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On A Multistage Decision Making Model in Farming Industry

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Summary

This work utilises network analysis and dynamic programming in field preparation and its post operations in a farm. The object is to find out the combination of machines and methods to get optimum or near optimum cost policies for different size of holdings.

Key Words : Dynamic programming; network; node; stage; state; sensitivity analysis; simulation.

Introduction

Agriculture has now become an industry in India. Techniques of agricultural production have changed resulting in substitution of labor by machinery. This has led to a significant increase in the cost of farm inputs. A feature of agricultural production is a large number of different machines or methods for use in one operation. These machines and methods can be obtained in different ways leading up to a large number of feasible systems. Methods for determining combination of machines and methods at different stages of farm operation to obtain an optimum or near optimum systems are not fully explored. Some authors have dealt with decision-making in such systems by using both analytical and optimisation techniques. Link and Bockhop [5] have presented an analytical approach in scheduling a system of farm field machinery with requirements of farm and environmental conditions as major constraints. Link [4] has applied network techniques (NA) for farm machinery selection problem, thus allowing widest possible latitude in random variations of durations restricting the topological complexity of network. Sowell et al., [10] have developed returns by selection of farm machines. Boyce et al., [3] have developed computer algorithms to identify and evaluate optimum and near optimum systems based on NA and simple application of DP without any specific logic. The

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program is situation specific as the value of unit operation varies considerably from enterprise to enterprise. These applications do not provide sufficient explanation of their underlying structure and potential usefulness. Here, an agricultural problem has been identified and the utilisation of multistage DP model and NA technique explored with justification in a real world farming industry.

The main points are:

(a) to utilize multistage DP model and technique of NA to field preparation and its post operations in a farm, and

(b) to enable the farmer or farm manager to determine suitable combination of machines and methods for getting optimum or, near optimum cost policies i.e., preferred sub-optimal policies for carrying out different operations in different size of holdings within allowable time.

2. *Lowest cost model*

DP is a computational method for optimizing multistage (sequential) decision process (see Bellman and Dreyfus [2]). It determines combination of decisions at different stages of field preparation and its post operations which optimizes the overall effectiveness in a farming industry. The various operations in order to complete the project is represented in a network (arrow diagram) following Rao [8]. Arrows in a network from one node (circle) to another node show the direction of work. The node indicates different machines or, methods at different stages (point of time). The successive stages of a problem are separated by using the concept of state.

The problem is generalised as a discrete deterministic DP process. The state of the system is specified by a finite dimensional vector, the components of which assume a finite set of values. At each stage, there is a choice from only a finite set of decisions. The problem of determining an N-stage policy is to optimize the prescribed function of final stage which becomes completely finite in nature and it is sensible to ask not only an optimal policy but also next best policy and so on. All policies leading to the minimum output are considered as optimal or first best, all policies leading to an output greater than optimum but atleast as small as all others as the second best and so on see [1].

Let, $g(x)$ = criterion function measuring value of final stage.

$((T_1\ (x))$ = set of allowable decisions resulting in transformations of the state of the system at each stage.

DYNAMIC NETWORK OF THE STUDY PROBLEM

0	1	2	3	4	5	6	7	8
Intial Stage	Field preparation	Sowing stage	Weeding and inter culture stage	Spraying and Dusting stage	Harvesting	Threshing	Drying	Final stage
(1) → → →	(1) → →	(1) → →	(1) → →	(1) → →	(1) → →	(1) → →	(1) → →	
		(2) → →	(2) → →	(2) → →	(2) → →	(2) → →	(2) → →	
	(2) → →			(3) → →	(3) → →	(2) → →	(3) → →	
		(3) → →	(3) → →		(4) → →	(4) → →	(4) → →	
	(3) → →	(3) → →						(1)
			(4) → →	(4) → →	(5) → →	(5) → →	(5) → → →	
		(5) → →	(5) → →					
		(6) → →	(6) → →		(6) → →	(6) → →		
		(7) → →	(7) → →		(7) → →			
		(8) → →						
		(9) → →						
		(10) → →						

FN (x) = return from an N–stage process obtained, using an optimal policy, starting with a system in state x.

$$N = 1, 2, 3 \ldots$$

In usual fashion the relation is developed as,

$$f_1 (X) = \min_{1} g (T_1 (X)) \tag{1}$$

$$f_N (X) = \min_{1} f_{N-1} (T_1 (X)) \tag{2}$$

$$(N = 2, 3, \ldots)$$

where $f_{N-1} (T_1 (X)) = f_1 (X) + g (T_1 (X))$ (3)

Then introducing the function,

$f_N^{(k)} (X)$ = return from an N–stage process with the system initially in state x, using kth best policy.

A kth best policy produces a return which is greater than all 1st, 2nd, . . ., (k – 1) th best policies but which is atleast as small as the return produced by all other policies.

