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AN EXPERT SYSTEM FOR SELECTION OF ECONOMIC MACHINES FOR MODERN RICE CULTIVATION IN BANGLADESH

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Abstract: The complexity and magnitude of the machinery selection problem in the analysis of crop production systems have led to numerous efforts to develop models as decision aid. In this paper an attempt has been made for appraisal of financial profitability and selection of economic set of machines and implement related to modern rice cultivation in Bangladesh condition. Considering the minimum operating cost, capacity of alternatives for each operation, size of annual operational farm holdings and farmers access to the machines, a procedure was developed to select an economic set of machines for each farm holdings using conceptual framework of critical path method. A computer simulation model was developed in Borland C++ language for easy computation and selection of economic set of machines and implement on the basis of farm size. The Computer model is capable of providing the individual and the cumulative cost of operations and able to accommodate farmer's options for specific machines at different operations.

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 remove drudgery associated with labour intensive agricultural systems. Machinery is a major capital cost in mechanized farming and thus, the reduction of costs and maintenance of the environment are major challenges for modern agricultural enterprises (Jannot *et al.*, 1994). Selection of appropriate mechanization system is a complex procedure. Theoretically, the selection of any technology starts with an assessment of the job to be done e.g. tillage, planting etc. The second step is to determine what tool, implement or equipment alternatives are available to do the job in the most effective way and efficient manner, and to make a choice accordingly (FAO, 1990). In addition to the above points there are two other considerations often become more prominent: (i) what levels and types of mechanization are appropriate? and (ii) how the advantages of mechanization be made available to the farmers ? These need careful considerations of the socio-economic conditions and cultural practices existing in the community. Positive and negative aspects of selective technology must be balanced. In all cases criteria for the technology must include technical factors (operational suitability); managerial suitability; financial and economic benefits; social aspects like income, employment, equity and poverty; environmental aspects of stability and degradation; and cultural and political objectives (Morris *et al.*, 1992). Technology selection based on the above criteria would further match with farmers' goal, practices and circumstances.

The selection of technology is prime importance for modern farm machinery

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management that will improve timeliness of farm operations and facilitate farm expansion where land is available. Gradual evolution of agricultural mechanization from hand-tool technology through animal draught technology (where appropriate) to engine power technology is based on a careful analysis of the situation for which a programme of agricultural development is being planned. The key to progress is the identification and application of the appropriate and economic machines for individual farmers. Farmers of Bangladesh have options for the selection of machines and implements from tilling to threshing for rice production. For sustainability of those machines and implements, it should be economically viable for different farm holdings. Therefore, selection of economic set of machines from tilling to threshing for different farm sizes, cost of operations, farmers' access to alternative machines and implements were felt important for sustainable mechanization in Bangladesh. In view of the urgent need for proper understanding of the situation, a study was felt necessary to select appropriate set of machines and implements for rice based farm holdings of Bangladesh. At present Bangladesh is thriving as self-sufficient in cereal production. To sustain this development, mechanization is inevitable. Appropriate mechanization strategy formulation is an urge of the time for efficient use of agricultural machines and implements available at farmers' level. It is expected that the findings of this study would be helpful for the farmers involved in rice based crop production to select appropriate machines and implements, and speed up the agricultural mechanization in Bangladesh. Considering the above facts the following specific objectives were formulated to give proper direction of the study.

1. To appraise an economic set of machines and implements for modern rice cultivation in representative farm holdings of Bangladesh.
2. To develop a computer simulation model for selection of an economic set of machines and implements for rice based farm holdings of Bangladesh.

Methodology

The concept of selective agricultural mechanization primarily deals with the choice of power sources and associated implements or machinery for farm operations. Proper selection of suitable machinery is crucial to the profitability of the farm considering the cost of owning. Therefore, economic selection of agricultural machinery is usually a complex problem because of the variations in farm sizes and differences in agro-climatology. Thus, methodologies were developed to assist in evaluating and selecting appropriate set of machines for mechanization of rice based farms in terms of economic benefit of the farmers. Secondary data from various sources were mostly used in this piece of research. Some essential data were collected from primary sources through a baseline survey involving key informants (farmers, machine owners, operators, mechanics, manufacturers and traders of machines, sub-assistant agricultural officers, extension personnel etc.) through personal interview during November, 2001-March, 2002. The data were verified by the specialists in the relevant field.

