E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; 7(6): 308-312
Received: 14-03-2024
Accepted: 17-04-2024

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Techno-economic feasibility of different storage modes for wheat and maize

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DOI: https://doi.org/10.33545/2618060X.2024.v7.i6e.850

Abstract
This research was conducted to evaluation of Techno-economic feasibility of different Storage modes for Wheat and Maize. Techno-economic feasibility of different storage methods for wheat and maize was analyzed: 40 kg of samples were taken in different modes and stored for 12 months in all 15 untreated and treated storages. The maximum profit in wheat for T_1, T_2 and T_3 were found as Rs. 254.0, 219.0 and 99.0 respectively. Whereas maize grain storage net profit was found Rs. 134.0, 99.0 & 19.0 in T_1, T_2 & T_3 respectively. The result revealed that the use of Hermetic bag with jute bag, Hermetic bag with plastic bag and Metal bin with hermetic bags were the best and suitable for storage of wheat and maize grains up to twelve months. Farmers need to be trained while storing wheat and maize to get maximum profit from grain storage. As a result, adoption rates will rise if hermetic bag prices are decreased through increased knowledge and increased supply chain effectiveness.

Keywords: Benefit-cost ratio, economic cost return, fixed cost, storage mode, techno-economic cost, variable cost

Introduction
The maize crop is the most widely cultivated cereal crop worldwide, together with wheat and rice are the three most important cereal crops in the world. Over 800 million metric tons were produced in 2012/13. Maize production is expected to double by 2025 (M'mboyi *et al.*, 2010) [12]. Maize is produced on a seasonal basis; usually once per year (FAO/GIEWS, 2014) [10], but consumption is evenly spaced throughout the year (Benirschka and Binkley, 1995) [5]. Thus, to maintain a constant supply throughout the year, maize should be properly stored. Grain storage plays a significant role to ensure a constant supply, and in stabilizing the food supply at the household level by smoothing seasonal food production. In addition, proper storage helps to minimize post-harvest losses of maize acts as guarantor for inflation-proof saving banks, and improves agricultural income (Tefera *et al.*, 2011) [19]. For the government, maize grain is stored as a food security reserve, a price stabilization stock, a national storage reserve or strategic reserve, buffer stocks, and production controls (Proctor, 1994) [15]. There are two main costs associated with wheat and maize storage: fixed and variable costs. Fixed costs are incurred regardless of whether the grain is stored in the storage facilities or not, whereas variable costs are those that increase or decrease, and are incurred only when maize is stored (Edwards and Johanns, 2015) [8].
The expense of new technical innovations, such as complex storage facilities, silos, warehouses, and pricey fungicide and insecticide treatment, must also be looked into. Structures that efficiently protect crop quality and yield could be too costly and complex for the target farmers' level of operation (Agboola, 2001) [3].
The issues brought on by rodents and insects are more noticeable than the issues brought on by fungus. If the country seeks to achieve food security, storage losses pose a serious issue. The market is prone to significant short-term and inter-seasonal price variations with the current indigenous storage practises, which affects the interests of both farmers and consumers. Successful farm storage enables farmer to sell maize when prices are favourable (off season). Traditional storage methods are relatively localised and primitive; some have been discovered to work and just require minor changes, while others are unsafe and out-of-date (Thamaga-Chitja *et al.*, 2004) [18].

Techno-economic feasibility characteristics of wheat and maize analyzed the economics associated with the off-farm storage farmers. Others include computing the profitability of various storage techniques as well as identifying challenges associated with the existing storage techniques used in the study area. There were two hypotheses of the study. The first one stated that there is no significant relationship between the socio-economic characteristics of respondents and storage decisions. The second one stated that there is no significant relationship between the cost of storage and revenue generated by the farmers. The main objective of conducting this research was to evaluation of Techno-economic feasibility of different Storage modes for Wheat and Maize.

Materials and Methods

Economic Cost

The study site of Techno-economic feasibility of wheat and maize was selected to Samastipur district, Bihar. The cost of storage grains was incurred by two significant groups. The first category includes costs for staff, space, and equipment. Cost of storage facilities, which included the price of metal bins, plastic bags, jute bags, hermetic bags and Metal bins. The second group was storage cost. Input on equipment cost was collected from several manufacturers and varied in size. According to estimates, the cost of installing and building a concrete floor was. Benefit-Cost Ratio was calculated by using equation (1 and 2)

$$\text{Net Rate of Return} = (\text{Gross Return} - \text{Gross Cost}) \quad (1)$$

$$\text{Benefit-Cost Ratio} = \frac{\text{Net Profit}}{\text{Gross Cost}} \quad (2)$$

