Energy balance was calculated using the different equivalents of cultivation practices and outputs. Energy equivalents of the machines which was commonly available [7] in India (Table 3).

Table 3. Energy equivalent of machineries for India

| S.No. | Particulars | Energy equivalent(MJ/h) |
|-------|-------------------------|-------------------------|
| 1 | Power tiller | 6.693 |
| 2 | Rice Transplanter | 5.02 |
| 3 | Power weeder | 0.251 |
| 5 | Knapsack sprayer | 0.258 |
| 6 | Power operated sprayer | 1.703 |
| 7 | Reaper | 1.96 |
| 8 | Pedal operated thresher | 1.01 |
| 9 | Power thresher | 16.2 |

2.4 Economic Analysis

Cost of cultivation of rice in different treatment was calculated by adding the cost of all input parameter such as seeds, fertilizers, pesticides, fuel, labourers, etc. and cost of operation machinery [4]. Costs of fertilizers, FYM, seeds and pesticides were calculated on the basis of the available market price in the corresponding years. Manual cost was used to estimate on the basis of available rate on the Government of India (Ministry of Labour and Employment). The cost of operation of the machinery was computed on hourly basis after including the cost of machine, depreciation of the machine, machine Life and rate of interest. Available fuel rates (petrol and diesel) were obtained from the locally available petrol pump. Gross returns were calculated on the basis of support price, price of rice announced by Government of India for kharif season of 2011.

Net returns (Rs/ha) were worked out by subtracting the total cost of cultivation of each treatment from the gross income of respective treatment. Benefit: Cost (B:C) ratio was calculated to ascertain economic viability of the treatment by using the following formula:

$$\text{Net return} = (\text{Product cost} + \text{Byproduct cost}) - \text{Input cost}$$

$$\text{Benefit-cost ratio} = \frac{\text{Total output cost}}{\text{Total Input cost}}$$

3. RESULTS AND DISCUSSION

3.1 Energy Input

Energy required for cultivation of the crop in seven cultivation systems are presented in Table 5. Significantly high amount of energy required in Haryana for irrigation which was 30 Rs/hr. Land preparation consumed 1468 Rs/ha for flat land without standing water table whereas 3033 Rs/ha for standing water table field. Consumption of considerably more energy for fertilizers and manure than that of other cultural systems [8,6,9,10].

The cost analysis of different establishment methods were analyzed and given in Table 4. The comparative economics of different establishment methods were analyzed and reported in Table 4. Cost of operation was maximum (Rs. 8033) under treatment T₇ followed by T₆ then T₅, T₁ then T₄ and minimum (Rs. 629)

was in treatment T₂ and T₃. It is clear from the table 4 maximum cost of operation was under manual method (8033 Rs/ha). It was minimum under treatment T₃ (Rs. 62/ha) because no tillage operation was performed in this treatment. The total cost of production was also maximum under treatments followed by T₆, T₅, T₄, T₁ and minimum was under treatment T₂ and T₃.

Tillage operations used great amount of energy for land preparation. The energy requirement was negligible in zero till systems for tillage operation, which were major advantages over the conventional tillage. Direct sowing (Rs 16491) and manual transplanting of seedling (Rs 25388) kind of treatment required higher energy input than compare to zero till treatment (Rs 14974) because it used energy for tillage, transplanting, and manpower to raise mat-type seedlings. On comparing other side direct sowing can reduced the energy input as compared to mechanical transplanting because there was no need to raise seedling. Land preparation, transplanting or sowing, harvesting, fertilizer, and FYM applications together accounted for great amount of energy input.

3.2 Crop Performance under Different Methods of Rice Establishment

The plant height under different methods of rice establishment was given in Fig 1. The plant height was recorded at the time interval of 7, 14, 21, 35, 42 and 49 DAS/DAP. During these time interval the maximum plant height was obtained in 4.63, 12.7, 21.86, 29.97, 35.83 and 44 cm respectively. The minimum height of plant was obtained 4.04, 11.25, 18.73, 28.33, 34.42, and 42.60 cm with the T₁(7), T₂ (14 & 21), T₅ (35), T₄ (42) and T₄ (49) day respectively. The overall plant height was maximum (126.59cm) under T₆ and minimum (121.00 cm) was obtained in T₂ respectively.

3.3 Crop Yield under Different Methods of Rice Establishment

The effect of various treatments on crop yield was days to crop maturity, number of grain in a panicle, panicle length, number tillers/m², straw and crop yield (grain) were recorded at time of crop harvesting and results are reported in Table 5. the plant height at crop maturity in mechanical transplanting varied from 121.8 to 126.5 cm whereas in direct sowing the plant height at crop maturity was in the range 121 to 123.5 cm and