Operating Cost of Machine

Operating costs are recurring costs that are necessary to operate and maintain an item during its useful life (White *et al.*, 1989). Annual operating costs of machinery were divided into fixed costs and variable costs. The annual fixed cost and the variable cost were calculated in Tk./ha and the summation of them provided the operating cost in Tk./ha.

For manual farm operations, the annual fixed cost was considered as zero, since the farmers or labourers own the hand tools. The cost of owning of hand tools was therefore

considered as the part of the labour cost. Consequently, the operating costs of manual operations considered only the number of man-days and labour rates. Appropriate rates, insurance, taxes and interest were considered to estimate operating costs of machines and implements for various operations.

Comparative Economic Analysis

Comparative economic analysis was done considering operating cost (Tk./ha) of different machines/methods for the particular field operations. The information obtained from a comparative economic analysis can be of considerable aid to any alternative investment decision involving a degree of uncertainty concerning the value of some parameter especially annual use (ha) of specific machines.

Selection Criteria for 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). The selection of set of machinery and implements for different operations, minimum operating cost, capacities of machines and implements, farmer's access to machines & implements and farm size were taken into consideration. For a definite farm size, a set of machines and implements were selected according to minimum operational cost among different technological options. Farmer's options for alternative technologies were also given due considerations.

Computer Modeling

The computation involved in determination of the economic set of machines and implements based on the annual operating cost for different farm sizes is a very tedious job. In order to facilitate a broad-based solution, a computer program was written in Borland C++ language. The program is able to compute minimum cost machines and implements for each level of operation for definite farm size.

The following computational equations were used to determine the operating cost of an individual operation:

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

Where, op_cost = Operating cost for each technological option (Tk/ha); init_fixed_cost = Initial fixed cost (Tk/yr); var_cost = Variable cost (Tk/ha).

$$m = \frac{fs}{n} + 1$$

Where, fs = Farm size (ha); n = Farm size after which an additional fixed cost of machinery should be added (ha); m = no of initial fixed cost.

Having operating cost of machines and implements, minimum cost machine or an implement for a certain land holding was found out for each technological option by sorting technique. The cumulative operating cost was than determined according to minimum operating cost of machines and implements from tilling to threshing. Simple equation was used for calculating cumulative operating cost as follows:

total_oc = min_oc_ till + min _ oc _ trans + min _ oc _ ferti + min _ oc _ irri + min_oc_spra + min_oc_weed + min_oc_harv + min_oc_thres

Where,

total_oc = Total operating cost from tilling to threshing for definite farm size, Tk/ha

min_oc_till = Minimum operating cost from different tillage options, Tk/ha

min_oc_trans = Minimum operating cost from seedling and trans-planting options, Tk/ha

min_oc_ferti = Minimum operating cost from different fertilizer application options, Tk/ha

min_oc_irri = Minimum operating cost from different irrigation options, Tk/ha

min_oc_spra = Minimum operating cost from different spraying options, Tk/ha

min_oc_weed = Minimum operating cost from different weeding 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

The computer program is devised so that, for a definite farm size, it can accommodate farmer's options based on access to alternative machines and implements. This program is also capable to identify the most economic set of machines and implements with their individual and cumulative operating costs. Systematic approach of the computer program is shown in Fig. 1.

Results and Discussion

This study was undertaken to find out economic set of machines and implements for rice based farm holdings of Bangladesh. Initially, economic feasibility of different technological options was studied. Later a computer model was developed to determine the economic set of machines and implements with individual and cumulative estimation of operating costs for definite land holdings. The model was also capable to accommodate farmer's options based on access to alternative machines and implements.