Where

Net Profit = Gross Income - Gross Cost (Including the imparted value of labour)

Gross Cost= Fix cost + Variable cost

The main expense for grain storage, on the other hand, is made up of variable costs, which include expenses that can only be incurred if grain is stored (Brennan and Lindner, 1991) [6]. Variable Costs fluctuate and are influenced by the quantity of stored grain as well as how long the items are stored (Pardey *et al.,* 2001; Dhuyvetter *et al*., 2007) [14, 7]. These may involve expenses. Including labour, administration, and shipping into and out of storing, using pesticides, and the price of energy (such as liquid for example, grain drying using propane and electricity.

Results and Discussion

Techno-Economic Feasibility of different grain Storage modes

The economic cost findings are compiled and presented in Table 1 and 2. The findings showed that wheat grain storage at a 40 kg storage capacity per storage mode increased the environmental impact. The price of storing treated and untreated includes a broad range of storage options, such as jute bags, plastic bags, hermetic bags, polythene bags, and metal bins, as well as 15 treatments available, including three untreated, six treated (Neem leaves), and six treated (chemical). In the cost calculation of packing, labour was employed as the primary parameter.

Economic feasibility of Wheat grain

Cost estimation was done for Untreated and treated wheat grain of different storage modes. The total economic cost for untreated wheat of storing 40 kg of was 746 in T_1, 741 in T_2 and 821 in T_3 and the return was 254, 219 and 99, respectively.

Wheat Grain Storage Jute Bags with Polythene T_4, Plastic Bags with Polythene T_6, Jute Bags T_{12}, Plastic Bags T_7, Metal Bin T_5, and the net return was found to be Rs. 174, Rs. 139, Rs. 46, Rs. 34 and 29 respectively. Loss was noticed in metal bin T8 (Rs. -21) and metal bin T_9 (Rs. -46) with two treated storage modes polythene bags.

Net profit of in Plastic bag with Polythene T_{12} (Rs 49) in Plastic bag T_{13} (Rs 29) and Jute bag with Polythene T_8 (Rs 9) was found in three treatments in possible storage mode. Loss of in Jute Bag T_{11} (Rs -16) in Metal Bin T_{14} (Rs-66) and Metal bin Polythene bag T_{15} (Rs-91) was found in three treatments in possible storage mode.

Net profit of all 15 treatments was found to be the best Jute bag with hermetic bag and the best of Plastic bag with hermetic bag.

Assumption

Grain per bag = 40 kg

Labour = 390/day (Institute approved wages as per year 2022)

Economic cost of Maize grain

The total economic cost of untreated storing 40 kg of maize grain was 706 in T_1, 701 in T_2 and 781 in T_3 and the return was 134, 99 and 19, respectively. Untreated and treated different storage mode of maize grain economic cost is shown in Table 3 and 4.

Net profit of maize grain storage decreasing order Plastic bag with Polythene T_6, Jute bag with Polythene T_4, Plastic bag T_7, Metal bin T_5, and Jute bag with Polythene T_8, and net return is Rs. 99, Rs 94, Rs,74, Rs. 69, and Rs. 59, respectively. The loss was found in one treatment Metal bin T_9 in (Rs. -6).

Net profit of the same (Rs 9) in jute bags with polythene T_{10} and plastic bags with polythene T_{12} was found in the treatment of two storage modes. Loss of (Rs -3) in plastic bag T_{13}, (Rs -16) in jute bag T_{11}, in metal bin T_{14} (Rs 66) and in metal bin T_{15} (Rs 91) were found in four treated storages.

The net benefit of all the 15 treatments was found to be the best in storage of 0 - 12 months in hermetic bag with jute bag and hermetic bag with plastic bag, which is suitable for storage.

Similar result of our analysis, reported by Shepherd, (1999) [17], the opportunity cost for each storage method and gross margin (GM) was viewed as the variation in the market price (price) of wheat and maize grain at the time of sale. The selling price includes the calculations. Each storage technology involved different costs. evaluated the storage technique's net gains.

In addition, the results of the partial budget analysis indicated that wheat or maize growers may switch to any type of storage method other than Traditional Storage with Pesticide (TSP) even though it had a negative Gross Margin (GM) in every scenario. PICS modifications made the biggest (beneficial) difference. Furthermore, the partial budget results are comparable with the MRR ratio, which was 3.196 when the storage method changed from No storage or sold immediately after harvest (NS) to (PICS). The partial budget and MRR findings are in line with the majority of research findings from other SSA areas, most of which demonstrate that hermetic bags have the greatest GM and MRR ratios Adetunji, M. (2009a) [1]; Sekumade and Oluwatayo, (2009) [16]; Jones *et al.,* (2011) [11].