Table 4. Economics of rice cultivation as influenced by different crop establishment techniques

| Sr. No. | Particulars | T ₁ | T ₂ | T ₃ | T ₄ | T ₅ | T ₆ | T ₇ |
|---------------------------|---|--------------------|-------------------|-------------------|---------------------|---------------------|---------------------|---------------------|
| Input cost (Rs/ha) | | | | | | | | |
| 1 | Preparatory tillage a. Harrowing @738 Rs/ha b. Planker along with cultivator @ 730 Rs/ha c. Rotavator two operation @ 1565 rs/ha | 1468 | - | - | - | 1468 | 3033 | 3033 |
| 2 | Sowing/transplanting Total operation cost | 629 2097 | 629 629 | 629 629 | 1372 1372 | 1372 2840 | 1372 4405 | 5000 8033 |
| 3 | Seed 20 kg/ha @ 40 Rs/kg | 800 | 800 | 800 | 800 | 800 | 800 | 800 |
| 4 | Nursery raising (6man/day/ha) | - | - | - | 1014 | 1014 | 1014 | 1014 |
| 5 | seed treatment emisalt @ 250 Rs/ha | 250 | 250 | 250 | 250 | 250 | 250 | 250 |
| 6 | Bund making | 250 | 250 | 250 | 250 | 250 | 250 | 250 |
| 7 | Fertilizers a. urea Rs 250/- 50 kg bag b. single superphosphate Rs 250/- 50 kg bag c. muriate of potash @ Rs 250/- 50 kg bag | 1575 | 1575 | 1575 | 1575 | 1575 | 1575 | 1575 |
| 8 | Irrigations30 Rs/ha | 5700 | 5700 | 5700 | 8000 | 8000 | 8000 | 8000 |
| 9 | Weeding 4man/day/ha | 676 | 676 | 676 | 676 | 676 | 200 | 200 |
| 10 | Plant protectionBrown spot, steam root cutter, indosulphan @2 kg/ha | 1500 | 1500 | 1500 | 1500 | 1500 | 1500 | 1500 |
| 11 | Harvesting/ threshing Total cost | 2600 15936 | 2600 14468 | 2600 14468 | 2600 18525 | 2600 19993 | 2600 20882 | 2600 24510 |
| 13 | Interest (3.5%) on total cost | 558 | 506 | 506 | 648 | 700 | 731 | 878 |
| 14 | Total input cost | 16494 | 14974 | 14974 | 19173 | 20693 | 21613 | 25388 |
| 15 | Rental value of land | 37500 | 37500 | 37500 | 37500 | 37500 | 37500 | 37500 |

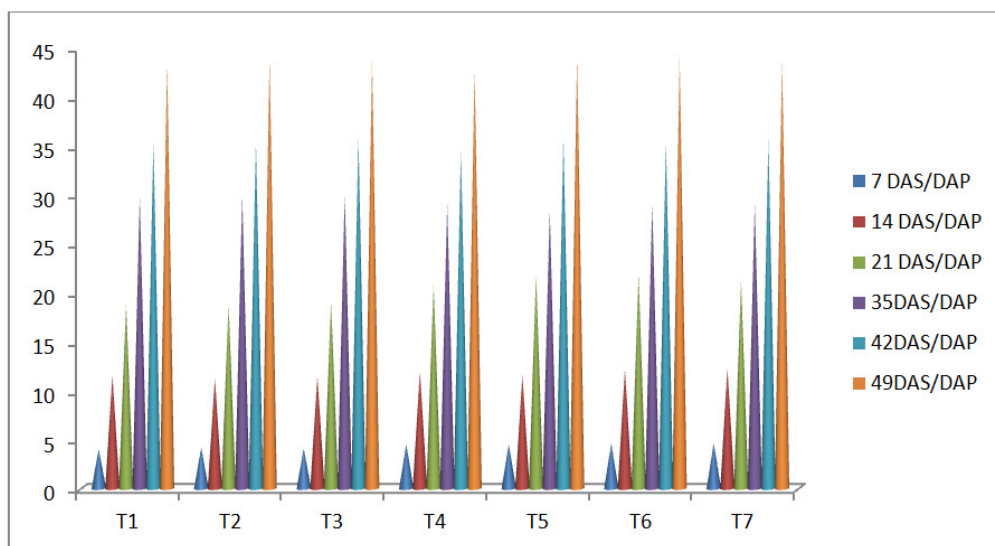


Fig. 1. Plant growth with time interval for different treatment

manual transplanting it was found 126.4 cm. Duration of the crop maturity in all treatment was nearly same and it was 144-145 days. The number of effective tillers per square meter was found in the range of 218 to 220 when rice crop was transplanted with mechanical transplanter and sown with direct sowing method. In manual transplanting number of effective tillers per square meter were 221. The numbers of grains per panicle in mechanical transplanting varied from 73.3 to 78.7 whereas in direct sowing numbers of grains per panicle were 73.5 to 78.33 and in manual transplanting it was observed 79.55.

