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Economic Evaluation and Mechanization Index of Selected Cropping Pattern in Madhya Pradesh

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ABSTRACT

Data collected from 280 farmers spread over seven districts (i.e. Raisen Dewas, Khandwa, Chhindwara, Seoni, Mandla & Ashok Nagar) of Madhya Pradesh. Average power availability was found 1.80 kW/ha which ranged 1.63 to 2.05 kW/ha across the selected villages. Mechanical power contribution was in the range of 80 to 88%. Input-output data were converted into monetary terms & calculated cost of cultivation for the crops grown in the each district. Farmers are getting better net return from wheat (₹ 19,591/ha) followed by gram (₹ 18,695/ha) production with a BCR of 1.71 & 1.86 respectively. The BCR from soybean, paddy and maize was found 1.31, 1.41 and 1.15 respectively. Production function fitted well with a value of the coefficient of multiple determinations (R^2) ranged 0.80 to 0.97 across the crops and statistically significant. Contribution of human labor in the yield was found significant for soybean and gram production while machinery and miscellaneous ((Seed, fertilizer, manure, agro-chemical) were contributed significantly in the wheat and gram productivity. Size of land holding and machinery contributed significantly in cultivation of wheat & gram. Thus, use of machinery showed a positive response with size of holding. Ratio of MVP/MFC (marginal value product/marginal factor cost) for human labour, machinery & miscellaneous were highly sensitive and contributed more than one while animal labour showed a marginal contribution. The level of mechanization index was found higher in crops like wheat (57.61%) and gram (44%) while it was comparatively low in paddy (40%), soybean (40.4%) and maize (43.5%). Mechanization level may increase with adoption of power operated machines for transplanting, weeding/inter-culture and spraying/dusting.

Keywords: Mechanization index, coefficient of multiple determinations, marginal value product, marginal factor cost

The technological improvements in Indian agriculture since mid-sixties have brought about revolutionary increase in agricultural production. Interestingly, the growth rate of food grain production particularly in case of wheat and rice was much higher than the growth rate of population. The country was facing acute food shortages till eighties has now become not only self-sufficient but also a net exporter of food grains. The country witnessed unprecedented growth in agriculture that helped country to graduate from hunger to self-sufficiency in food grains by increasing the food grain productivity from 0.64 t/ha in year 1965-66 to 2.11 t/ha in 2013-14, resulting for export with surplus. This growth is mainly due to the agricultural technology during green revolution period, which is back-up by agricultural scientists including agricultural engineering, supported by positive policy support, liberal public funding for agricultural research and development and un-tired work of farmers. The increased use of purchased inputs in agriculture necessitated to raise their use efficiencies through mechanization. The factors that justify the strengthening of farm mechanization in the country can be numerous. The timeliness of operations has assumed greater significant in obtaining optimal yields from different crops, which has been possible by way of mechanization. The quality and precision of the operations are equally significant for realizing higher yields. The various

operations such as land levelling, irrigation, sowing and planting, use of fertilizers, plant protection, harvesting and threshing need a high degree of precision to increase the efficiency of the inputs, productivity enhancement and reduce the losses.

The productivity of farms depends greatly on the availability and judicious use of farm power by the farmers. Agricultural implements and machines enable the farmers to employ the power judiciously for production purposes. Availability of adequate farm power is very crucial for timely farm operations for increasing production and productivity and handling the crop produce to reduce losses. With the increase in intensity of cropping the turnaround time is drastically reduced and it is not possible to harvest and thresh the standing crop, on one hand, and prepare seed bed and do timely sowing operations of subsequent crop, on the other hand, in the limited time available, unless adequate farm power is available. Similarly, for precision farming, increasing area under irrigation, conservation tillage, straw management and diversification in agriculture, more power is required.