Comparative cost analysis Tilling options

Direct comparison between the costs of alternative tilling method 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 the operating cost per ha of cultivation over the relevant range of farm sizes. It is important to mention that almost 93% of small holders in Bangladesh have holdings less than 2 ha and almost 98.73% of the total farm holdings are below 4 ha (BBS, 2001). Therefore, custom-hire service of PT is likely to be benefited to most farm holdings of Bangladesh. The study also suggested that the ownership of PT was profitable if the size of farm holding was larger than 8.6 hectares. Tractor power was too expensive for less than 45 hectares. PT ownership for small farm holdings may also prove profitable if the extra capacity of the PT is hired out after fulfilling the demand of the farm.

Fertilizer application options

The results of comparative economic analysis (comparison of manual and seed fertilizer distributor) are presented in Fig. 3. The cost of manual fertilizer application was estimated considering the present wage of labour, which was Tk. 100 per day. Fig. 3 showed that a farmer having only one hectare of land incurred a fertilizer application cost of Tk. 382 per hectare when seed fertilizer distributor was used and the cost of manual fertilizer application was Tk. 741 per hectare. The cost of mechanical fertilizer application decreased exponentially from 1-7 ha, above 7 hectare the cost was found almost constant. At any stage mechanical fertilizer application was found much superior over manual operation. Therefore, seed fertilizer distributor may be recommended for all categories of farms.

Irrigation options

The comparative economic analysis for owned STW, hired STW, owned DTW, hired DTW are presented in Fig. 4. Owned STW was appeared as the best option for all farm holdings. Owned DTW was found profitable for the farm size greater than 12

hectares and if STW was not available in the locality or where ground water table was beyond the reach of STW.

Spraying options

Fig. 5 showed that a farmer having only one hectare land incurred an operating cost of Tk. 486, Tk. 607 and Tk. 836 per hectare for hand, compression and knapsack sprayers, respectively. With the increase in annual use (of land) the cost of spraying decreased exponentially. Therefore, spraying with compression and knapsack sprayer could be beneficial to the farmers when the annual use exceed 2.1 hectares and 3.1 hectares, respectively. On the other hand, when the annual use level was less than 2.1 hectare, the use of existing hand spraying technique was found beneficial for the farmers.

Weeding options

The comparative economic analysis for weeding options is presented in Fig. 6. The cost of manual wedding was estimated considering the present labour wage level in Bangladesh, which was Tk. 100 per day and the operating cost of Push Pull Weeder and manual fertilizer application was Tk. 1295 and Tk. 2600 per hectare, respectively. The operating cost curve of Push Pull Weeder had shown almost a straight line because of minimum purchase price. The operating cost of Push Pull Weeder at all farm holdings was less than manual weeding. Therefore, Push Pull Weeder may be recommended for all categories of farm holdings.

Harvesting options

The comparative economic analysis of harvesting options is presented in Fig. 7. The cost of machine harvesting decreased exponentially from 1-7 ha, after that the cost reduction was only slight, and above 2 hectares of annual use the self-propelled reapers were found economic compared to manual harvesting. Therefore, harvesting with reaper could be beneficial to the farmers when the annual uses exceed 2 ha and farmers are advised to use reaper over manual harvesting. When the annual use level is less than 2 hectares the farmers are advised to continue with the existing manual harvesting technique.

Threshing options

Figure 8 showed that a farmer having only one hectare of land incurred a threshing cost of Tk. 6134, Tk. 2263, Tk. 2663 and Tk. 5806 per hectare for traditional, pedal, open drum and power threshing, respectively. The figure also revealed that threshing with open drum thresher could be beneficial to the farmers if the annual use exceed 2.8 hectare and farmers could be advised to own open drum thresher, rather farmers could continue with exiting pedal threshing option. In case of larger holdings and special circumstances e.g. in low laying areas where only panicles are harvested in the event of flood and natural disasters, close drum threshers may appear as suitable and could be recommended for the farmers.

