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A PROPOSED MODEL FOR REDUCING THE OVERALL INVENTORY CARRYING COST FOR PERISHABLE PRODUCTS

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Abstract:

The Vision of the Department of Food and Public Distribution (DFPD), Government of India is that every household in the country is enabled to become food secure at all times. An integrated production and distribution system includes facilities producing the products and number of warehousing products to the distribution centers. This problem is simultaneously finding the decision variables from various functions that have conventionally been optimized separately. The Government supplies the food products from warehouse to some distribution centres referred to as Mandal Level Stock Points (MLSP). Each MLSP in turn supplies materials to some associated Fair Price Shops (FPS) like Ration Shops and Cooperative Stores. A study on a multi level Public Distribution System (PDS) of warehouses like godowns, some distribution centres like MLSP's and a large number of retail servicing centres like FPS's were taken for this project. It is proposed to suggest a model to reduce the total overheads including ordering and reordering costs and inventory holding costs for smooth distribution of product from warehouses to MLSP's and to fair price shops. The proposed model has resolute at Food Corporation of India (FCI), the optimum ending inventory at the end of each time period, total variable cost estimate for FCI by considering realistic available data for implementation of Binary Particle Swarm Optimization (BPSO) technique. The total cost obtained for the PDS problem under consideration by BPSO method and it is observed that the total cost is reduced nearly fourty cores and 33.47 % of reduction when compared to the total cost of existing system.

Keywords: FCI, MLSP, FPS, PDS, Ordering Cost, Holding Cost

Introduction

Food Corporation of India was established to fulfill the objectives of procurement of agricultural products, its storage, movement, export if asked, disposal in case of excess amount, and quality control. FCI has five

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zones with each zone having its member state representing region. For example, South zone of FCI has five regions namely Telangana, Andhra Pradesh, Kerala, Karnataka and Tamilnadu regions. Both State and Central Governments in India are implementing many welfare schemes for benefit of poor people. One among most the popular schemes is the public distribution system, through which the Government distributes food grains like rice at subsidized prices through fair price shops to the public. The Government procures the rice stocks from millers and stores at their warehouses. The FCI supplies to some distribution centres referred to as mandal level stock points. Each MLSP, in turn supplies materials to some associated fair price shops. We have the distribution system like FCI warehouses, a small number of mandal level stock points and a large number of fair price shops which are, in sets, associated with each mandal level stock points. This is the structure of a multi echelon public distribution system. The procurement of rice by FCI, its storage, supply to mandal level stock points ordering/reordering by mandal level stock points for their respective demands, their storage and supplies to fair price shops, all these involve considerable expenditure. The procurement and record maintenance, under PDS in Chennai district was taken as a trial and error basis but not methodically. Sometimes total cost involved may be on higher side also. In this project the authors considered the planning of this distribution at FCI scientifically using techniques of inventory control and reduction of total cost.

Literature Review

Previous researches on freight distribution system concern mostly on private companies. Their anxieties are more often than not for minimizing distribution cost. A model has been proposed for finding out distribution centers of a two-stage distribution system which reduces overall cost which are concerned with the fixed cost for opening the distribution centers and also the operating cost. On the other hand, supply planning deals with decision of how to deliver the finished products to the customers respecting to meet their demands on time with minimum cost [1]. In routing problems, allocation of a product(s) from central location to multiple geographically dispersed customers using definite/ indefinite number of capacitated vehicles is considered. The decisions are when to deliver to each customer, how much to deliver to each customer at each time and how to serve customers using the vehicles [2]. Integrated production and delivery planning in the context of supply chain management has been under attention for the past few years. There might be two primary reasons behind this trend like positive effect of integrated production and allocation planning on profitability of supply chains and positive effect of integrated production and allocation planning on minimizing lead times and offering quicker responses to market changes [3]. An extension of a multi-agent transport modeling system was proposed to link between suppliers and receivers of commodities and also deals with the performance of each individual actor in the cargo allocation system, predominantly the interactions amongst freight agents [4]. Other significant issues which were raised to develop the efficiency of commodity allocation system are the use of logistics information systems [5] and the electronic trading [6]. A multi

