Archives of Current Research International

Volume 24, Issue 5, Page 646-655, 2024; Article no.ACRI.118299
ISSN: 2454-7077

Interaction of Agriculture and Farm Mechanization-paving the Path for Transformed Indian Agriculture: A Case Study of Mechanized Harvesting and Threshing of Chickpea in India

Shilpa .P. Chowti [a++*] and Saraswathi J. M. [a#]

[a] *ZAHRS, Hiriyur, Karnataka, India.*

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/acri/2024/v24i5738

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/118299

Original Research Article

Received: 10/04/2024
Accepted: 13/06/2024
Published: 20/06/2024

ABSTRACT

The present study attempted to evaluate the financial feasibility of custom hiring of machines for harvesting and threshing of chickpea in two major chickpea growing states of India namely Maharashtra and Madhya Pradesh. The study was based on data collected from field survey. Two major states namely, Maharashtra and Madhya Pradesh were selected based on the area under chickpea. A multistage sampling procedure was adopted for the selection of study area, sample farmers and machine owners. The study was based on 90 samples of which 60 were chickpea

[++] *Assistant Professor;*
[#] *Scientist;*
**Corresponding author: Email: agrichoutishilpa@gmail.com;*

Cite as: *Chowti, Shilpa .P., and Saraswathi J. M. 2024. "Interaction of Agriculture and Farm Mechanization-Paving the Path for Transformed Indian Agriculture: A Case Study of Mechanized Harvesting and Threshing of Chickpea in India". Archives of Current Research International 24 (5):646-55. https://doi.org/10.9734/acri/2024/v24i5738.*

growing farmers and 30 were machine owners. Farm budgeting, financial feasibility and Garrett ranking techniques were used to analyze the data. About 70 per cent of the sample farmers harvested chickpea engaging human labour and threshed it with machine and remaining 30 per cent of the sample farmers have used machine both for harvesting and threshing. The net profit of mechanical harvesting and threshing over manual harvesting and machine threshing was Rs. 2613 and Rs.3044 in Maharashtra and Madhya Pradesh respectively. Cultivation of spreading type of chickpea variety was the major constraint in adoption of mechanization. Investment on combined harvester was financially feasible and economically viable with NPV, Benefit Cost Ratio and IRR of Rs. 3307101.18, 2.91 and 25.52 per cent, respectively and payback period was 5.12 years. Investment on thresher was found to be profitable, financially feasible and economically viable with NPV, benefit cost ratio and IRR of Rs. 1126722.09, 3.92 and 29.36 per cent, respectively. The major problems faced by the machine owners was the high cost of machines and their maintenance, non-availability of trained machine operators and coverage of long distances in different states/ districts. Cooperative model of custom hiring as successfully operated in Punjab should be introduced in different states to facilitate easy availability of machines to the farmers with uniform rates to overcome the problem of scarcity of labour during peak farm operation period, reduce cost of machines and harvesting and threshing charges.

Keywords: Custom hiring; mechanization; financial feasibility.

1. INTRODUCTION

"The transformation in Indian agriculture since mid-sixties, in terms of technological advancements, cropping pattern, cropping intensity, mechanization of some of the farm operations, use of HYV seeds, fertilizers, irrigation, plant protection chemicals and the employment of human labour has undergone various structural changes. Though, it is said, India has abundant labour force in agriculture, but non-availability of manpower during peak crop season is growing over the years, more particularly during recent years" [1-3].

"Labour in agriculture is becoming scarce in most parts of India" (Ghunabhagya *et al.,* 2017). High economic growth, fast infrastructure development, and availability of alternative employment opportunities led to migration of farm labors to semi urban and urban areas. Besides this, the introduction of social safety programme like MGNREGA and supply of food grains through Annabhagya scheme has further intensified the scarcity of labour in agriculture. In view of increased wages of farm labour, shortage of availability of labour for farm operations and migration of skilled labour force from rural to urban areas resulted in increased cost of agricultural production. These changes forced the farmers to incline towards mechanization in farming, which is the only possible option for substituting labour and improving the productivity of land, labour and other inputs. The purpose of mechanization is also to produce more from the existing land, using machinery as complementary input, required to achieve higher land productivity and also to enhance efficiency in farm operations to reduce cost of production, drudgery of farm work, greater leisure, or reduction of risk, etc.

