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Selection of Minimum Cost Inputs for Boro Rice Cultivation in Bangladesh

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Abstract

The main purpose of the study was to select minimum cost inputs and selection of economic set of machines and implements for tilling to threshing operations in Boro rice cultivation. Primary and secondary data from various sources were collected and used in this piece of research. A procedure was developed to select the minimum cost inputs and select an economic set of machines for each farm holdings, considering the minimum cost of inputs, operating costs and capacities of alternatives for each operation, size of annual operational farm holdings and farmers access to the machines. BRRI-dhan 29 was found profitable among Boro rice variety and Leaf Colour Chart (LCC) appeared as best option for determining the amount of fertilizer requirement for Boro rice cultivation. For tilling operation, custom hire service of Tractor appeared profitable for a yearly operational farm holding of 8.29 hectares and above 8.29 hectares ownership of Tractor is profitable. For irrigation options, hired DTW was found profitable for farm sizes less than 2 hectares and STW owning was found profitable for the farm size exceeding 2 hectares. Drum seeder, Japanese Rice Weeder and hired Reaper were found significantly superior for all farm holdings. BAUzia fertilizer distributor was found profitable to the farmers when the annual use exceeded 1.12 hectares. For spraying options, Compression sprayer and Knapsack sprayer could be beneficial to the farmers when the annual use exceed 2.05 hectares and 5.71 hectares, respectively. Owned Reaper was found profitable to the farmers when the annual use exceeded 2.88 hectares. For threshing options, Closed drum power thresher was found profitable to the farmers when the annual use exceed 7.32 hectares. A computer simulation model was developed using Microsoft Visual Basic 6.0 language for easy computation and selection of minimum cost inputs and economic set of machines and implements on the basis of farm size. Agricultural Engineers and DAE personnel may use this expert system as a guiding tool for suggesting farmers for Boro rice cultivation in Bangladesh.

Key words : Minimum cost inputs, Economic machines and implements, Selective farm holdings, Boro rice cultivation

1. Introduction

Agricultural mechanization has long been recognized as an important event to increase farm outputs and as a suitable strategy for overall agricultural development. The goals of mechanization are to increase the profitability of farming and to remove drudgery associated with labour intensive agricultural activities. Machinery is a major capital cost in mechanized farming and thus the reduction of costs and maintenance of the environment is major challenges for modern agricultural enterprises (Jannot *et al.*, 1994). Appropriate inputs, machinery and power selections are of important part of rice production. The main aim of power and machinery selection studies is to complete a certain field operation during a specified time and at a minimum cost (Ghassan *et al.*, 1986, Duniak *et al.*, 1991). The studies revealed that better selection of equipment could reduce fuel and labour requirements, particularly for tillage and fertilizer distribution. In practice, farmers depend on their experience or recommendation of other farmers or input dealers when selecting power tillers, tractors, engines, implements and other inputs. The success of many farm-level production systems depends on wise selection of inputs and machinery systems (Rahman *et al*, 2008). At present Bangladesh is thriving as self-sufficiency in cereal production. To sustain this production growth development of mechanization is imperative. Appropriate mechanization strategy formulation is an urge of the time for efficient use of agricultural machines and implements, and other inputs available at farmers' level. It is expected that the findings of this study would be helpful for the farmers involved in Boro rice production to select appropriate inputs and options for machines and implements, and boost up agricultural mechanization in Bangladesh. Considering the problems stated above the following specific objectives were formulated to give proper direction of the study:

1. To determine the important minimum cost input options for Boro rice cultivation.

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2. To develop a computer simulation model for selecting the minimum cost input options for Boro rice cultivation in Bangladesh.

2. Methodology

The concept of selective agricultural mechanization primarily deals with the choice of power sources and associated implements and machines for farm operations. Proper selection of suitable machinery is crucial to the profitability of farm considering the cost of owning and using. Economic selection of agricultural machinery is usually a complex problem because of the variations in farm sizes and differences in agro-climatology. In view of the above complexity, a methodology is developed in this study to assist in evaluating and selecting appropriate set of machines for mechanization of rice based farms in terms of economic benefits of the farmers. Secondary data from various sources were mostly used in this piece of research. Some essential operational data were collected from primary sources through a survey designed for this purpose. An interview schedule was developed and data collected from key informants through personal interview during December '07-February '08. The data were scrutinized by the specialists in the relevant field.

2.2 Criteria for selection of Boro rice variety

Boro rice varieties were selected based on the production per unit area, minimum crop duration and popularity of the variety. The Boro season was selected because of its inherent maximum input demand for production.

2.3 Criteria for selection of fertilizer application techniques

There are several practices for fertilizer application at farmers' level such as application of fertilizer according to the recommendation of agricultural scientists, at the whim of the farmers, use of granular nitrogen fertilizer, leaf color chart (LCC) etc. LCC is one of the best practices for fertilizer application. LCC is a tool that helps farmers to improve their decision-making processes in nitrogen (N) management. It is an ideal tool to optimize nitrogen (N) use at reasonably high yield levels. Therefore, LCC was used to determine the amount of nitrogen fertilizer needed to optimize the Boro rice yield.

2.4 Operating cost

Operating costs are recurring costs that are necessary to operate and maintain a machine during its useful life (White *et al.*, 1989). Annual operating costs of machinery were divided into fixed costs and variable costs. All calculated fixed costs and variable costs were converted into Tk./ha and then the operating costs in Tk./ha was determined by the summation of fixed and variable costs. For determining operating cost (Tk./ha) of manual operation only the number of man-days and labour rates were considered. Appropriate rates, insurance, taxes and interest were considered to estimate operating costs of machines, implements and practices for various operations.

2.5 Comparative economic analysis

Comparative economic analysis was done considering operating cost (Tk./ha) of different inputs, machines and implements for particular field operations. The information obtained from a comparative economic analysis can be of considerable aid to any degree of uncertainty concerning the value of some parameters especially annual use (ha) of specific machines.

2.6 Criteria for selection of machines and implements

The minimum cost flow problem provides a unified approach to many other applications because of its far more general structure. It holds a central position among network optimization models, both because it encompasses such a broad class of applications and because it can be solved extremely efficiently (Hillier *et al.*, 1990). For the selection of a set of machines and implements for different operations, minimum operating cost, capacities of machines and implements, farmer's access to machines & implements and farm sizes were taken into consideration. For definite farm size a set of machines and implements were selected according to minimum operational cost among different technological options. Alternative technological options were also considered according to the farmer's choice.

2.7 Computer modeling

The computations involved in determination of the economic set of machines according to the annual operating cost depending in relation to farm size which is a very tedious job. In order to facilitate a broad-based solution, a computer program was written using Microsoft Visual Basic 6.0. This program can compute the minimum cost machines or implements for each level of operation for selective farm size.

The following equations were used in computer program for calculating operating cost:

$$m = 1 + \frac{(f_s - n)}{n}$$

Where, m = No of initial fixed cost
f_s = Farm size, ha
n = Farm size after which additional cost of machine should be added, ha

$$op\_cost = \frac{init\_fixedcost \times m}{fs} + var\_cost$$

where
op_cost = Operating cost for each technological option, Tk./ha
init_fixedcost = Initial fixed cost, Tk./yr
m = No of initial fixed cost
var_cost = Variable cost, Tk./ha.