Additionally, TSP is not commercially viable, as evidenced by the high TVC ratio of TSP to NS (4.5:1) and PICS (3.1:1). PICS,

which was considered the most profitable option in this assessment, PICS provided the best GM. Qualitative and quantitative findings of studies that demonstrate the profitability of PICS bags in SSA, reported by Baributsa *et al.*, (2014) [4], FAO, (2018) [9].

Table 1: Cost expenditure of different Storage Modes of Wheat grain

Storage Modes	Per packet storage in kg	Rate (Rs) Per kg of Wheat	Selling Price/kg	Capacity	Rate (Rs.) of storage bag	Total Requirement (Bag no.)	Packaging Charge (Rs)	Total (Rs.)
T_1- Jute bag + Hermetic bag	40	15	25	50 kg/-pc	95, 25	1+1	26	95+25=120
T_2- Plastic bag + Hermetic bag	40	15	24	50 kg/-pc	20, 95	1+1	26	20+95=115
T_3 -Metal bin + Hermetic bags	40	15	23	100 kg/-pc	100 (After depreciation), 95	1+1	26	100+95=195
T_4- Jute bag + Polythene + Neem leaves	40	15	21	50 kg/-pc	25, 15	1+1	26	25+15=40
T_5- Jute bag + Neem leaves	40	15	17	50 kg/-pc	25	1	26	25
T_6- Plastic bag + Polythene + Neem leaves	40	15	20	50 kg/-pc	20,15	1+1	26	20+15=35
T_7- Plastic bag + Neem leaves	40	15	17	50 kg/-pc	20	1	26	20
T_8- Metal bin + Polythene + Neem leaves	40	15	18	100 kg/-pc	100 (After depreciation), 15	1+1	26	100+15=115
T_9- Metal bin + Neem leaves	40	15	17	100 kg/-pc	100 (After depreciation)	1	26	100
T_{10}- Jute bag + Polythene + Chemical	40	15	17	50 kg/-pc	25,15	1+1+1	26	25+15+5=45
T_{11}- Jute bag + Chemical treatment	40	15	16	50 kg/-pc	25	1+1	26	25+5=30
T_{12}- Plastic bag + Polythene + Chemical	40	15	18	50 kg/-pc	20,15	1+1+1	26	20+15+5=45
T_{13}- Plastic bag + Chemical	40	15	17	50 kg/-pc	20	1+1	26	20+5=45
T_{14}- Metal bin + Chemical	40	15	17	100 kg/-pc	100 (After depreciation), 15	1+1+1	26	100 +15+5=120
T_{15}- Metal bin + Polythene +Chemical	40	15	16	100 kg/-pc	100 (After depreciation)	1+1	26	100+5=105

Table 2: Economic cost return of different storage modes of wheat grain

S. N.	Storage Modes	Total Cost (Rs. /Pkt.)	Gross Return (Rs. /Pkt.)	Net Return (Rs. /Pkt.)	B:C Ratio
1	T_1- Jute bag + Hermetic bag	746	1000	254	0.34
2	T_2- Plastic bag + Hermetic bag	741	960	219	0.30
3	T_3- Metal bin + Hermetic bags	821	920	99	0.12
4	T_4- Jute bag + Polythene + Neem leaves	666	840	174	0.26
5	T_5- Jute bag + Neem leaves	651	680	29	0.04
6	T_6- Plastic bag + Polythene + Neem leaves	661	800	139	0.21
7	T_7- Plastic bag + Neem leaves	646	680	34	0.05
8	T_8- Metal bin + Polythene Bag + Neem leaves	741	720	-21	-0.03
9	T_9- Metal bin + Neem leaves	726	680	-46	-0.06
10	T_{10}- Jute bag + Polythene + Chemical	671	680	9	0.01
11	T_{11}- Jute bag + Chemical treatment	656	640	-16	-0.02
12	T_{12}- Plastic bag + Polythene + Chemical	671	720	49	0.07
13	T_{13}- Plastic bag + Chemical	651	680	29	0.04
14	T_{14}- Metal bin + Chemical	746	680	-66	-0.09
15	T_{15}-Metal bin + Polythene Bag +Chemical	731	640	-91	-0.12