The average farm power availability (uses) in India is already at very low level than many other countries with middle income categories [4]. For mechanization process, the small land holding, lack of availability of suitable machine for crops grown, non-suitability of existing machines for harvesting and threshing are some of the constraints. In this context, development of custom hiring services (rental market services) of machines can address the problem of majority of the farmers in the country. No doubt majority of the smallholding farmers are not afford to invest on machines for farm operations. Therefore, custom-hiring facility is being promoted by the market forces as well as public agencies to increase pace of mechanization in India. Establishment of custom hiring service like facilities has potential for increased adoption of farm mechanization.

Pulses are an important and integral ingredient of rich protein diet for human being but the per capita availability of pulses is declining while their prices are increasing manifolds. One of the major hurdles in adoption of pulse crops by the farmers is the lack of mechanization of various farming operations especially harvesting. Chickpea is one of such crops which has considerable potential for adoption of mechanization at large

scale by the farmers for major farming operations like harvesting and threshing. Chickpea (*Cicer arietinum* L.) is the most important pulse crop in India with an area of 8.56 million ha and production of 8567.8 thousand tone. It is said to be one of the oldest pulses known and cultivated from ancient times both in Asia and Europe. Maharashtra and Madhya Pradesh are the two major chickpea growing states in the country. Mechanical harvesting of chickpea is getting popular among large as well as medium scale farmers in view of farmers facing acute shortage of labour and high wage rates during harvesting and threshing.

The present study has made an attempt to evaluate the feasibility of custom hiring of machines for harvesting and threshing of chickpea in two major chickpea growing states of India namely Maharashtra and Madhya Pradesh with the specific objectives viz., i) To identify methods of harvesting and threshing of chickpea. ii) To estimate cost and benefits of manual v/s mechanical harvesting and threshing of chickpea. iii) To analyse the financial and economic feasibility of investment on machines. iv) To identify the constraints in mechanical harvesting and threshing of chickpea and suggest suitable measures.

1.2 Review of Literature

"The mechanization in agriculture is always viewed in two perspective i.e cost reduction (agricultural operational income) and agricultural production/income. In agriculture, the resource efficiency is most important in order to reduce the cost of production. In this perspective, some of the previous studies explored the ways to reduce the cost of production/cultivation due to mechanization. The study showed that the availability of sound agricultural infrastructure can promote the utilization of agricultural factors and income" [5] "another study indicated that the availability of rural public goods and agricultural machinery can alleviate declines in operating income caused by rural aging" (He *et al*., 2016), [6]. "The cost incurred per acre of chickpea harvesting using labour was less compared to threshing with machine. The per acre cost of manual harvesting and mechanical threshing was more than mechanical harvesting and threshing of chickpea" [7]. "The net return realized by mechanical harvesting and threshing of per acre of chickpea was more. Some viewed that mechanization will increase farm efficiency and productivity through the labour-saving technique" [8,9] discovered that "agricultural mechanization considerably impacts farmers' income". Sorat *et al.* revealed "higher rice yield in farmers field by using combined harvesters compared to manual harvesting. Another study showed that the mechanical harvest representing the highest contribution per cent in total crushing of cane per day (71 %) while manual harvest represents 29 % [10]. Upasana et al. [11] studied "the economics of mechanical harvesting and threshing in comparison to manual harvesting and mechanical threshing in Vijayapur and Bagalakote districts, Karnataka". "Result revealed net additional benefit of mechanical harvesting cum threshing over manual harvesting and mechanical threshing per hectare was 3041 for Vijayapur district and 2960 for Bagalakote district. Moussa reported that combiner harvester reduced the cost of harvesting by 32 and 36 % compared to semi mechanical system (mower + transportation + thresher) and traditional system (manual + transportation + thresher), respectively. The timeliness of operations has assumed greater significant in obtaining optimal yields from different crops, which has been possible by way of mechanization" [12-14].