After getting the alternative operating cost of machines and implements, minimum cost machine or an implement was found out from each technological option by sorting technique. The total operating cost was determined according to minimum operating cost of machines and implements from tilling to threshing. Then the total production cost of Boro rice was determined as the summation of minimum cost machine and implement inputs and other non-machinery inputs.

The following equation was used in computer program for calculating the total production cost of Boro rice:

Total production cost = Seed cost + min_oc_till + min_oc_irri + Fertilizer cost + min_oc_seeder + min_oc_weed + min_oc_ferti + min_oc_spra + min_oc_harv + min_oc_thres.

Where, Total production cost = Total production cost from seed to threshing, Tk./ha
Seed cost = Seed cost depending upon the farmer's choice, Tk./ha
min_oc_till = Minimum operating cost from different tillage options, Tk./ha
min_oc_irri = Minimum operating cost from different irrigation options, Tk./ha
Fertilizer cost = Fertilizer cost depending upon the farmer's choice, Tk./ha
min_oc_seeder = Minimum operating cost from different seeding/transplanting options, Tk./ha
min_oc_weed = Minimum operating cost from different weeding options, Tk./ha
min_oc_ferti = Minimum operating cost from different fertilizer application options, Tk./ha
min_oc_spra = Minimum operating cost from different spraying options, Tk./ha
min_oc_harv = Minimum operating cost from different harvesting options, Tk./ha
min_oc_thres = Minimum operating cost from different threshing options, Tk./ha.

For the selective farm size farmers have alternative options to choose their desired access of machines, implements and other inputs, and able to know the total operating cost (Tk./ha) from tilling to threshing. Systematic approach for computer programming is given in Fig. 1.

3. Results and Discussion

3.1 Selection of rice variety

The rice varieties, BRRI dhan 28 and BRRI dhan 29 were selected in terms of crop duration, production per unit area and popularity in the country. The seed rate of both BRRI dhan 28 and BRRI dhan 29 was 25 kg/ha. The cost of seed for BRRI dhan 28 and BRRI dhan 29 were found Tk. 675 per ha and Tk. 625 per ha, respectively for the year February 08.

3.2 Selection of fertilizer application techniques

The amount of fertilizer needed could be determined by two techniques namely Leaf Color Chart (LCC) and traditional practice. The fertilizer cost by using Leaf Color Chart (LCC) for BRRI dhan 28 and BRRI dhan 29 were found Tk. 5795 per ha and Tk. 7000 per ha, respectively. The cost of fertilizer by using traditional practice for BRRI dhan 28 and BRRI dhan 29 were found Tk. 6370 per ha and Tk. 7585 per ha, respectively for the year February 08.

3.3 Comparative cost analysis of tilling options

Direct comparison between the costs of alternative tilling methods was found difficult as they involved different methods, qualities of operation and other variables. Nevertheless, a comparison was found useful for determining the financial feasibility of alternative methods. Fig. 2 shows cost per ha of cultivation over the relevant range of farm sizes. Custom-hire service of tractor with implement was found beneficial to most farm holdings in Bangladesh. The study also suggested that the ownership of tractor with implement was profitable if farm holding was larger than 8.29 hectares.

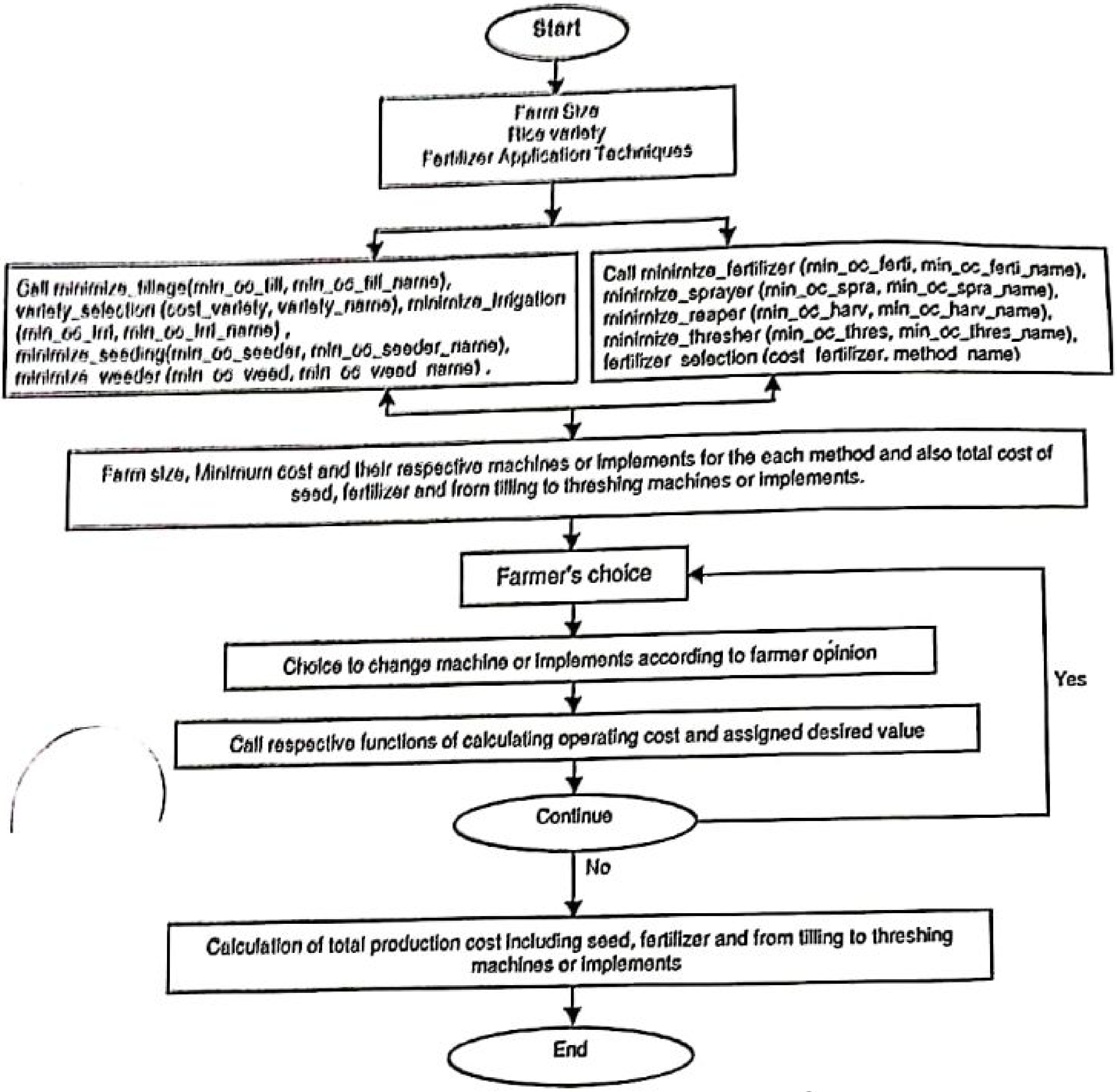

Fig. 1. Flow chart for selecting set of minimum cost inputs, machines, techniques and implements depending on farmer's choice and farm size