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echelon location inventory model has been proposed to consider network design and inventory management for a single item at a time which is formulated a mixed-integer non-linear program [7]. It is solved in different ways, one of which is heuristic method which depends on initializations from convex relaxations and Lagrange relaxations. Hereby their formulations tackle both retailers and warehouse. Bilgen [8] presented an integrated production scheduling and truck routing model for a supply chain of fruit juice with different transportation modes. An improved clustering model was established for the latter problem with an algorithm based on a reactive tabu search for solving the clustering problem. Liu [10] addressed production, distribution, and capacity planning of global supply chains considering cost, responsiveness, and customer service level simultaneously. They developed a multiobjective Mixed-Integer Linear Program (MILP) with total cost, total flow time, and total lost sales as key objectives. Considering perishable products, production/inventory and distribution decisions are often studied separately.

Problem Statement

The food grains entitled to the households under public distribution system are distributed to each eligible household at the informed price, with maximum efficiency, in a most clear manner. The objective of the present paper is to minimize the total expenditure with respect to warehouses and MLSP's considering procurement costs, ordering/reordering costs and inventory holding cost for a planning horizon of twelve months in the year of 2014. The formulated problem is solved using BPSO technique through C++ code, which is tested on realistic data collected. It has been suggested that the best way to meet this problem is to set up district MLSP's which enable the reduction of wastage and holding cost of rice. In this research, the present PDS utilizes several owned go downs of FCI MLSP's and which are incurring cost of holding and ordering/reordering for the transport demands of all points, all of which are required to meet the necessary demand.

Methodology

The overall demand should be calculated initially based on the demand on the MLSP. The lot sizing problem that we considered can be described as follows. We have 'N' items to be produced in 'T' periods in a planning horizon such that a demand forecast would be attained. In a multistage production system, the planning horizon of each item depends on the production of other items, which are situated at lower levels. The resources for production and set up are limited and lead times are assumed to be zero. No shortages are allowed and demands are deterministic. Mathematical models for different lot sizing problems are formulated for the integration problem using capacity constraints, sequence dependent setup costs and times. The constraints that are included in the formulation are those of machines capacity, of non-simultaneity and of the classical inventory balance equation.

The uncapacitated single item no shortages allowed and single level lot sizing model is the simplest model in the inventory lot sizing problems. Lot

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sizing formulation for this kind of lot sizing problem takes the following objective function

$$\text{Min } \left(\sum_{i=1}^{n}(Ax_i + cI_i)\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

$i = 1, 2, 3 \ldots\ldots\ldots, n$

Where,

n= number of months i.e. 12

A= ordering cost per month and c= holding cost per unit per month

Subject to

$I_0 = 0 \qquad \forall\, i \ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$

$I_{i-1} + x_i\, Q_i - I_i = R_i \qquad \forall\, i \ldots\ldots\ldots\ldots\ldots\ldots \text{(3)}$

$I_i \geq 0 \qquad \forall\, i \ldots\ldots\ldots\ldots\ldots\ldots \text{(4)}$

$Q_i \geq 0 \qquad \forall\, i \ldots\ldots\ldots\ldots\ldots\ldots \text{(5)}$

$x_i \in \{0, 1\} \qquad \forall\, i \ldots\ldots\ldots\ldots\ldots\ldots \text{(6)}$

Where,

R_i = Net requirement for month i, Q_i = Order quantity for month i,

I_i = Projected inventory balance for month i,

X_i = 1 if an order is placed in month i and X_i = 0 otherwise.

In the above first equation, a penalty A is charged for each order placed along with a penalty c for each unit carried in inventory over the next period. Second equation guaranties that no initial inventory is available. Third equation is the inventory balance equation in which the order quantity Q_i covers all the requirements until the next order. Forth equation satisfies the condition that no shortages are allowed. And finally, fifth equation shows the decision variable xi to be either 1 (place an order) or 0 (do not place an order). It should be noted that initial inventory is zero, I_o=0, such that x_1=0 by equation-3 if R_i>0. Because of the minimization nature of the problem, the ending inventory at each period is minimized to avoid the penalty charge c, particularly I_n= 0.