2. METHODOLOGY

2.1 Sampling Procedure

A multistage sampling procedure was adopted for the selection of study area and the sample farmers. In the first stage, Maharashtra and Madhya Pradesh states were selected purposively as the states were the chickpea bowls of India. From each state one major district with highest areas under chickpea was selected namely, Ahmednagar and Vidisha, respectively from Maharashtra and Madhya Pradesh. From each district, two taluks namely Rahuri and Sangamner from Ahmednagar and Basoda and Sironj from Vidisha districts were selected as they were having highest area under chickpea. From each taluk three villages were selected and from each village five farmers growing chickpea were selected for the purpose of evaluating objectives. Thus, for each taluk a sample size selected was 15 farmers constituting 30 for each district. From each selected district, 15 machine owners (persons carrying out custom hiring services) were selected. Thus, from each state 30 chickpea farmers and 15 machine owners were selected and thereby the final sample size for the study states was in

all 90 (60 chickpea farmers and 30 machine owners).

2.2 Nature and Sources of Data

Using a pre-tested schedule created specifically for the purpose of personal interviews, the study's primary data was obtained from the sample farmers and machine owners. The main information included general characteristics, land holding, cropping patterns, cost and return in the production of chickpeas, input and herbicide usage, labor utilization patterns for various farm operations, yield and income, and various techniques for harvesting and threshing chickpeas. It also included advantages and disadvantages associated with each technique in the study area [15-18]. In order to learn more about the expenses and benefits of having combined harvesters and threshers, the machine owners were questioned.

2.3 Analytical techniques employed

a. **Budgeting technique:** To assess the costs and returns in the production of chickpea and economics of owning different machines.
b. **Tabular analysis:** The descriptive statistics like averages, percentages, *etc* were used and tabulated to compile the data on socio-economic characteristics of farmers and the machine owners, resource use pattern, cost and return structure to ensure the meaningful interpretation of information.
c. **Financial feasibility analysis:** To study the financial feasibility in the investment on machineries viz., combined harvester and thresher, the tools of financial feasibility were employed.
d. **Garrett ranking technique:** The constraints faced by the farmers and the machine owners in the mechanical harvesting of chickpea were prioritized by using Garrett's ranking technique. For purpose of assessing priority assigned to various constraints by respondents, nearly eight to nine most important constraints were identified. Each of the 90 respondents selected were asked to rank these identified constraints from rank 1 to 9. In this analysis, rank 1 meant most important constraint and rank 9 meant least important constraint. In the next stage, rank assigned to each constraint by each individual was converted into per cent position using the following formula.

Per cent position = $100 (R_{ij} – 0.5) / N_j$

Where,

R_{ij} stands for rank given for the i^{th} factor (i=1, 2……9) by the j^{th} individual

(j = 1, 2…….90) N_j stands for number of factors ranked by j^{th} individual.

Once the per cent positions were calculated, scores were determined for each per cent position by referring Garrett's table. Then, the scores for each constraint were summed over the number of respondents who ranked that factor. In this way, total scores were arrived for each of the nine constraints and mean scores were calculated by dividing the total score by the number of respondents who gave ranks. Final overall ranking of the nine constraints was done by assigning rank 1, 2, 3… *etc* in the descending order of the mean scores.