In particular,

$$f_N (X) = f_N^{(k)} (X) \tag{4}$$

The application of the principle of optimality leads to the following relations.

$$f_N^{(k)} (x) = \min_{1} k (f_{N-1}^{(1)} (T_1 (X)),$$

$$f_N^{(2)} (T_1 (X)) \ldots, f_{N-1}^{(k)} (T_1 (X))$$

$$(N = 2, 3, \ldots)$$

$$f_1^{(k)} (X) = \min_{1} k\, g (T_1 (X)) \tag{5}$$

3. *Material*

Some assumptions made are as follows:

(a) The farmer or farm manager has willingness and resources to go for most economical combination or for any of the combinations.

(b) The result may not be an indicator of the present trend in field preparation and its post operations, rather it may be a guideline to initiate programmes on these lines so far as technology is concerned.

(c) Sufficient inputs are made available to achieve reasonable crop yield.

(d) In situations, where timeliness and independence in scheduling of the operation are less important, the farmer may have the option for custom hiring or joint ownership, whichever is convenient.

Seven stages namely field preparation, sowing, weeding and interculture, spraying and dusting, harvesting, threshing and drying are considered. Various stages have been justified on importance of each stage on paddy crops independently and sequentially. Central Farm of Orissa University of Agriculture and Technology is taken as experimental place. The data of cost of machine, depreciation, interest, insurance, housings and tax were considered fixed cost, where as data of repair and maintainance cost of machine, fuel consumption, oil lubricants, operating cost, profit, speed of travel and rated width of implement were taken for total variable cost. Given, effective field capacity and average yield, procedures in working out different constants for finding fixed cost and variable cost were followed as given by Michael [6] and Sharmugham [9]. However unit cost for bullock for field preparation and various methods of drying were taken from farm records and test reports. The primary data were collected by personal communication with farm superintendent and skilled labourers of Central Farm [7]. The secondary data were collected by trained investigators from business houses in Cuttack and Bhubaneswar, concerned manufacturing agencies and test report of National Cooperative Development Organisation.

The combination of optimal systems for different holdings enable farmers to select a particular combination depending upon farm size, availability of facilities and psycho-economic limitations. The minimal and near minimal cost routes were considered for different holding size.

The constants of hyperbolic-function and capacities for methods of various stages are not illustrated due to paucity of space. A computer programme in Fortran is developed and tested at the Computer Centre of O.U.A.T.

Table. Some optimum and near optimum systems and their costs for n hectare farm holding

n	Cost	Field preparation	Sowing	Weeding and Interculture	Spraying and dusting	Harvesting	Threshing	Drying
1	114.72	1	7	6	1	2	3	5
1	114.72	1	7	7	1	2	3	5
1	114.73	1	7	6	1	1	3	5
1	114.73	1	7	7	1	1	3	5
2	186.84	1	7	6	1	2	3	5
2	186.84	1	7	7	1	2	3	5
2	186.84	1	7	6	1	1	3	5
2	186.84	1	7	7	1	1	3	5
2.5	250.98	1	7	6	1	2	3	5
2.5	250.98	1	7	7	1	2	3	5
2.5	250.99	1	7	6	1	1	3	5
2.5	250.99	1	7	7	1	1	3	5
3	309.76	1	7	6	1	2	3	5
3	209.76	1	7	7	1	2	3	5
3	309.77	1	7	6	1	1	3	5
3	309.77	1	7	7	1	1	3	2
5	358.02	2	7	6	1	2	3	5
5	358.02	2	7	7	1	2	3	5
5	358.02	2	7	6	1	1	3	5
5	358.02	2	7	7	1	1	3	5

n	Cost	Field preparation	Sowing	Weeding and Interculture	Spraying and dusting	Harvesting	Threshing	Drying
6	402.73	2	7	6	1	2	3	5
6	402.73	2	7	7	1	2	3	5
6	402.73	2	7	6	1	1	3	5
6	402.73	2	7	7	1	1	3	5
7	445.38	2	7	6	1	2	3	5
7	445.38	2	7	7	1	2	3	5
7	445.39	2	7	6	1	1	3	5
7	445.39	2	7	7	1	1	3	5
12	562.69	2	7	6	1	2	3	5
12	562.69	2	7	7	1	2	3	5
12	562.69	2	7	6	1	1	3	5
12	562.69	2	7	7	1	1	3	5

4. *Conclusions*

The farmer selects combination of his optimum cost of production depending upon cost limit, machine-availability, viability and his choice.

- The cost of production increases with increase in farm size for a particular combination of machines or methods, because many of the unit operations involve either human or bullock power or both.

- The tractor system of field preparation has not been found feasible due to high initial involvement.

- The field preparation by power tiller has been the lowest cost per unit operation along with GSFC seed drill, star weeder. Hand sprayer, Vaibhab sickle, Power operated multicrop thresher and mechanical drying (80, 150) for farm holding of 5 to 12 hectares.

- However, optimum combinations for 1 to 3 hectare farm holding remains same except replacing bullock system of field preparation as againt power tiller.

- The hand spraying always contributes to optimum combination because of its very low cost as compared to power spraying.

- It is worth that for one cost of production, a number of alternative combinations have been found. This gives a good chance to the farmer to decide the best feasible.

- The traditional method for bullock system has been found feasible upto 3 ha. farm holding only.

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