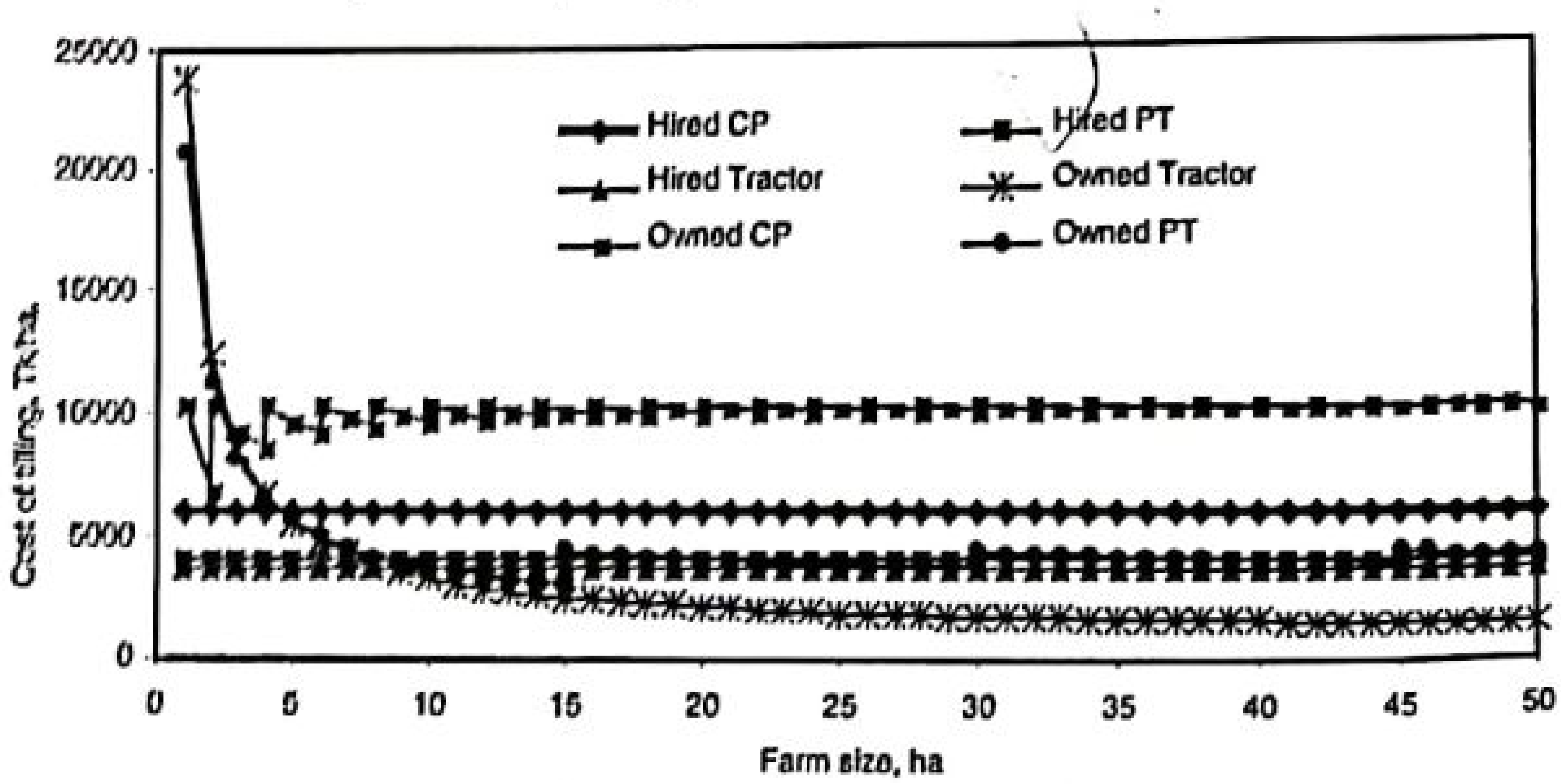

Fig. 2. Comparative cost of different tilling methods

3.4 Comparative cost analysis of irrigation options

The Comparative cost analysis for owned STW, hired STW, owned DTW and hired DTW is presented in Fig. 3. Hired DTW and STW were found profitable for the farm size less than 2 hectares and owned STW was found profitable for the farm sizes in the range 2 to 3 hectares. Hired DTW was also found profitable for the farm sizes in the range 3 to 11 hectares and owned DTW was found profitable for the farm size greater than 11 hectares.

3.5 Comparative cost analysis of seeding/ Transplanting options

The comparative cost analysis of manual transplanting and Drum seeding is presented in Fig. 4. The cost of manual transplanting was estimated considering the present wage of labour, which was Tk. 140 per day. Fig. 4 showed that a farmer having only one hectare of land incurred an operating cost of Tk. 5250 per ha for Manual transplanting and the cost of Drum seeding was Tk. 716.68 per ha. The operating cost of Drum seeder at all farm holdings was less than manual transplanting. Therefore, Drum seeder was recommended for all categories of farms provided that the land is suitable for drum seeding.

3.6 Comparative cost analysis of weeding options

The comparative economic analysis of manual weeding and Japanese Rice weeder is presented in Fig. 5. The cost of manual weeding was estimated considering the present wage rate of labour, which was Tk. 140 per day. Fig. 5 showed that a farmer having only one hectare of land incurred an operating cost of Tk. 3450 per ha for manual weeding and cost of Japanese Rice weeder was Tk. 1158.33 per ha. The operating cost of Japanese Rice weeder at all farm holdings was less than manual weeding. Therefore, Japanese Rice weeder was recommended for all categories of farms.