3. RESULTS AND DISCUSSION

3.1 Methods of Harvesting and Threshing of Chickpea

Methods of harvesting and threshing of chickpea in the study area is presented in Table 1. In Maharashtra, about 70 per cent of the sample farmers harvested chickpea engaging human labour and threshed it using machine and remaining 30 per cent of the sample farmers harvested and threshed chickpea using machine. Whereas in case of Madhya Pradesh, about 56.67 per cent of the sample farmers harvested chickpea by human labour and threshed it using machine and about 43.33 per cent of the sample farmers have used machine both for harvesting and threshing. Overall, out of 60 sample farmers from two states, 63.33 per cent of the sample farmers harvested chickpea by human labour and threshed it using machine and about 36.67 per cent of the sample farmers harvested and threshed using machine. It can be inferred from the result that in spite of several efforts made to introduce mechanization in farming, still 57 per cent farmers in Madhya Pradesh and 70 per cent in Maharashtra have employed human labour for harvesting of chickpea and threshed using machine. This may be due to non-availability of suitable machines as well as varieties for mechanical harvesting and threshing of chickpea.

Table 1. Manual and mechanical harvesting and threshing of chickpea

Sl.No	Harvesting Method	Maharashtra n=30		Madhya Pradesh n=30		Overall n=60	
		Number	**Area(ha)**	**Number**	**Area (ha)**	**Number**	**Area(ha)**
1	Harvested by human labour and threshed by machine	21(70.00)	2.18(63.79)	17(56.67)	2.80(50.80)	38(63.33)	2.50(55.77)
2	Harvesting and threshing by machine	9(30.00)	1.24(36.21)	13(43.33)	2.72(49.20)	22(36.67)	1.98(44.23)
	Total	30(100)	3.42(100)	30(100)	5.52(100)	60(100)	4.47(100)

3.2 Cost of Manual and Mechanical Harvesting and Threshing of Chickpea

The cost incurred in manual v/s mechanical harvesting and threshing of chickpea in the study area is depicted in Table 2. Sample farmers of Maharashtra and Madhya Pradesh respectively incurred Rs. 6613 and Rs. 7544 in manual harvesting of chickpea. Of the total cost, the expenditure towards labor was Rs. 5542 and Rs. 6344 while the share of machinery charge in the total cost was Rs. 1071 and Rs. 1200 in Maharashtra and Madhya Pradesh respectively. In case of combined harvester, the total cost towards harvesting and threshing was Rs. 4000 and Rs. 4500 respectively in Maharashtra and Madhya Pradesh. The share of labour cost and machinery charge was Rs. 1500 and Rs. 2500 respectively in Maharashtra while in Madhya Pradesh it was Rs. 1700 and Rs. 2800 respectively [19-21]. The net profit of mechanical harvesting and threshing over manual harvesting and machine threshing of chickpea was Rs. 2613 and Rs.3044 in Maharashtra and Madhya Pradesh respectively. the findings of the analysis of manual v/s mechanical harvesting and threshing of chickpea in the study states revealed that the mechanical method of harvesting and threshing of chickpea not only profitable but also reduce substantial time of the farmers. This method was fallowed mostly by medium and large farmers with large area under chickpea.

3.3 Constraints in Mechanical Harvesting and Threshing of Chickpea

Constraints in mechanical harvesting and threshing of chickpea are depicted in Table 3. The result indicates that, cultivation of spreading type of chickpea variety was the major constraint and was Ranked I in both the states. Non availability of mechanical threshers on time and Non availability of suitable machines for existing varieties were ranked II and III respectively in Maharashtra whereas, in case of Madhya Pradesh Rank II and Rank III were attached to non-availability of suitable machines for existing varieties and non-availability of mechanical threshers on time respectively. Other constraints as opined by the sample farmers were splitting/damage of grains, difficulty in shifting of machine from one village to another, non-availability of suitable varieties, non-availability of skilled workers to operate machines, frequent repair of harvester-cum-threshers due to improper handling and non-availability of fuel for machine in nearby village/operating area.