Analysis and Results

A. Allotment of Rice for Various Divisions in Chennai District-2014

The allotment of rice to the various divisions of Chennai district for the year of 2014 is given in the following table 1 with the total allotment for every month in quintal. The ordering cost of rice is Rs. 1,00,000/- and the carrying cost per quintal is Rs. 5/- with the total cost of the rice of Rs. 500/- are considered for the analysis.

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Table 1. Rice allotment of various divisions in Chennai district for 2014

CHENNAI DISTRICT DIVISIONS					
Chennai North	Chennai South	Chennai Central	Chennai East	Chennai West	Total (Quintal)
49383	22180	25374	13320	26470	136727
46492	21771	24407	12810	25990	131470
46493	21770	24508	12910	26010	131691
47270	21680	24220	13120	25110	131400
47274	21820	24280	13110	44510	150994
47052	21054	24020	24350	13120	129596
47047	20956	24050	23970	12650	128673
47236	21056	24060	24110	12520	128982
47345	21148	24150	24120	12510	129273
47110	21089	24120	24310	12880	129509
47090	21072	24110	24310	12990	129572
47214	21091	24120	24330	13100	129855

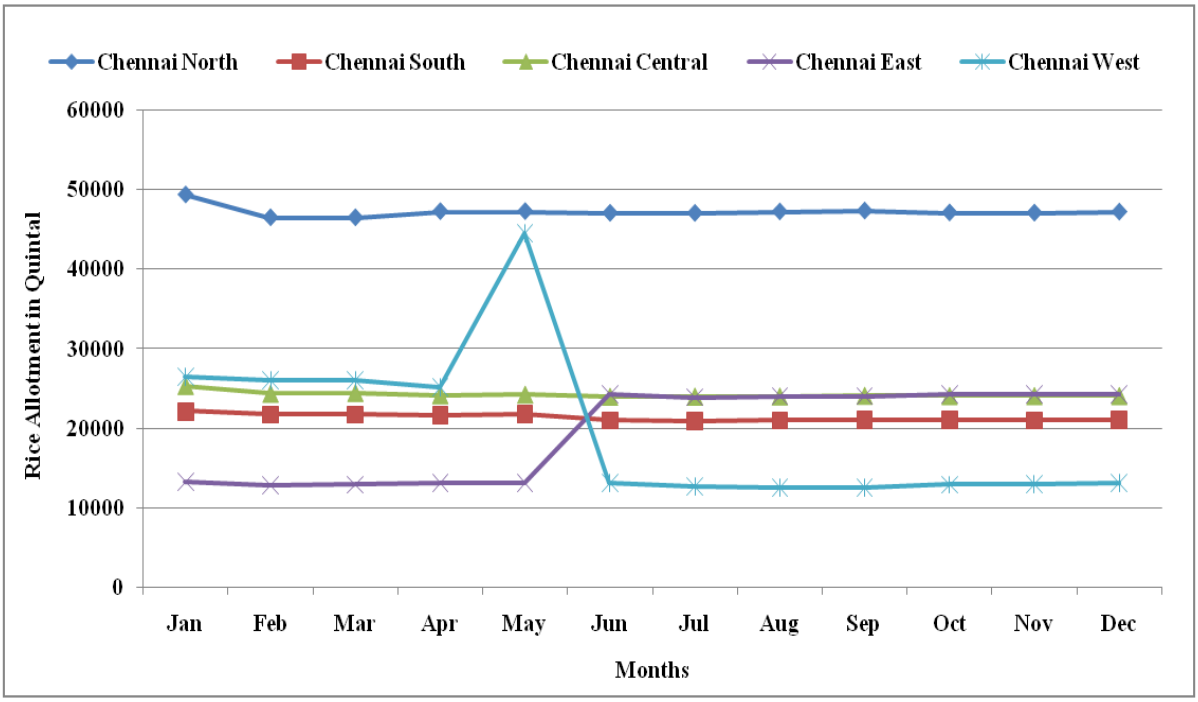

Fig. 1 Rice allotment of various divisions for 2014

A. Month wise Inventory for the year of 2014

The data for month wise required inventory was collected and the carrying inventory was calculated based on the inventory maintained by the FCI which is 20000 quintals for the year of 2014 and the same is illustrated in the following figure 2.