Selection of Machines and Implements

For the selection of economic set of machines and implements for different operations of rice based crop production, minimum operating cost, capacities of machines and implements, farmer's access to machines and implements and farm size were taken into consideration. For a definite farm size, a set machines and implements was selected according to minimum operational cost among different technological options. Alternative technological options were also considered according to farmer's choice. An example of this model for the selection of economic set of machines and implements for a farm size of 2.2 ha is given in Fig. 9. Fig. 9 showed a typical set of minimum cost machines suggested by the model e.g. Hired PT for tilling, Owned STW for irrigation, Manual seeding and Transplanting (as there was no option), seed fertilizer distributor for fertilizer application, Compression sprayer for spraying, Push-pull weeder for weeding,

Reaper for harvesting and Pedal thresher for threshing. The total operating cost for the selected machines was Tk. 15,838 per hectare. If the farmer does not have owned STW, but access to hired DTW; the model showed the alternative operating cost would be Tk. 17,889 per hectare.

Conclusions

The comprehensive techniques used to determine the financial profitability of different technological options for rice based farm operations in order to select an economic set of machines and implements for different farm holdings caters 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 for prompt advisory service for the farmers by accommodating farmers options and access to certain machines and implements for selecting appropriate economic set of machines and implements.

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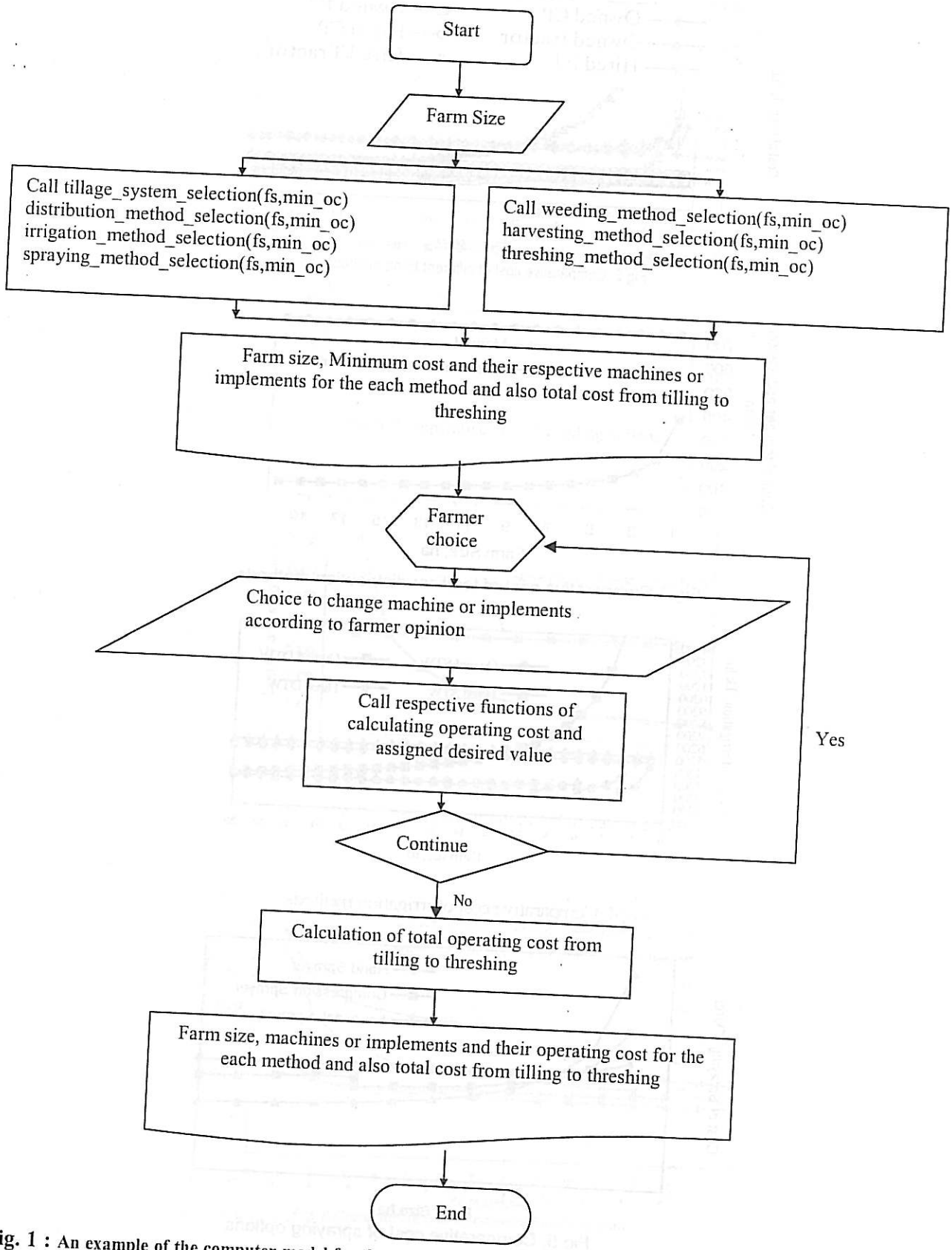