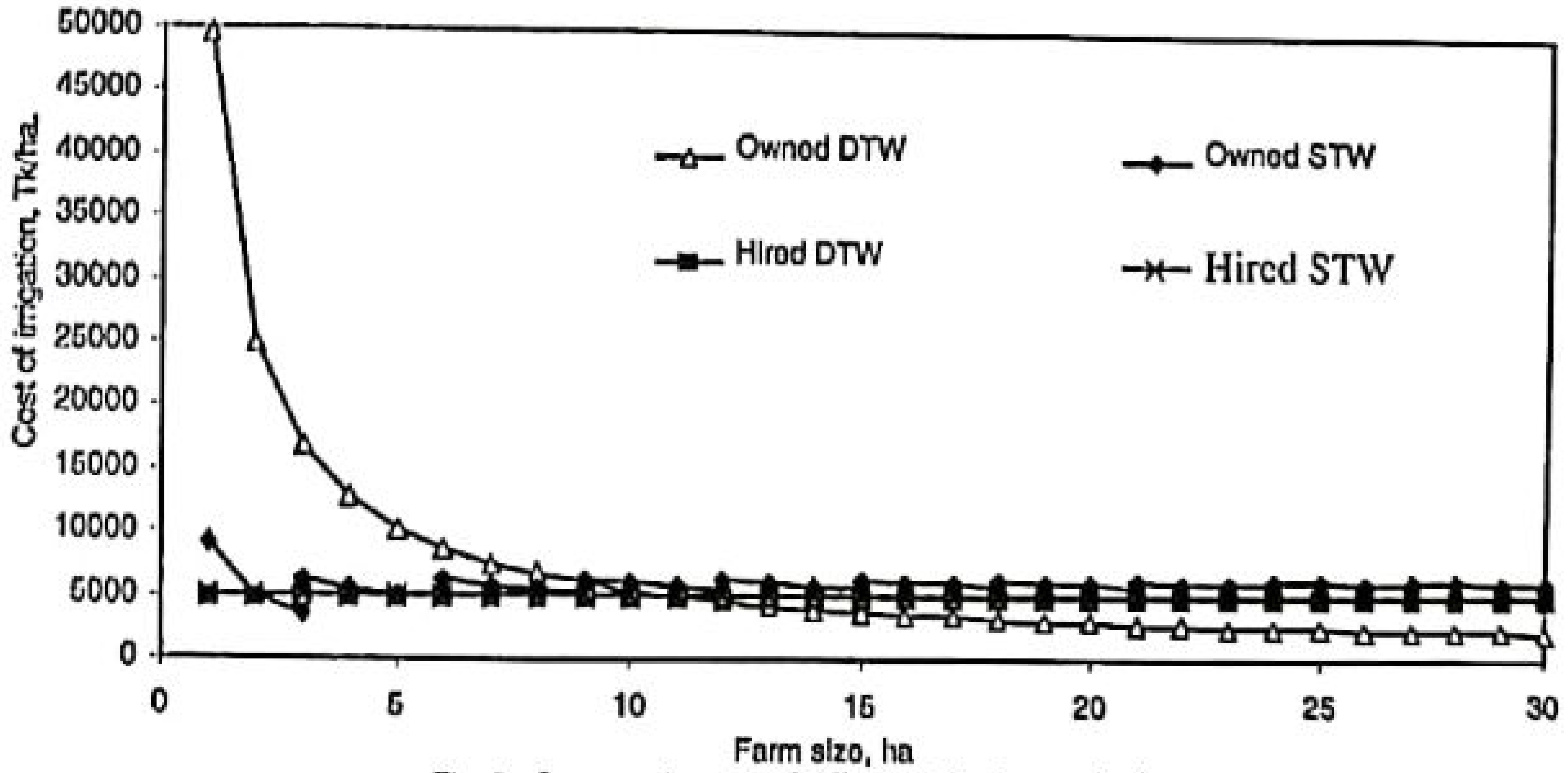

Fig. 3. Comparative cost of different irrigation methods

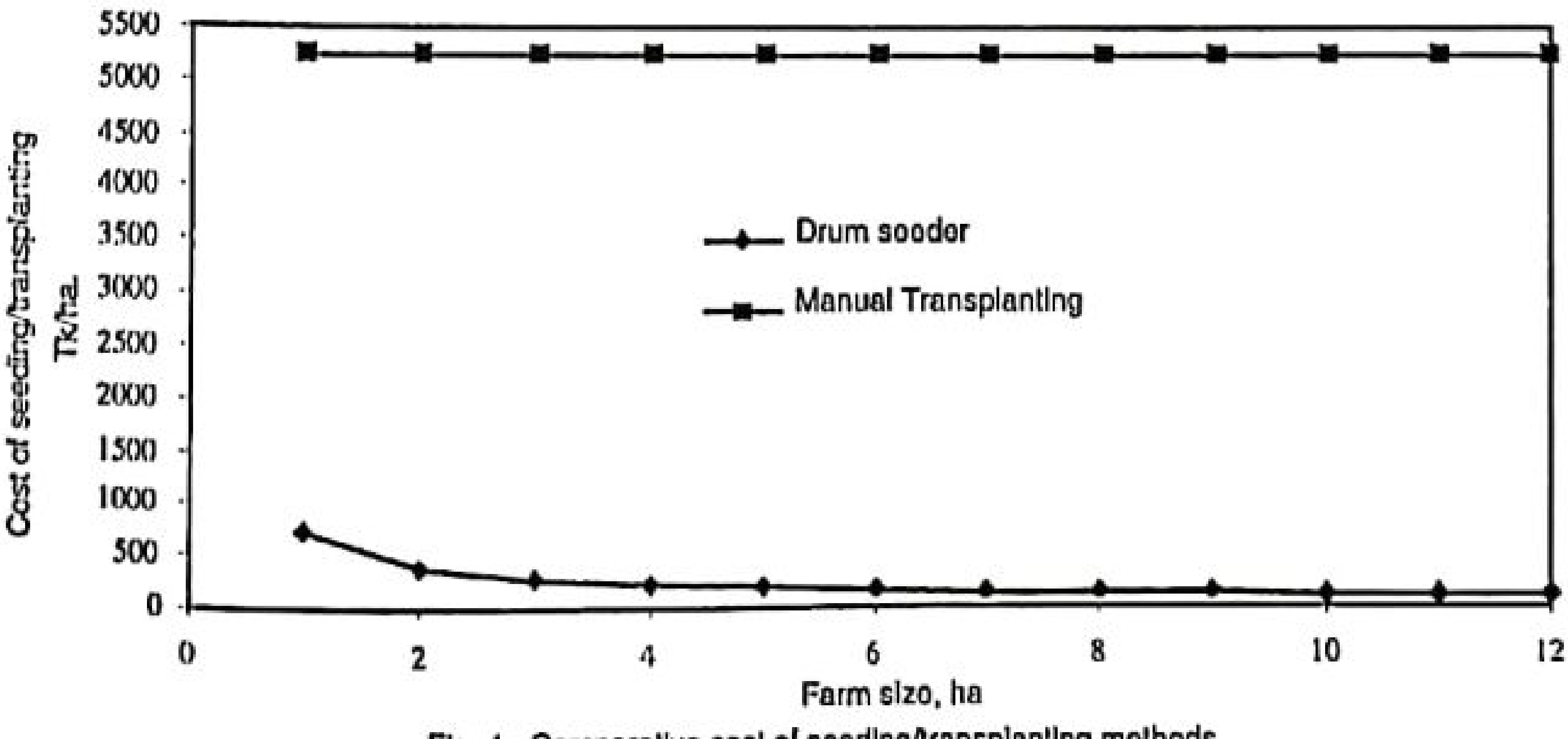

Fig. 4. Comparative cost of seeding/transplanting methods

3.7 Comparative cost analysis of fertilizer application options

The comparative economic analysis for distribution of fertilizer by manual and BAUzia fertilizer distributor is presented in Fig. 6. The cost of manual distribution was estimated considering the present wage of labour, which was Tk. 140 per day. Fig. 6 showed that a farmer having only one hectare of land incurred a operating cost of Tk. 1251.25 per ha when BAUzia fertilizer distributor was used and cost of manual distribution was found Tk. 1120 per ha. Therefore, BAUzia fertilizer distributor could be beneficial to the farmers when the annual use exceeded 1.12 ha and in those cases farmers were advised to use BAUzia fertilizer distributor over manual distribution.

3.8 Comparative cost analysis of spraying options

Fig. 7 showed that a farmer having only one-hectare land incurred operating cost of Tk. 717.5, Tk. 872.5 and Tk. 1560.67 per ha for Hand sprayer, Compression sprayer and Knapsack sprayer, respectively. Spraying with Compression sprayer and Knapsack sprayer could be beneficial to the farmers when the annual use exceed 2.05 hectares and 5.71 hectares, respectively. On the other hand, Hand sprayer could be beneficial to the farmers when the annual use is limited to 2.05 hectares.