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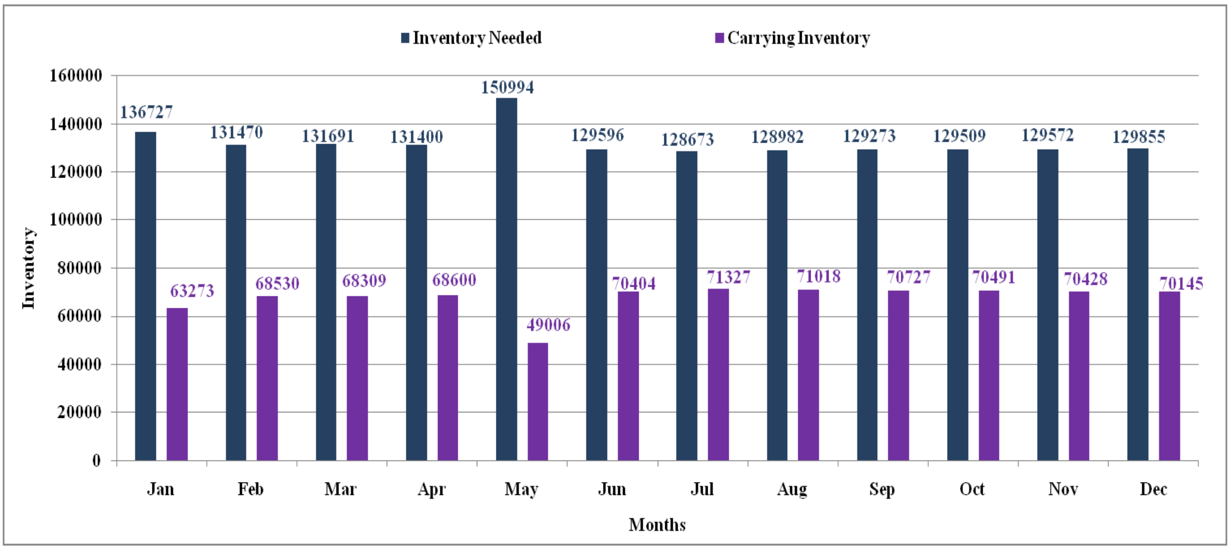

Fig. 2 Month wise required and carrying inventory for the year 2014

B. Month wise Assessment of Total Cost for 2014

The month wise rice cost requirement, carrying cost of Rs. 5 per quintal, ordering cost and the total cost without BPSO is calculated using the appropriate data and given in the table 2.

Table 2. Total cost in rupees without BPSO

Month	Total Cost of Rice	Carrying Cost (Rs. 5/Qtl)	Ordering Cost	Total Cost
JAN	100000000	316365	100000	100416365
FEB	100000000	342650	100000	100442650
MAR	100000000	341545	100000	100441545
APR	100000000	343000	100000	100443000
MAY	100000000	245030	100000	100345030
JUN	100000000	352020	100000	100452020
JUL	100000000	356635	100000	100456635
AUG	100000000	355090	100000	100455090
SEP	100000000	353635	100000	100453635
OCT	100000000	352455	100000	100452455
NOV	100000000	352140	100000	100452140
DEC	100000000	350725	100000	100450725

C. Execution of BPSO Model for Rice allotment and variable costs

The overall demand for the region wise in Chennai district for the year of 2014 has been taken and the ordering inventory and carrying inventory was calculated using the ordering decision in month wise and given in the following table 3. Rice allotment at every month is calculated with binary values (1, 0). Binary digit '1' is suggesting for order and ordering cost incurred at that particular time and binary digit '0' suggesting for no order, i.e., at that time carrying cost of rice is incurred. In March 2014, the ordering inventory of 414085 quintals of rice is ordered in order to serve for April and May. Similarly in June 2014 the total ordering inventory of

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646033 quintals of rice is ordered in order to serve for July, August, September and October 2014.