Fig. 1 : An example of the computer model for the selection of economic set of machines and implements for the farm size of 2.2 ha

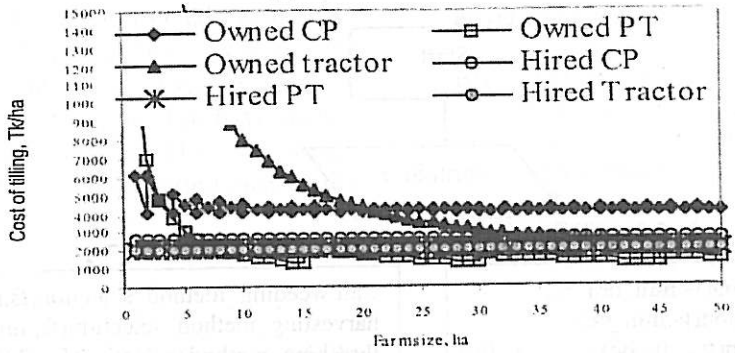

Fig 2. Comparative cost of different tilling methods

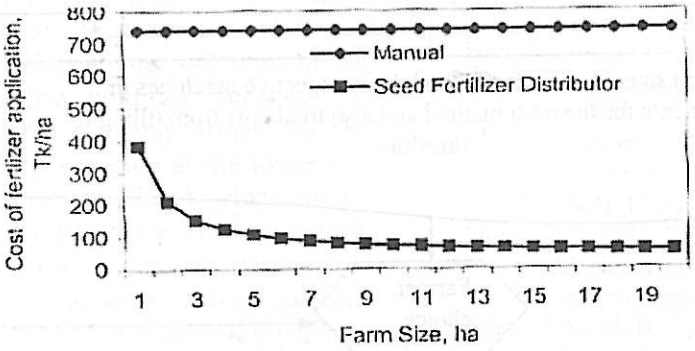

Fig 3 Comparative cost of fertilizer distribution methods