3.4 Financial Feasibility of Investment on Machines

The feasibility of investment on combined harvester and thresher was analysed using most commonly used project evaluation techniques such as Net Present Value/worth, Benefit-Cost Ratio and Internal Rate of Return and the results are presented in Table 4. The net present worth of combined harvester in Maharashtra, Madhya Pradesh and in the overall study area was 30,75,945.20 Rs per annum Rs.35,38,257.15 per annum and Rs.33,07,101 per annum respectively at a discount rate of 12 per cent. Thus, the NPW for combined harvester was not only positive but also very high. The benefit cost ratios in that order were 2.85, 2.97 and 2.91. It values of IRR was found to be 24.49 per cent, 26.54 per cent and 25.51 per cent respectively for Maharashtra, Madhya Pradesh and in the study region indicating that the investment on combined harvester was financially feasible and economically viable. Payback period was 5.09, 5.15 and 5.15 for Maharashtra, Madhya Pradesh and overall in the study area. The Net present worth of investment on thresher in Maharashtra, Madhya Pradesh and in the study area was Rs. 1050362, Rs. 1203082.17 and Rs. 1126722 per annum respectively. Thus, the NPW for thresher was not only positive but also very high. The Benefit Cost ratios were 3.89, 3.95 and 3.92, respectively for Maharashtra, Madhya Pradesh and overall in the study area. The estimated IRR was found to be 28.36 per cent, 30.36 per cent and 29.36 per cent respectively in the order of both the states and overall study area mentioned indicating that the investment on threshing machine economically viable and financially feasible. In the study states in the order and in the overall study area, the Payback period was 1.27, 0.81 and 1.04 indicated that the investment made on threshing machine can be recovered in a very short period of one and half year.

3.5 Constraints Faced by Machine Owners in Mechanical Harvesting and Threshing of Chickpea

The constraints faced by machine owners in mechanical harvesting and threshing of chickpea

were analyzed employing garret ranking technique and results are presented in Table 5 and eight constraints were opined by them. The major problem faced by the machine owners was the high cost of machines (Rank I) and the minor problem was bad roads/ transportation problem (Rank VIII). Other problems as opined by the machine owner in mechanical harvesting and threshing of chickpea were high cost of maintenance of machines and workers, non-availability of trained machine operators, coverage of long distances in different states/districts, non-availability of financial support, fluctuations in area under the crop and quantity of output, no standard price for unit harvested/ threshed and bad roads/transportation problem.

Table 2. Cost estimation of combined harvester over the manual harvesting methods in chickpea in the study area

Unit: Rs/ha

		Maharashtra		Madhya Pradesh	
S.N.	**Particulars**	**Manual**	**CH***	**Manual**	**CH***
1	**Harvesting/cutting**				
	No. of labour days	17.5	1	20	1
	Male	7.5	1	5	1
	Female	10	0	15	0
	Labour cost	3549	214	4192	189
2	**Stacking, bunding and Threshing**				
	No. of labour days	10	0	8	0
	Male	4	0	4	0
	Female	6	0	4	0
	Labour cost	1330	0	1148	0
	Rental charges of thresher/harvester	591	2020	680	228
3	**Cleaning, winnowing and bagging**				
	No. of labour days	3	3	4	4
	Male	2	2	3	2
	Female	1	1	1	2
	Labour cost	398	643	574	756
4	**Transportation from farm yard to home**				
	No of labour days	2	3	3	4
	Male	2	3	3	0
	Female	0	0	0	0
	labour cost	265	643	430	756
	Rental charges of tractor	480	480	520	520
5	**Total cost of manual v/s mechanical harvesting and threshng**				
	Total labour days	32.5	7	30	9
	Total labour cost	5542	1500	6344	1700
	Machinery charges	1071	2500	1200	2800
	Total cost	6613	4000	7544	4500
	Net benefit of mechanical harvesting and threshing over manual harvesting and machine threshing	**2613**		**3044**	