Table 3. Demand and order decision matrix during the year 2014

Month	Demand (Quintals)	Order Decision	Inventory (Ordering)	Inventory (Carrying)
JAN	136727	1	136727	0
FEB	131470	1	131470	0
MAR	131691	1	414085	282394
APR	131400	0	0	150994
MAY	150994	0	0	0
JUN	129596	1	646033	516437
JUL	128673	0	0	387764
AUG	128982	0	0	258782
SEP	129273	0	0	129509
OCT	129509	0	0	0
NOV	129572	1	129572	0
DEC	129855	1	129855	0

The month wise preserved inventory for ordering and carrying inventory for the year of 2014 has been identified and given in the following figure 3

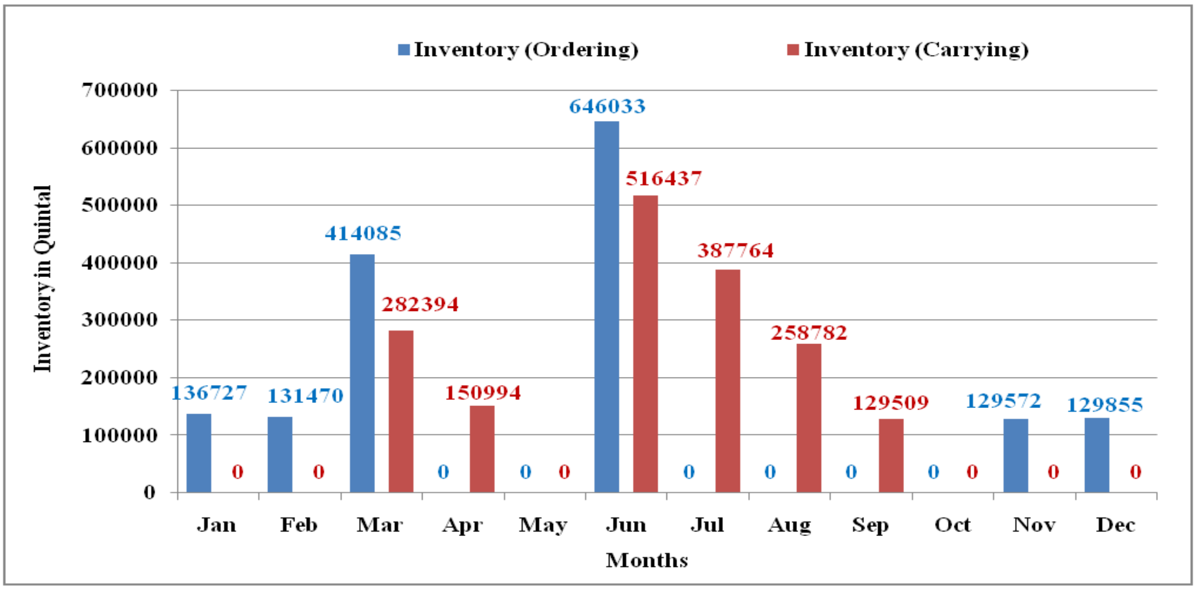

Fig. 3 Ordering and carrying inventory-2014

D. Evaluation of carrying, ordering and total costs

The total cost of the rice after implementing the BPSO was calculated from the calculated ordering and carrying cost. The carrying cost of the rice was calculated as per the desire rate by the government. The total cost of the rice after execution of BPSO is given in the following table 4. The graphical representation of the total cost after execution of BPSO is in the figure 4.