Table 3: Cost expenditure of different Storage Modes of Maize grain

Storage Modes	Per packet storage in kg	Rate (Rs) Per kg of Wheat	Selling Price/kg	Capacity	Rate (Rs.) of storage bag	Total Requirement (Bag no.)	Packaging Charge (Rs)	Total (Rs.)
T_1- Jute bag + Hermetic bag	40	14	21	50 kg/-pc	95, 25	1+1	26	95+25=120
T_2- Plastic bag + Hermetic bag	40	14	20	50 kg/-pc	20, 95	1+1	26	20+95=115
T_3 -Metal bin + Hermetic bags	40	14	20	100 kg/-pc	100 (After depreciation), 95	1+1	26	100+95=195
T_4- Jute bag + Polythene + Neem leaves	40	14	18	50 kg/-pc	25, 15	1+1	26	25+15=40
T_5- Jute bag + Neem leaves	40	14	17	50 kg/-pc	25	1	26	25
T_6- Plastic bag + Polythene + Neem leaves	40	14	18	50 kg/-pc	20,15	1+1	26	20+15=35
T_7- Plastic bag + Neem leaves	40	14	17	50 kg/-pc	20	1	26	20
T_8- Metal bin + Polythene + Neem leaves	40	14	19	100 kg/-pc	100 (After depreciation), 15	1+1	26	100+15=115
T_9- Metal bin + Neem leaves	40	14	17	100 kg/-pc	100 (After depreciation)	1	26	100
T_{10}- Jute bag + Polythene + Chemical	40	14	16	50 kg/-pc	25,15	1+1+1	26	25+15+5=45
T_{11}- Jute bag + Chemical treatment	40	14	15	50 kg/-pc	25	1+1	26	25+5=30
T_{12}- Plastic bag + Polythene + Chemical	40	14	16	50 kg/-pc	20,15	1+1+1	26	20+15+5=45
T_{13}- Plastic bag + Chemical	40	14	15	50 kg/-pc	20	1+1	26	20+5=45
T_{14}- Metal bin + Chemical	40	14	14	100 kg/-pc	100 (After depreciation), 15	1+1+1	26	100+15+5=120
T_{15}- Metal bin + Polythene +Chemical	40	14	13	100 kg/-pc	100 (After depreciation)	1+1	26	100+5=105

Table 4: Economic cost return of different storage modes of Maize grain

S. L.	Storage Modes	Total Cost (Rs. /Pkt.)	Gross Return (Rs. /Pkt.)	Net Return (Rs. /Pkt.)	B:C Ratio
1	T_1- Jute bag + Hermetic bag	706	840	134	0.19
2	T_2- Plastic bag + Hermetic bag	701	800	99	0.14
3	T_3- Metal bin + Hermetic bags	781	800	19	0.02
4	T_4- Jute bag + Polythene + Neem leaves	626	720	94	0.15
5	T_5- Jute bag + Neem leaves	611	680	69	0.11
6	T_6- Plastic bag + Polythene + Neem leaves	621	720	99	0.16
7	T_7- Plastic bag + Neem leaves	606	680	74	0.12
8	T_8- Metal bin + Polythene Bag + Neem	701	760	59	0.08
9	T_9- Metal bin + Neem leaves	686	680	-6	-0.01
10	T_{10}- Jute bag + Polythene + Chemical	631	640	9	0.01
11	T_{11}- Jute bag + Chemical treatment	616	600	-16	-0.03
12	T_{12}- Plastic bag + Polythene + Chemical	631	640	9	0.01
13	T_{13}- Plastic bag + Chemical	631	600	-31	-0.05
14	T_{14}- Metal bin + Chemical	706	640	-66	-0.09
15	T_{15}-Metal bin + Polythene Bag +Chemical	691	600	-91	-0.13

Conclusion

Present study reveals wheat and maize grain were untreated and treated stored under all the fifteen treatments of storage modes. Economical costs and benefits related to different storage methods, both untreated and treated, were observed after 12 months. In which the maximum benefit in untreated wheat grain storage was found in Jute Bag with Hermetic Bag - T_1 Rs.254 more than all untreated and treated. Whereas in comparison to all untreated and treated storage methods, maximum benefit was found in maize in jute bags with hermetic bag- T_1 of Rs.134. Moreover, additional study is required to determine the advantages of utilising hermetic bags for both human health and the environment.

Acknowledgement

I am also grateful to the scientist and staff of the BISA, Pusa (Samastipur) for providing the basic facility for conducting my research. Study leave with pay granted Dr. RPCAU, Pusa, Samastipur greatest acknowledge

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