**CH-Combined Harvester*

Table 3. Constraints in mechanical harvesting and threshing of chickpea

Sl. No	Particulars	Maharashtra(n=30)		Madhya Pradesh(n=30)	
		Score	Rank	Score	Rank
1	Chickpea variety cultivated are spreading type	66.47	I	62.77	I
2	Non availability of suitable machines for existing varieties	60.47	III	58.40	II
3	Non availability of mechanical threshers on time	66.27	II	57.60	III
4	Frequent repair of harvester-cum-threshers due to improper handling	42.57	VIII	53.57	IV
5	Difficulty in shifting of machine from one village to another	50.93	V	49.10	VII
6	Non availability of fuel for machine nearby village	38.27	IX	40.30	VIII
7	Non availability of suitable varieties	45.07	VI	52.63	V
8	Non availability of skilled workers to operate machines	43.40	VII	39.13	IX
9	Splitting/damage of grains	54.40	IV	51.63	VI

Table 4. Financial feasibility of investment on combined Harvester and thresher

Sl. No	Particulars	Combined Harvester			
		Units	Maharashtra	Madhya Pradesh	Overall
1	Net Present Value	Rs.	3075945.2	3538257.15	3307101.18
2	Benefit Cost Ratio	Ratio	2.85	2.97	2.91
3	Internal Rate of Return	Per cent	24.49	26.54	25.52
4	Payback period	Year	5.09	5.15	5.12
Thresher					
1	Net Present Value	Rs.	1050362	1203082.17	1126722.09
2	Benefit Cost Ratio	Ratio	3.89	3.95	3.92
3	Internal Rate of Return	Per cent	28.36	30.36	29.36
4	Payback period	Year	1.27	0.81	1.04

Table 5. Constraints faced by machine owners in mechanical harvesting and threshing of chickpea

Sl. No	Constraints	Maharashtra		Madhya Pradesh		Overall	
		Score	Rank	Score	Rank	Score	Rank
1	Coverage of long distances in different states/districts	52.00	IV	45.40	V	50.27	V
2	High cost of machines	71.67	I	72.93	I	74.93	I
3	Non-availability of financial support	51.93	V	47.47	IV	51.47	IV
4	Fluctuations in area under the crop and quantity of output	48.27	VI	39.93	VI	45.43	VI
5	Non-availability of trained machine operators	53.60	III	60.40	II	59.23	II
6	High cost of maintenance of machines and workers	55.20	II	55.80	III	57.47	III
7	Bad roads/ Transportation problem	26.20	VIII	20.27	VIII	23.90	VIII
8	No standard price for unit harvested/ threshed	37.27	VII	28.27	VII	33.83	VII

4. CONCLUSION

Mechanization is one such technique that will help to address the issue of labor scarcity and high wage rates during harvesting and threshing, as chickpeas are developing as a key pulse crop in the rabi season. The study clearly shows that the automated approach to chickpea harvesting and threshing proved to be more profitable than human harvesting. Without a doubt, the exorbitant cost of mechanization machinery like combination harvesters prevents small and marginal farmers from affording them. Therefore, cooperative model of custom hiring facility should be popularized both by private and public agencies to increase the peace of mechanization in India and to facilitate easy availability of machines to the farmers at affordable price. The results indicated that chickpea varieties cultivated by farmers across states are of spreading type and posed major constraint in mechanical harvesting of crop. Hence, efforts should be made to popularize the erect type chickpea varieties among the farmers with the help of large-scale demonstrations in the major chickpea growing regions of the state.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