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Table 4. Various costs after execution of BPSO

Month	Rice Cost	Ordering Cost	Carrying Cost (Rs.5/Quintal)	Total Cost
JAN	68363500	100000	0	68463500
FEB	65735000	100000	0	65835000
MAR	207042500	100000	1411970	208554470
APR	0	0	754970	754970
MAY	0	0	0	0
JUN	323016500	100000	2582185	325698685
JUL	0	0	1938820	1938820
AUG	0	0	1293910	1293910
SEP	0	0	647545	647545
OCT	0	0	0	0
NOV	64786000	100000	0	64886000
DEC	64927500	100000	0	65027500

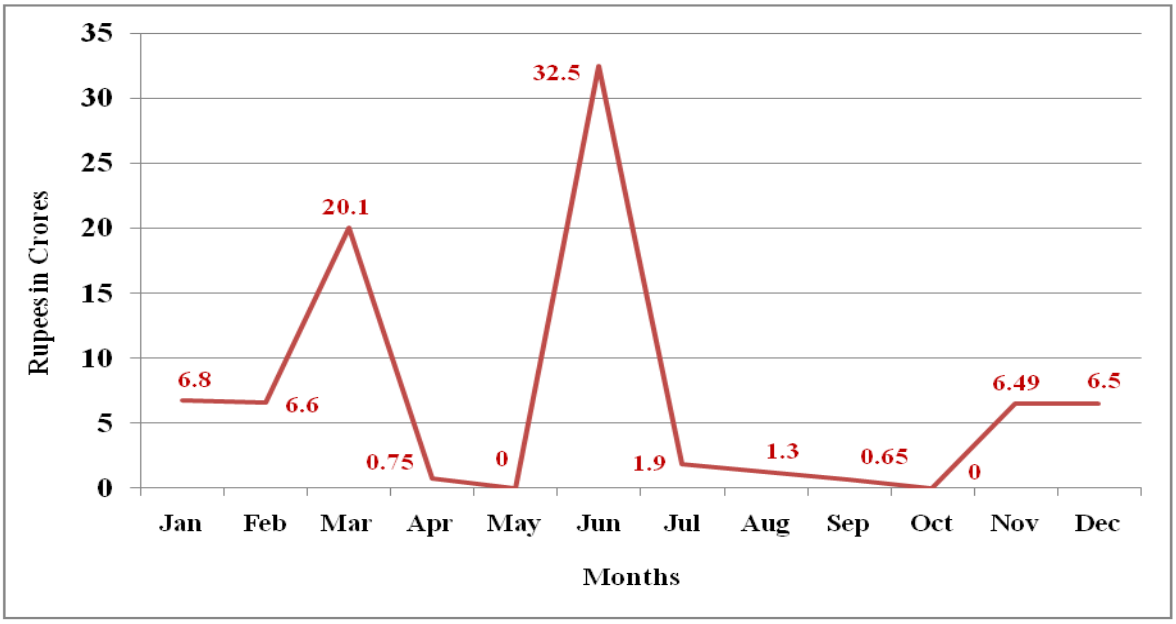

Fig. 4 Total cost after execution of BPSO

E. Comparison of Results with and without BPSO

The total costs of the rice before the execution of BPSO and after the execution of BPSO were compared and the percentage of reduction was calculated according to the analysed data. The comparison of month wise cost and percentage of reduction is given in the following table 5 and the graphical representation for the month wise percentage of reduction given in the following figure 5.

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Table 5. Comparison of total cost before and after BPSO execution

Month wise Cost Difference in Rupees				
Month	**Before BPSO**	**After BPSO**	**Difference**	**% of Reduction**
Jan	100416365	68463500	31952865	32
Feb	100442650	65835000	34607650	35
Mar	100441545	208554470	-108112925	-107
Apr	100443000	754970	99688030	99
May	100345030	0	100345030	99
Jun	100452020	325698685	-225246665	-223
Jul	100456635	1938820	98517815	98
Aug	100455090	1293910	99161180	99
Sep	100453635	647545	99806090	99
Oct	100452455	0	100452455	100
Nov	100452140	64886000	35566140	35
Dec	100450725	65027500	35423225	35