3.9 Comparative cost analysis of harvesting options

The Comparative cost analysis for owned reaper, hired reaper and manual harvesting is presented in Fig. 8. The cost of manual harvesting was estimated considering the present wage of labour, which was Tk. 250 per day. Fig. 8 showed that the operating cost of harvesting with hired reaper was found Tk. 1850 per ha and the cost of manual harvesting was found Tk. 4000 per ha. The analysis indicated that owned reaper could be beneficial to the farmers when the annual use exceeded 12 ha. On the other hand, hired reaper could be beneficial to the farmers when the annual use is limited to 12 hectares.

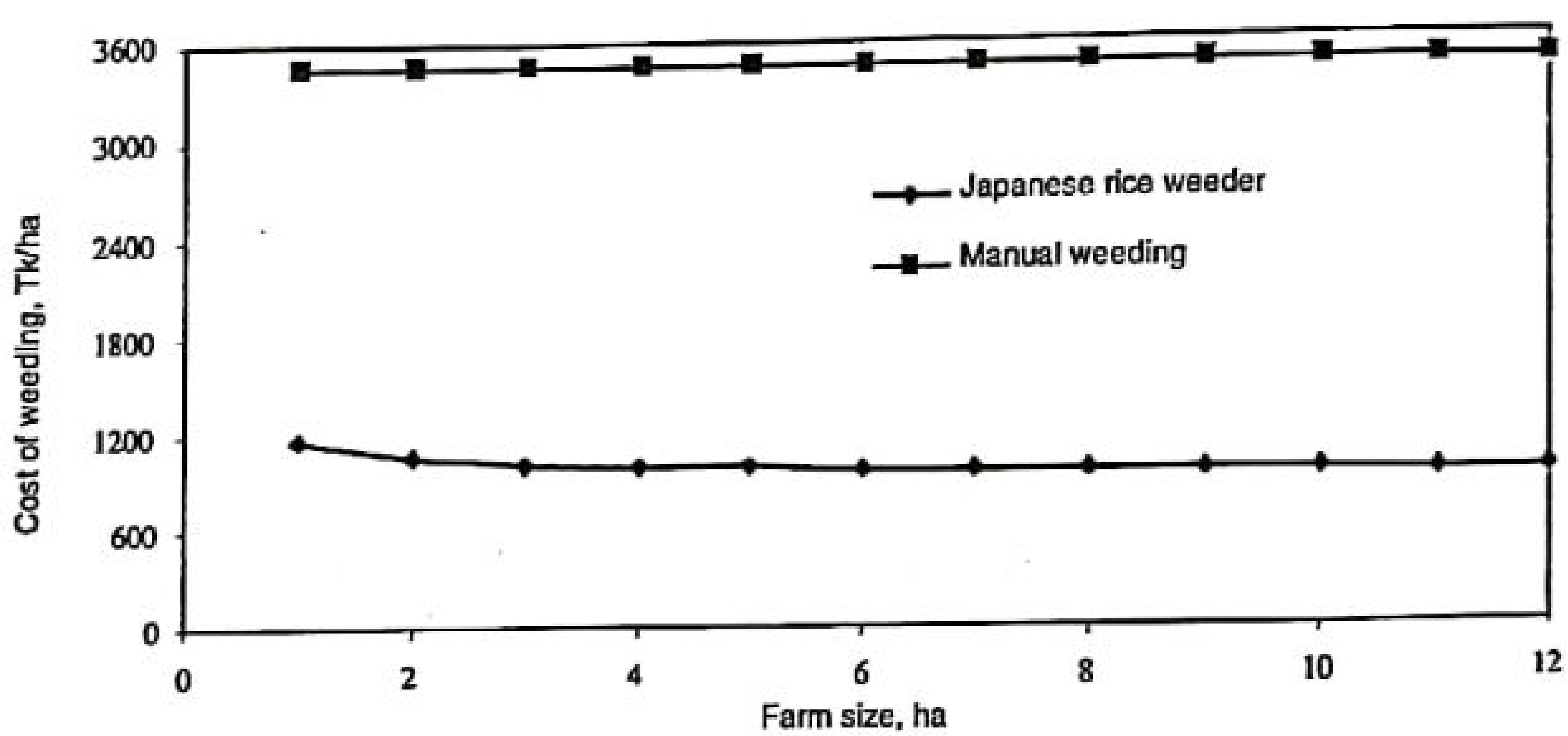

Fig. 5. Comparative cost of weeding methods

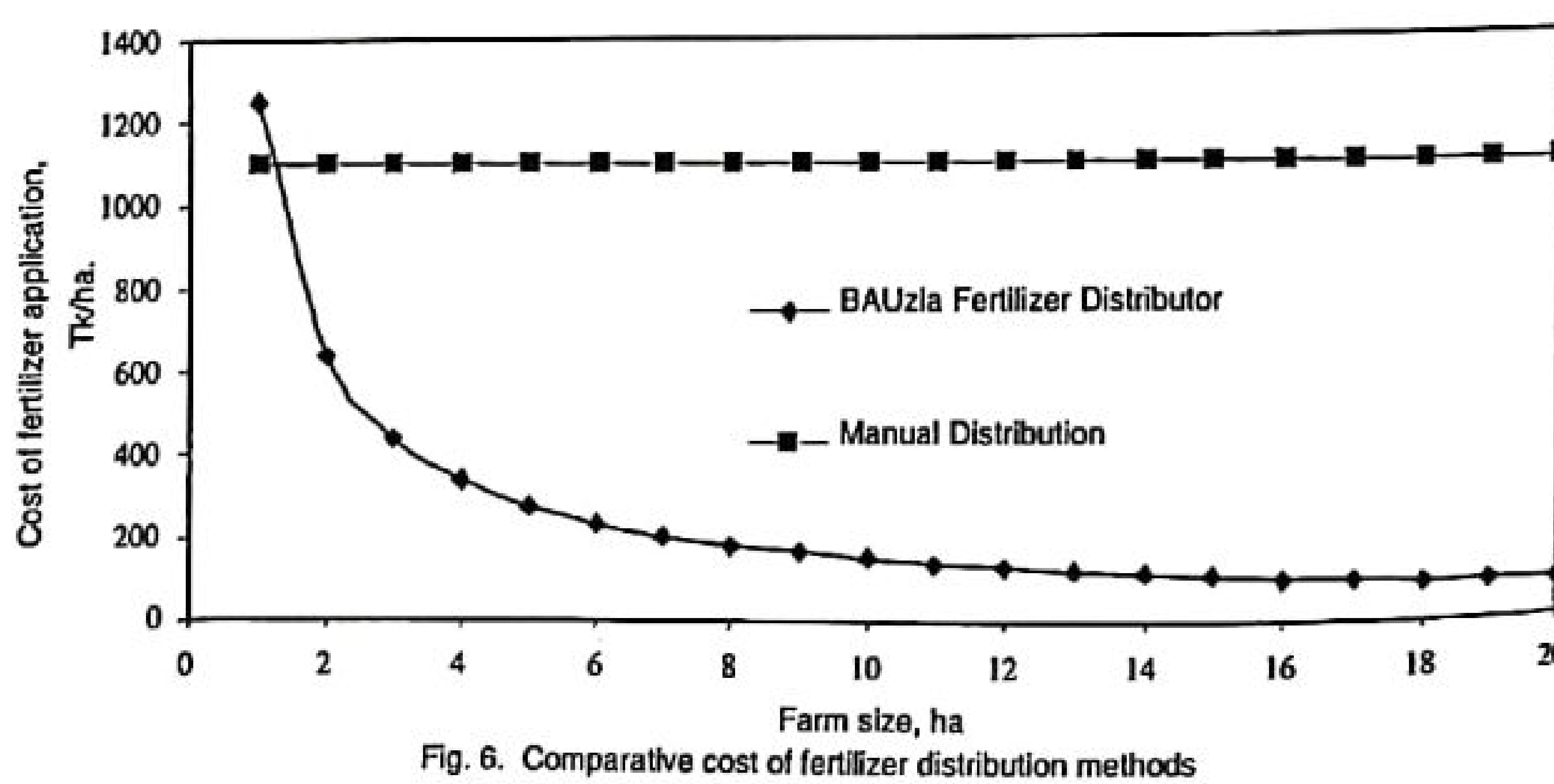

Fig. 6. Comparative cost of fertilizer distribution methods

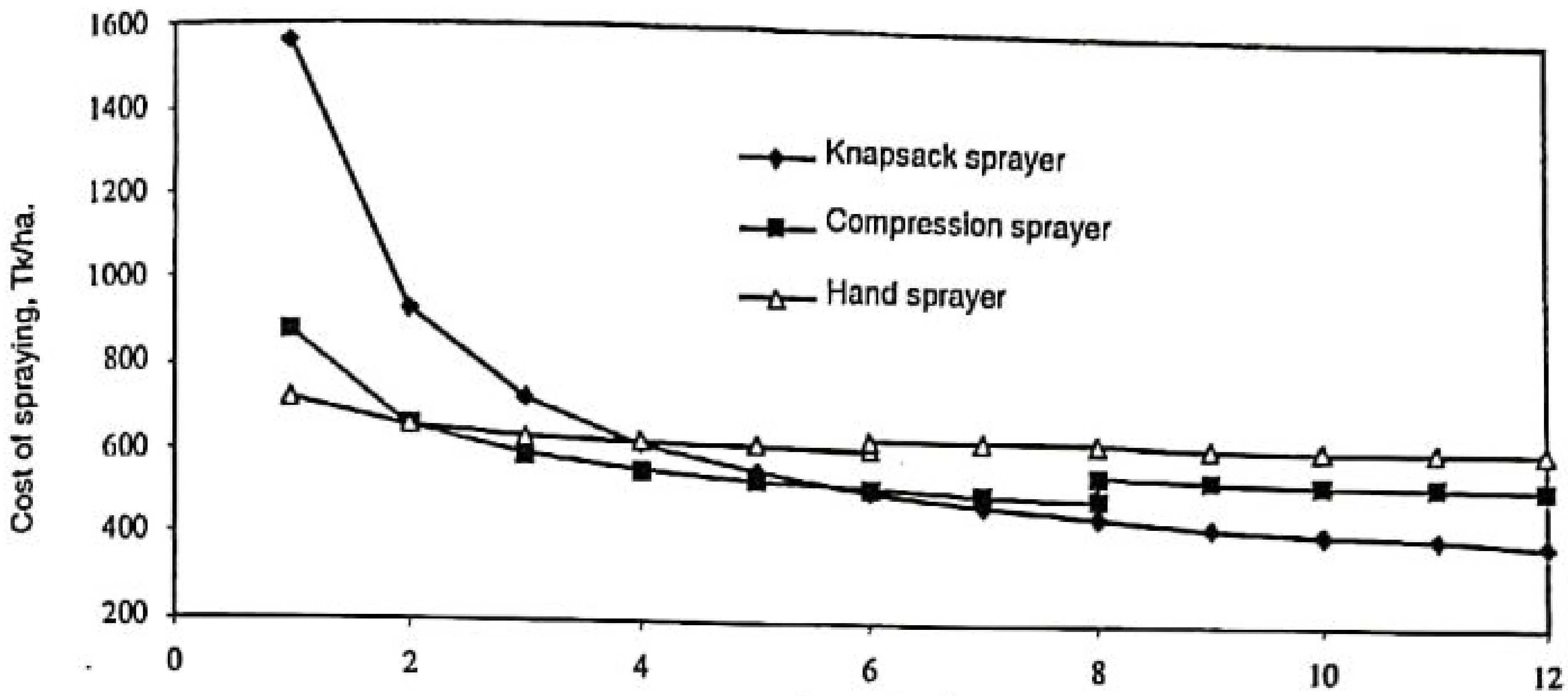

Fig. 7. Comparative cost of different spraying methods

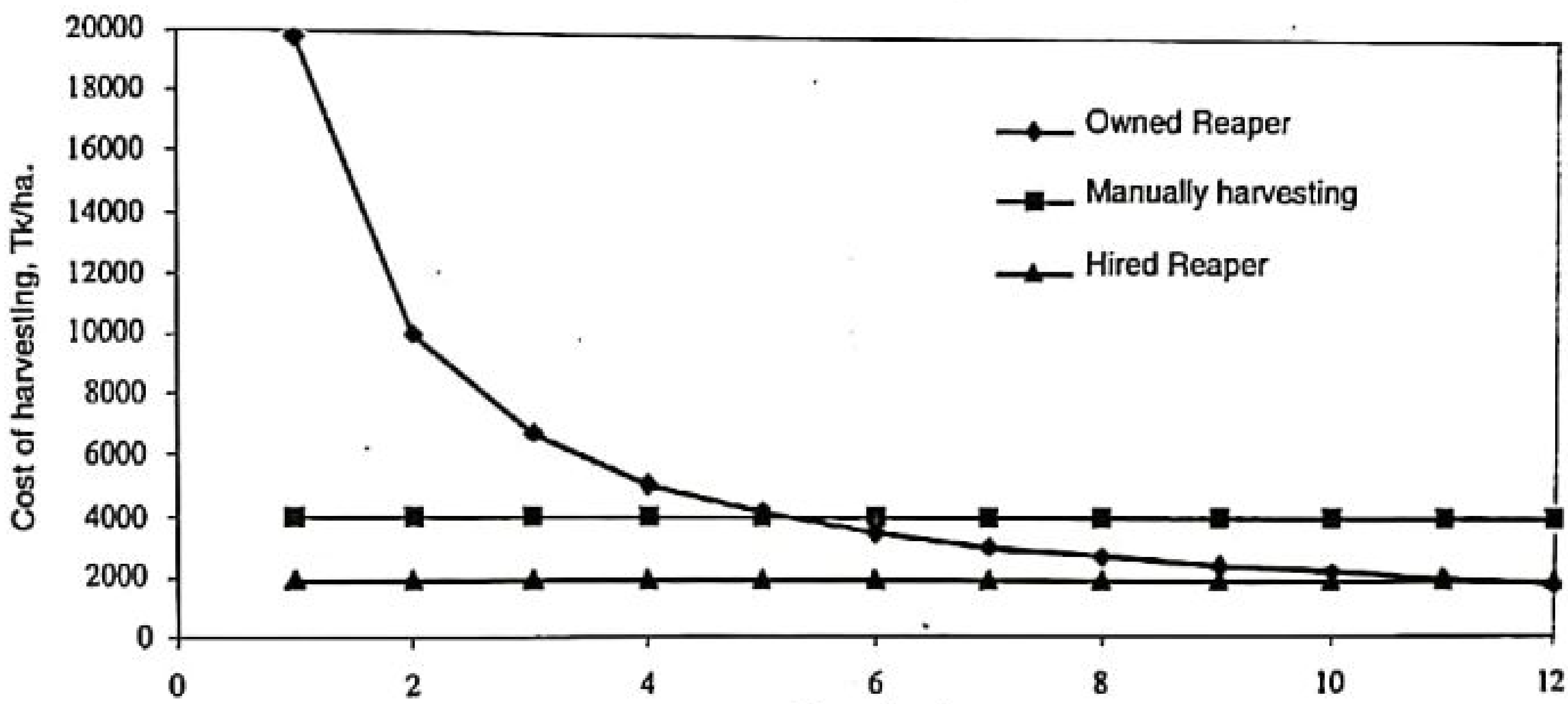

Fig. 8. Comparative cost of harvesting methods

3.10 Comparative cost analysis of threshing options

Fig. 9 showed that a farmer having only one hectare land incurred threshing cost of Tk. 14838.09, Tk. 5268.15, Tk. 5756.48, Tk. 10707.45 and Tk. 2250 per ha for traditional manual threshing, pedal thresher, open drum power thresher, closed drum power thresher and hired power thresher, respectively. Operating cost of hired power thresher at all farm holdings was found less than other threshing options and recommended for all categories of farms.

3.11 Computer model

A computer model was developed for selection of minimum cost inputs and selection of economic set of machines and implements from tilling to threshing operations for the farmers according to their farm sizes. The model is able to provide information on operating cost (Tk./ha) for tilling to threshing. The advantage of this model is that the model can accommodate alternative choice of farmers in all input events. Sample outputs for a farm size of 2.95 hectares of the computer model are given in Fig. 10.0 to 10.1. On the basis of farm size, the computer model is able to show the minimum cost of inputs and economic set of machines and implements accommodating farmer's options for different inputs and machines along with their individual and cumulative operating costs.