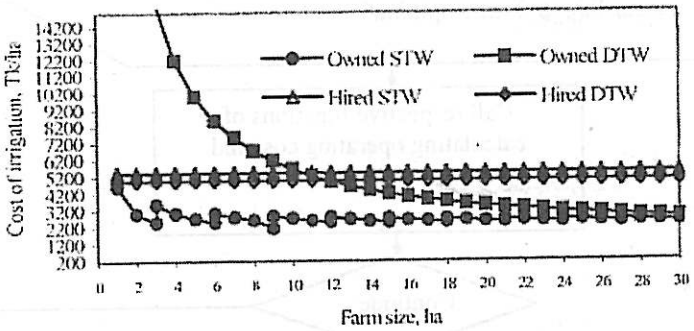

Fig 4. Comparative cost of irrigation methods

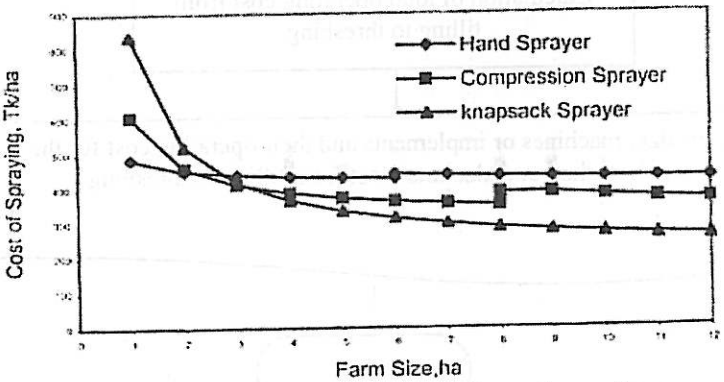

Fig 5. Comparative cost of spraying options

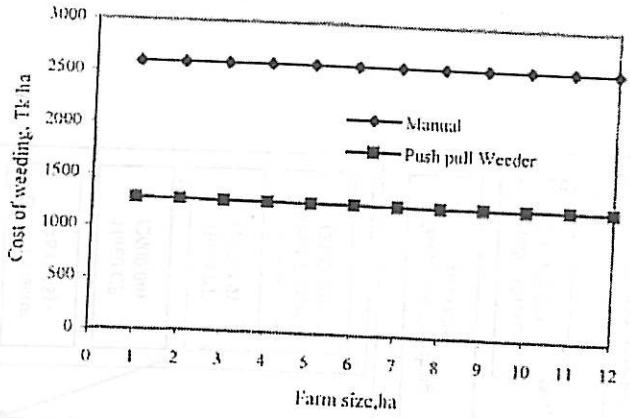

Fig 6. Comparative cost of weeding options

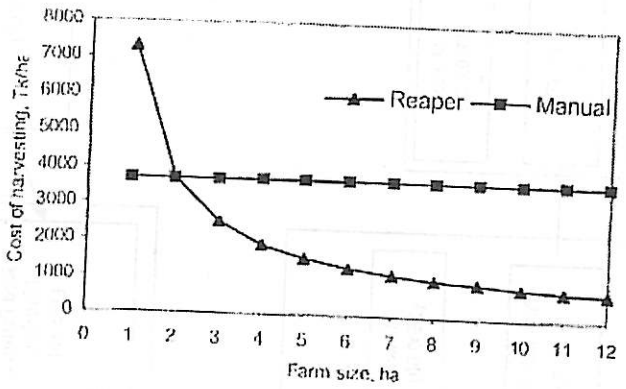

Fig. 7 Comparative cost of Harvesting options