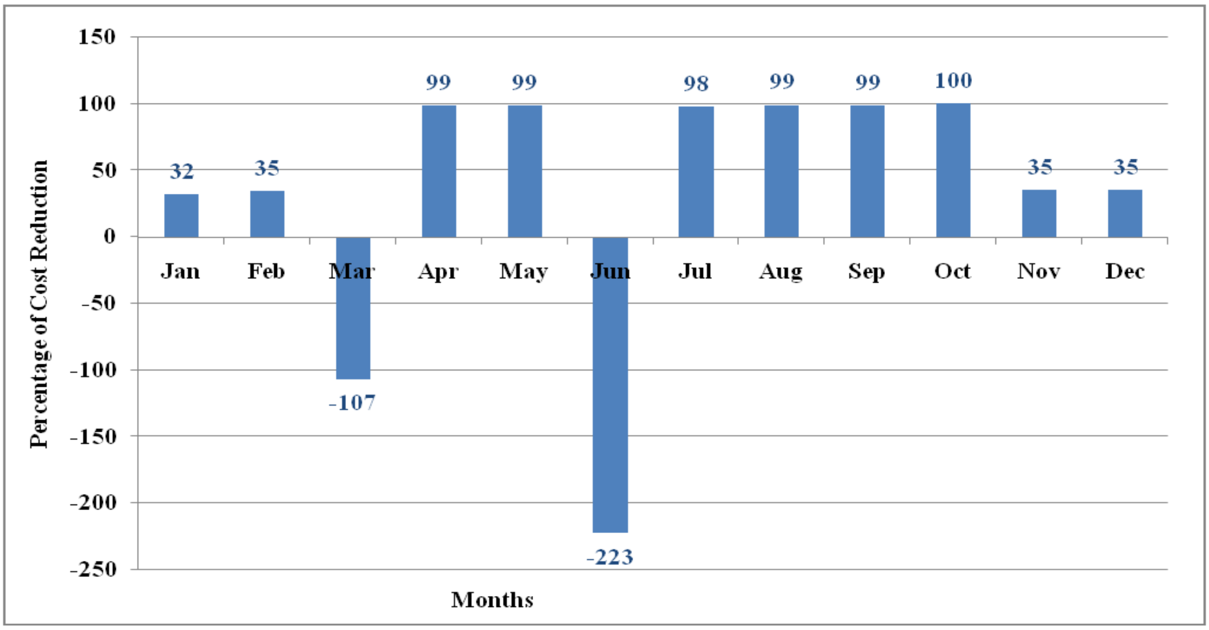

Fig. 5 Month wise Percentage of Reduction for the year of 2014

F. Comparison of annual budget

Annual cost difference of Rs. 40, 21, 60, 890 /- (nearly 40 Crores) is observed by executing the BPSO model and the reduction observed is 33.47% which decreases the annual cost. The total variable cost of the presently used system i.e. before execution of BPSO is Rs. 120, 52, 61, 290/- and the total variable cost of the optimized inventory cost after execution of BPSO model is Rs. 80, 31, 00, 400/-. The difference cost between the before and after execution of BPSO is Rs. 40, 21, 60, 890/-.

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Conclusions

In this study, we have measured a typical public distribution system consisting of FCI, MLSP and FPS in our state regarding necessary commodity of rice. Based on the above study and analysis the following conclusions were made.

- A suitable mathematical model is proposed for the problem involving in total variable cost/expenses reduction of the PDS through certain limitations.
- The model has fixed at FCI, the optimum inventory at the end of each time period, total variable cost estimate for FCI by considering realistic available data in execution of BPSO technique.
- The total cost was reduced using successful execution of BPSO technique for single item single level competence problems.
- Also through the inventory holding cost and setup cost the entire expenses was reduced by means of resolving the best possible holding inventory.
- The total cost obtained for the PDS problem under consideration by BPSO method it is observed that cost is reduced nearly fourty cores and the reduction 33.47 % compared to the total cost of existing system.

We have considered only the perishability of the product and as a continuation of the present work additional improvement of networking model, for distribution of all perishable items from FCI to FPS to recognize about the availability and utilization of resources of PDS by executing appropriate method.

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