Grain output was also considerably higher in mechanized transplanting seedling compare to direct sowing. Direct sowing and zero till mechanized transplanting methods produced the low grain yield because of poor crop growth. Low productivity was observed in zero till mechanized

transplanting the reason may be due to missing hills of the seedlings while transplanting with the machine or soil bed not prepared well in standing water. Further, production of straw or biomass was more in zero till direct sowing treatment with stubble leading to a higher straw production compare to other cultivation treatment. The grain yield in mechanical transplanting varied from 29.5 to 32.6 q/h where as in direct sowing treatment 31.2 to 32.1 q/ha. The maximum production kg/ha per hectare was from under treatment T₆ followed by T₇ and minimum was under treatment T₄. The gross return (69578 Rs/ha) was maximum under treatment T₆ followed by T₅ and T₂ and minimum was under treatment T₄. Net return (Rs. 63367/ha) was maximum under treatment T₃ followed by T₂. The benefit cost ratio was maximum (1.3) under treatment T₂ whereas in other treatment it varied from 1.27 to 1.30.

Table 5. Crop yield under different methods of rice establishment

| Treatments | Days to crop maturity | Panicle length (cm) | No. of effective tillers/m ² at harvest | No. of grains/panicle | Grain yield (kg/ha) | Straw (kg/Ha) |
|----------------|-----------------------|---------------------|--|-----------------------|---------------------|---------------|
| T ₁ | 144 | 23.26 | 220 | 76.66 | 3178 | 4225.0 |
| T ₂ | 144 | 23.26 | 220 | 73.52 | 3129 | 4693.5 |
| T ₃ | 144 | 23.77 | 221 | 78.33 | 3219 | 4828.5 |
| T ₄ | 145 | 22.56 | 218 | 73.30 | 2975 | 3834.3 |
| T ₅ | 145 | 23.55 | 220 | 76.61 | 3194 | 4299.6 |
| T ₆ | 145 | 23.98 | 220 | 78.77 | 3267 | 4304.2 |
| T ₇ | 145 | 24.34 | 221 | 79.55 | 3202 | 4076.5 |

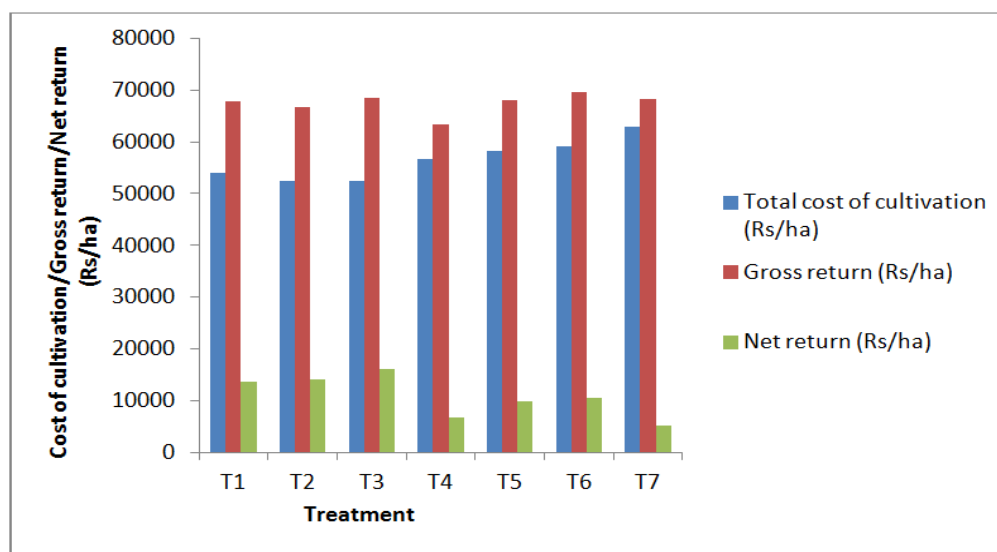


Fig. 2. Cost of cultivation/gross return/net return (Rs/ha) for different treatment

3.4 Economics

Zero till direct sowing (T2 and T3) was cost-effective energy saving rice cultivation treatment. Cost of cultivation in all mechanized treatment was considerably less as compare to the manual transplanting treatment. Total cost of cultivation in treatment T2 and T3 was lower and the amount was 52474 Rs/ha and the cost of cultivation in transplanting treatment was higher shown in Fig. 2. The cost of manual transplanting was highest among all the treatment and that was 62888 Rs/ ha. Above result suggest the requirements for mechanization of rice production in the Northern region of India. Advantages of mechanized system had requirement of labour was low as compare to manual transplanting, which effect cost of cultivation.

Economic return of the crop cultivation was directly related to the yield (q/ha) of rice in different cultivation treatment. The benefit to cost ratio (B:C) of the T3 treatment was considerably higher than all other treatment and the lowest benefit to cost ratio was observed in manual transplanting.

4. CONCLUSION

Following conclusion from the above study:

1. Cost of manual transplanting was INR 62888 per Ha and it was observed highest compared with other treatments.

2. The numbers of grains per panicle in mechanical transplanting varied from 73.3 to 78.7 whereas in direct sowing numbers of grains per panicle were 73.5 to 78.33 and in manual transplanting it was observed 79.55.
3. The benefit to cost ratio for T3 treatment was 1.30 and it was highest as compared to other treatment.
4. The benefit cost ratio for treatment T₂ and T₃ were obtained highest 1.21 and 1.25 respectively. However T₇ and T₄ were obtained lowest 1.08 and 1.16 respectively

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:

The peer review history for this paper can be accessed here:
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