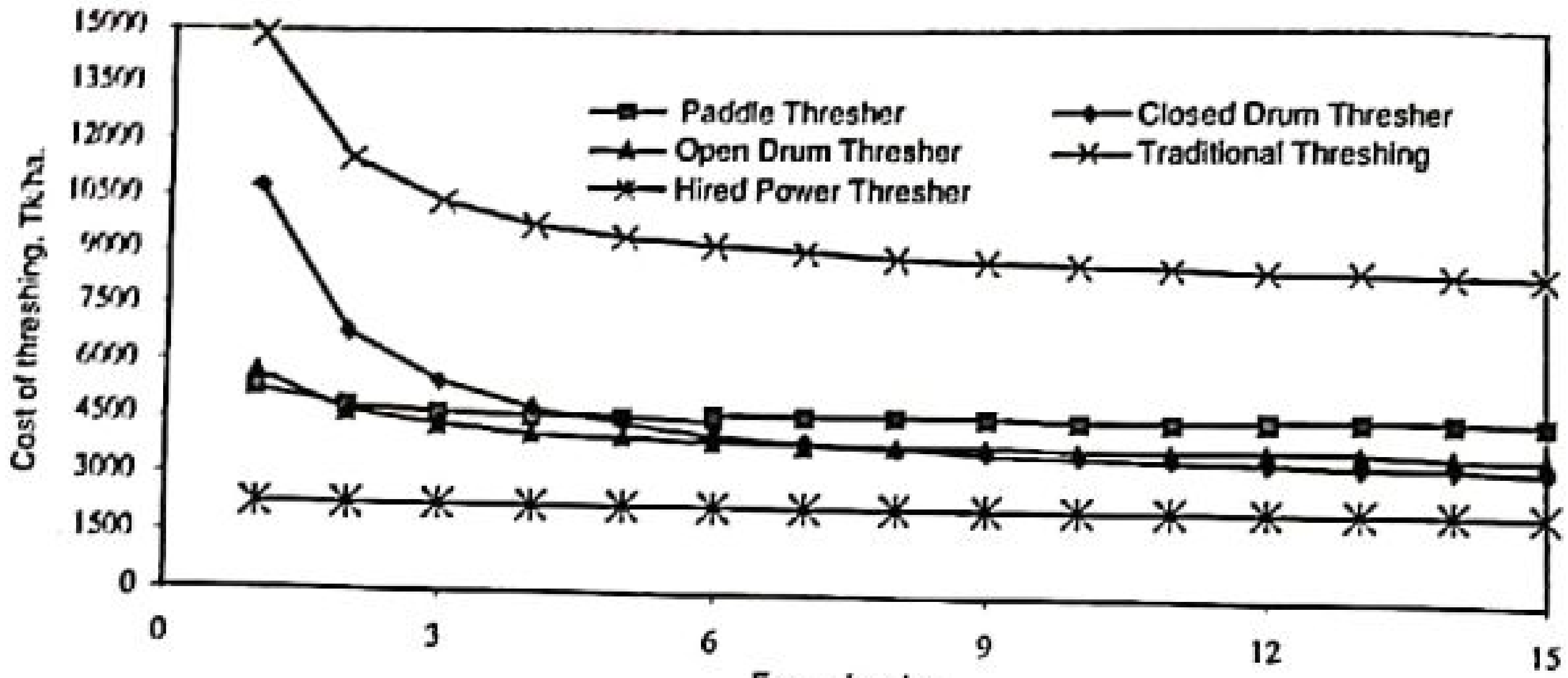

Fig. 9. Comparative cost of different threshing methods

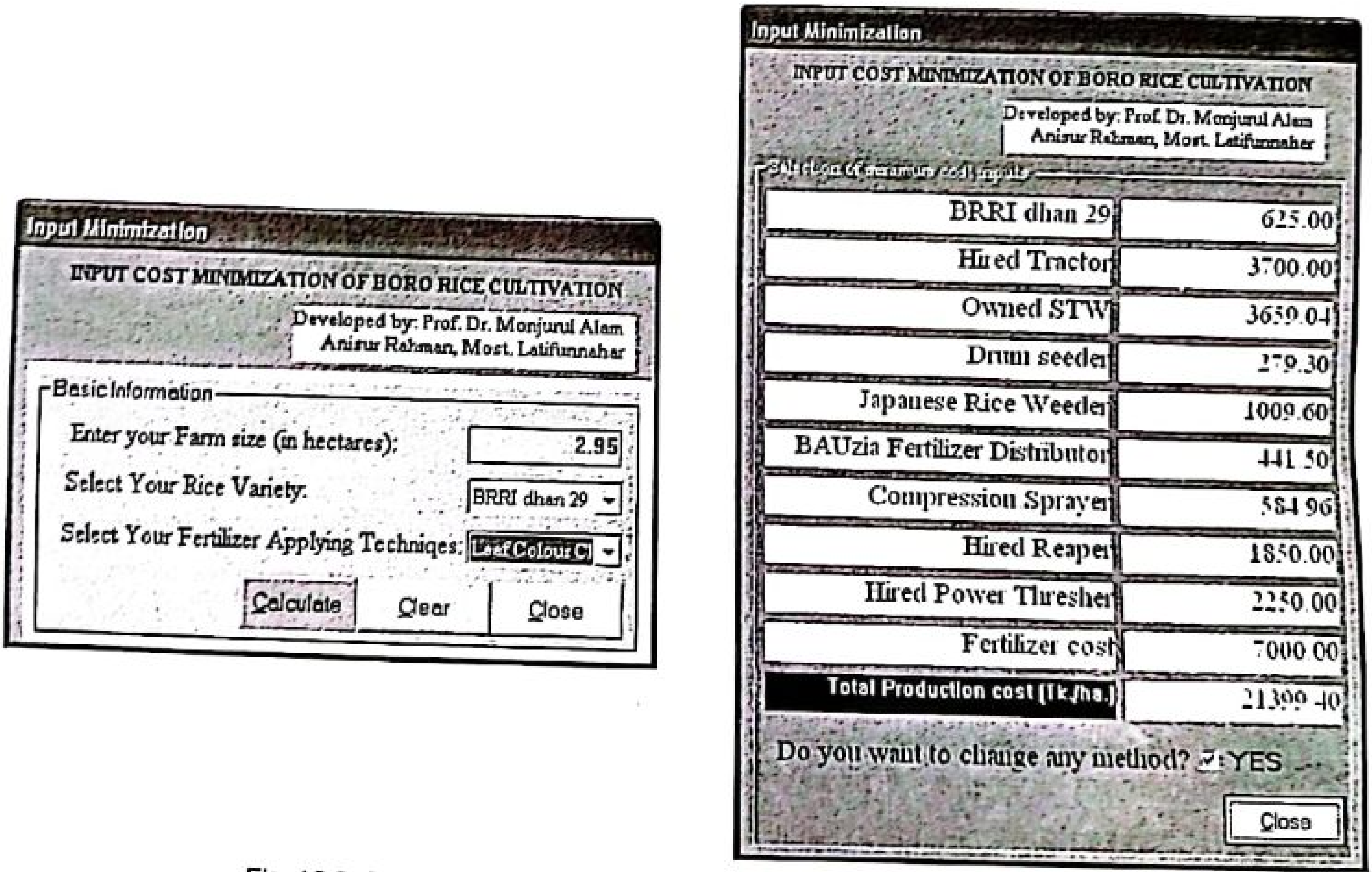

Fig. 10.0. An example output for a farm size of 2.95 hectares of the computer.

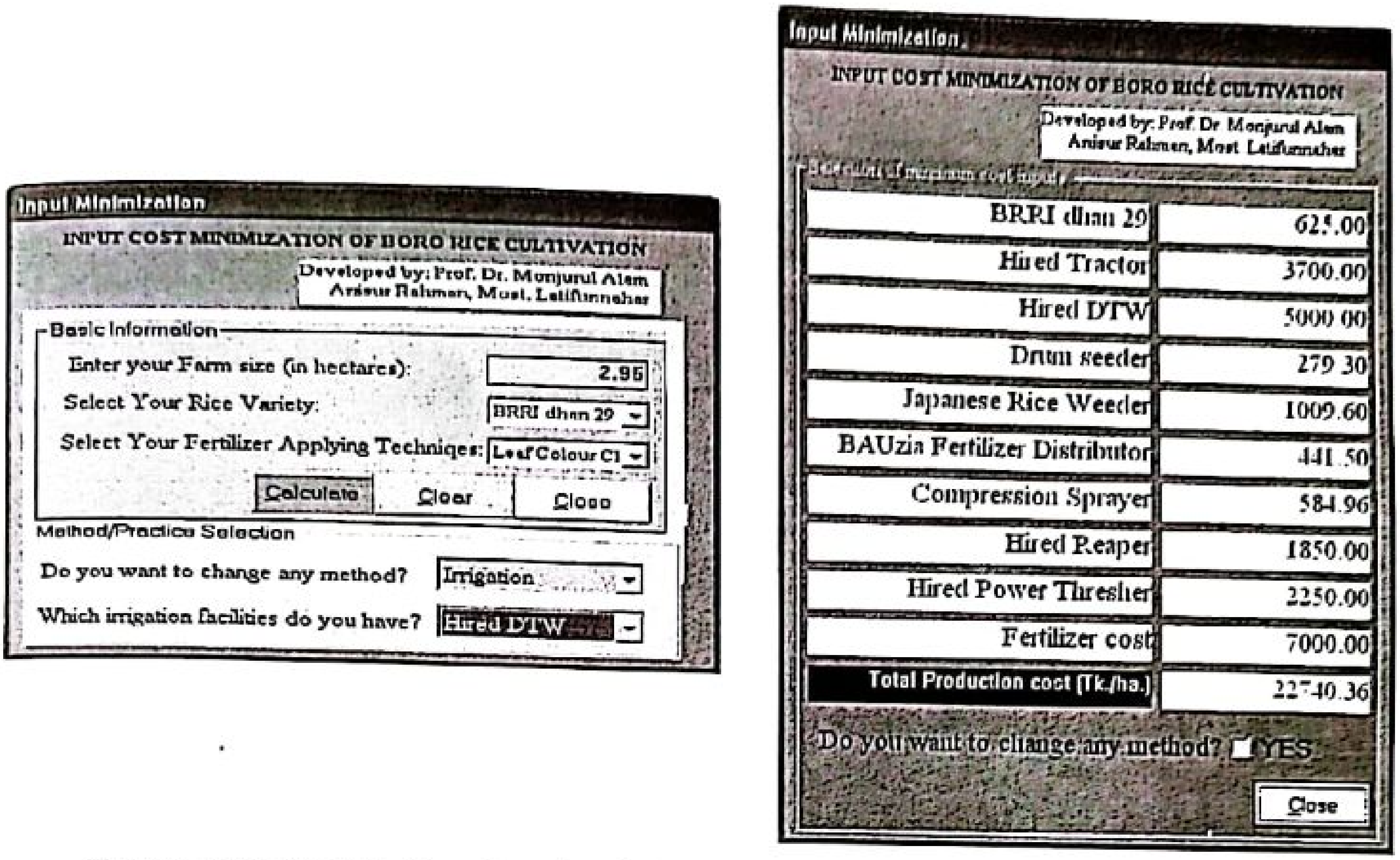

Fig. 10.1. A sample output for a farm size of 2.95 hectares of the computer changing option according to the farmers choice.

4. Conclusions

The financial profitability of different input options for Boro rice production were estimated through economic analysis in order to select minimum cost inputs on the basis of farm size as an useful means of suggesting farmers for the extension officers working at the lower tire of the administration. The development of the computer model also provide an added advantage to facilitate farmers led advisory service personnel to help farmers in selecting minimum cost input options for Boro rice cultivation.

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