Mechanized agriculture is the process of using agricultural machinery to massively increase farm output. In modern era, agricultural mechanization draws a major controversy that it is often considered only as the application of mechanical power technology, particularly tractors. However, three main levels of mechanization technology need consideration: human power, animal power and mechanical power technologies, with varying degrees of sophistication within each level, on the basis of capacity to do work, costs, and precision and effectiveness. Agricultural mechanization technology further varies from location to location and crop to crop. Thus, the quality of inputs of mechanization, and consequently land and labour productivity may differ considerably. So, mechanization planning requires the quantification of level of mechanization for each crop production. Once the quantification of mechanization is done, it is very much important to identify the variables which are having highly significance towards the mechanization. This would help monitoring the mechanization status in the target region in combination with other agronomic indicators. Multi-stage stratified sampling technique was used to select the districts, blocks, villages and cultivators.

Several authors developed different methods to quantify the level of mechanization based on power or energy availability, and its impact in agricultural and labour productivity. Singh and De (1999) reviewed the methodologies adopted by several authors to express a mechanization indicator. For macro-level planning, a mechanization indicator based on the ratio of electrical and mechanical power over total farm power was introduced as a measure of qualitative assessment of modernization of agriculture. A higher mechanization indicator based on electrical power and stationary engines might only reveal mechanization of stationary operations.

From a qualitative drudgery reduction point of view, a mechanization index based on mechanical tractive power could be a better measure. A major defect in quantifying a mechanization indicator based on the ratio of mechanical tractive farm power to total farm power is that it does not bring to light the actual use scenario. Whilst unit farm power could be considered as indicative of potential power availability, it may not necessarily be fully utilized on the farms. This may depend upon availability of diesel and electricity, and adequate workload. The majority of the farmers in developing countries use tractors for transport of agricultural and non-agricultural commodities. Mechanisation index expressed by the percentage of machine work to the sum of manual, animal and machine work expressed in energy units, as suggested by Nowacki (1978), has been accepted for model forecasting. Zangeneh *et al.* (2010) defined Mechanization Index (MI) and Level of Mechanization (LOM), to characterize farming system of potato in the Hamadan province of Iran. The MI elaborated here is an expression of the deviation of the actual amount of motorized farm work from the normal values at the regional level.

The MI index, proposed by Andrade and Jenkins (2003) is an indication of the amount of machinery a given farmer uses for farm work compared with the average in the region. The LOM index is based on the premise that a mechanized farmer is the one that finds a way to utilize amounts of mechanical energy that are higher than the typical values using locally available technology. Field capacity was multiplied by rated power so the quantification of energy expenditure was made in work units (kWh). The regional normal will be obtained after

compiling a full dataset of all respondents and then it would be defined the mode for the number of passes for each operation as well as the mode in tractor size and field capacity. Ramirez *et al.* (2007) predicted mechanization index using artificial neural network model as a Mexican case study. Zangeneh *et al.* (2010) used artificial neural network model to assess the agricultural mechanization status of potato production in the Hamadan province of Iran. Many of the equations which are used to formulate mechanization indices, lack some information at farm level in Indian condition. Especially mechanization of agricultural production was mainly carried out by mainly three sources viz., machine, human and animal technologies. This also varies from crop to crop and location to location. Measure the mechanization status by considering either stationary or non-stationary power, but ignored the importance of individual production unit. So, all these indicators should have further modifications to assess the mechanization status of a farming system of production of various agro-products in a region. Therefore, a new approach to assess mechanization index has been discussed in the present study, which is suitable at farm level in the Indian condition.

MATERIALS AND METHODS

Sampling Technique

Multi-stage stratified sampling was used to select the districts, blocks, villages and farmers.

District wise power availability

Power availability (kW/ha), tractor density (no/000ha) and ratio of mechanical power to total power for all the 50 districts of Madhya Pradesh was analyzed. All districts were categorized in three groups – high, medium & low ratios of mechanical to total power availability.

- Higher ratio ranged: 0.90 & above,
- Medium ratio ranged: 0.70 to 0.89,
- Lower ratio ranged: less than 0.70.

Thus, a total of seven districts ((i.e. Raisen, Dewas, Khandwa, Chhindwara, Seoni, Mandla & Ashok Nagar) from entire state were selected for survey and data collection. The selected districts were also represented eight agro-climatic regions of the Madhya Pradesh. Two blocks from each selected district, two villages from each selected block and ten farmers from each selected village were finally selected for the survey and data collection. Thus, the study covered 7 districts 14 blocks, 28 villages and 280 farmers of Madhya Pradesh. Data were collected on suitably designed and pre-tested survey proforma through personal interview from selected farmers.