We the authors are hereby declare that this study was conducted by us only in the selected area and no generative Language/methodologies/technologies/models/images/tables have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Kumar, Pradeep HL. Kushwaha Adarsh Kumar, Roaf Ahmad Parray, Teekam Singh MC. Meena, Susheel Kumar Sarkar, Madhusudan BS, Sunil Kumar Rathod. Efficiency and Cost-effectiveness analysis of developed embedded system-controlled seed and fertilizer applicator. Journal of Experimental Agriculture International. 2024;46(5):626-35. Available:https://doi.org/10.9734/jeai/2024/v46i52418.
2. Barman S, Deka N, Deka P. Impact of Farm Mechanization on Cropping Pattern and Cropping Intensity - A Case Study from Assam, India. Asian Journal of Agricultural Extension, Economics & Sociology. 2019;32(2);1–7. Available:https://doi.org/10.9734/ajaees/2019/v32i230149
3. Rahman MM, Ali MR, Oliver MM, Hanif MA, Uddin MZ, Saha KK, Islam MH, Moniruzzaman M. Farm mechanization in Bangladesh: A review of the status, roles, policy, and potentials. Journal of Agriculture and Food Research. 2021;6: 100225.
4. Singh SP, Surendra Sing. Farm power availability and its perspective in indian agriculture, J. of Scie. for Society 2021;3 (2):114-126.
5. Zeng F, Li F. Estimation of Cost Saving Effect of Agricultural Infrastructure on grain production--Based on seemingly unrelated regression method. Chin. Rural Econ. 2015;6:4–12.
6. Yao CS, Hou FG, Chen HY. Logical relation and its policy implications between agricultural mechanization and food security: Based on a contrastive study of the cost and benefit of three main grain crops between China and the United States. J. Chin. Agri. Mechan. 2021;42:1–8.
7. Mundinamani SM, Bhattarai B, Upasana M. Farm mechanization is an alternative for labour scarcity in agriculture sector- A comparative study of manual versus mechanical harvesting of chickpea in North Karnataka. Indian J. Agric. Econ. Conf. Number. 2014;374.
8. Murali P, Balakrishnan R. Labour scarcity and selective mechanization of sugarcane agriculture in Tamil Nadu, India. Sugar Tech. 2012;14(3):223-228.
9. Wang Z, Sun H. Empirical research of agricultural mechanization on the effect of increasing famers' income. Manag. Sci. Eng. 2014;8:7–13.
10. Adam EA, Amna OM, Alam E. An assessment of mechanical vs manual harvesting of the sugarcane in Sudan. J. Saudi Soci Agric. Sci., 2013;12(5):44-45.
11. Upasana. An economic analysis of mechanical harvesting of tur in North Karnataka. M. Sc (Agri.)., Thesis, Univ. Agric. Sci., Dharwad, Karnataka (India); 2016.
12. Singh Surendra. Farm machinery - Principles and applications. Directorate of Information and Publications on Agriculture, Indian council of Agricultural Research, New Delhi; 2007.

13. Agricultural Research, New Delhi. and applications. Directorate of Information and Chandrakanthappa K, Batagurki SB. Evaluation of different threshing methods for primary processing of finger millet. Mysore Journal of Agricultural Sciences. 2001;35(2):128-132.
14. Gunabhagya Joshi AT, Wali VB, Lokesha, H. Labour scarcity -Its enormity and Influence on Agriculture, Int. J. Pure App. Biosci. 2017;5 (6):1597-1603. ISSN: 2320 - 7051.
15. Moussa, Mechanical and traditional harvesting methods for wheat crop. Misr. J. Agric. Engg. 2008;25(4):1094-1111.
16. Munirathnam P, Jayalakshmi V, Ashok K, Padmalatha Y. Suitability of chickpea 'NBeG47' for mechanical harvesting under rainfed condition. J. Food Legumes, 2015;28(2):64-66.
17. Publications on Agriculture, Indian council of
18. Singh Surendra.. Farm machinery - Principles; 2007.
19. Sorat, P, Suwit L, Terry AR. Impacts of rice combined harvesters on economic and social of farmers in a village of the Tung kula ronghai region. Res. J. Agric. Biol. Sci. 2010;6 (6):778-784.
20. Sreelakshmi C, Sameer Kumar CV, Shivani D., Productivity enhancement of pigeon pea through improved production technologies, madras agric. J. 2012;99 (4):248-250.
21. Vishwanatha BT. An economic analysis of threshing of maize crop in Karnataka: A comparative study of mechanical v/s traditional threshing methods. M.Sc (Agri) Thesis. Univ. Agric. Sci., Dharwad; 2007.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/118299