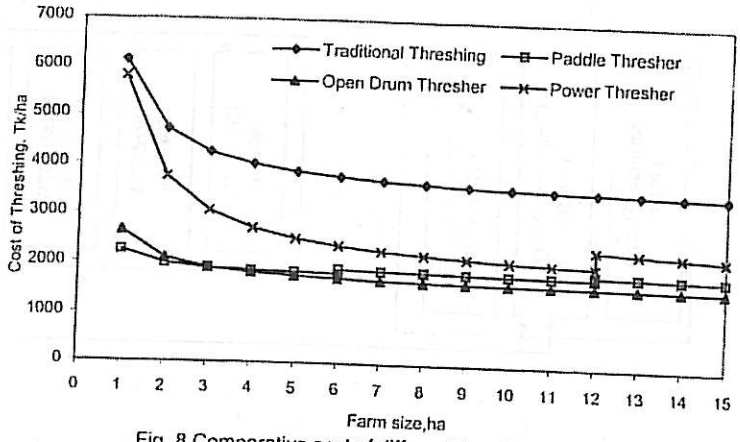

Fig. 8 Comparative cost of different threshing methods

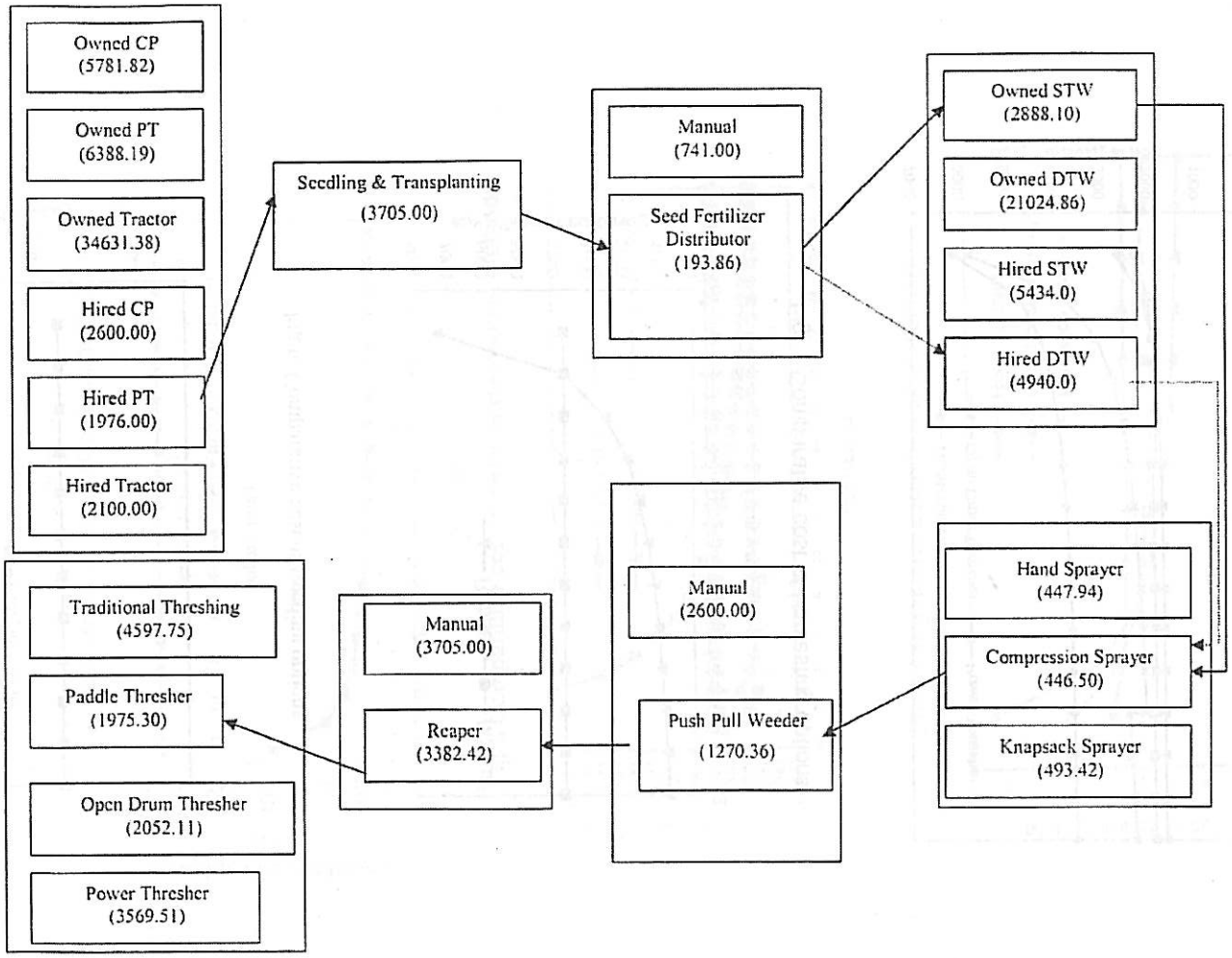

Fig. 9. An example of the computer model for the selection of economic set of machines and implements for the farm size of 2.2 ha

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