Data analysis

A mechanization index based on the matrix of use of animate and mechanical energy inputs was used by incorporating cost factors as following:

$$I_{mij} = C_{EMij} / (C_{EHij} + C_{EAij} + C_{EMij}) \quad \ldots(1)$$

Where,

I_{mij} is the mechanization index of the i^{th} crop in the j^{th} district,

C_{EMij} is the cost of use of machinery in the j^{th} crop in i^{th} district,

C_{EHij} is the cost of use of human labour in the j^{th} crop in i^{th} district,

C_{EAij} is the cost of use of animal labour in the j^{th} crop in i^{th} district.

Eqn (1) requires component wise details of cost of the cultivation of different crops.

Input-output data were converted into monetary terms & calculated cost of cultivation for the crops grown in the each district and calculated mechanization index using equation 1 as used by G Singh (2006). Economic analysis was carried out using means and averages.

RESULTS AND DISCUSSION

General Information of study areas

General information about study areas has been given in Table 1. General information covered gross area, cultivated area, irrigated area, no of cultivators falling under different sizes of land holdings, no of agricultural workers, no of bullocks, no of tube wells, no of tractors under different horse power, no of electric motors and diesel engines, no of agricultural equipment/tools, daily electricity availability and average size of land holdings. Gross area was found highest in the villages of Khandwa

Table 1: General Information of study areas

Particulars	Khandwa	Raisen	Mandla	Seoni	Chhindwara	Dewas	Ashok Nagar	Overall
Gross area, ha	1205.7	1133.4	878.8	965.7	876.2	965.4	1065.6	1013.00
Cultivated area, ha	1044.5	973.6	786.3	810.6	783.7	835.5	845.7	868.5
Irrigated area, %	70.5	84.5	53.4	62.4	67.5	58.8	54.6	64.5
No. of cultivators	442	333	470	305	414	534	450	421
-Below 2 ha	270	184	252	160	237	284	232	231
-2 to 4 ha	115	142	176	110	165	198	176	155
-Above 4 ha	132	43	42	35	12	52	42	51
No. of Agril workers	415	345	492	342	451	545	492	440
No. of bullocks	708	224	543	676	612	648	377	541
No. of tube wells	142	136	86	72	11	44	66	79
No. of tractors	28	37	22	24	11	18	23	23
-Below 35 hp	11	13	10	11	7	8	10	10
-35 hp & above	18	33	12	12	4	10	14	15
No. of electric motor pump	165	228	168	134	202	168	171	155
-Up to 3 hp	154	186	111	143	195	156	198	163
-5 hp & above	77	42	88	23	63	31	14	48
No. of diesel engine	10	14	12	17	7	18	13	13
- Below 5 hp	9	10	9	14	5	15	11	10
-5 hp & above	2	4	3	3	1	2	3	3
No. of Rotavator	12	11	8	11	2	4	5	8
No. of cultivator	25	43	22	27	10	15	23	24
No of Seed cum Fertilizer Drill	0	4	7	4	1	1	2	3
No of Seed Drill	17	43	22	27	10	18	23	23
No. of Threshers	22	44	26	24	16	24	13	24
Seed Treatment Drum	1	2	4	3	0	1	1	2
Spiral Grader	1	0	0	1	0	0	1	0
No. of Sprinkler Set	1	1	0	3	14	2	3	3
Hand Sprayer	461	342	288	355	156	242	354	314
Electricity availability, h/day	16.75	17.87	18.43	14.54	15.67	15.87	16.26	16.48
Av size of holding, ha	2.36	2.92	1.67	2.66	1.89	1.56	1.88	2.14

district (1205.75 ha) followed by Raisen (1133.45 ha) and Ashok Nagar (1065.60 ha). Average gross area in the villages of selected districts was found 1013 ha. Overall cultivated area was 868.55 ha ranged between 1044.5 ha to 784.6 ha across the district.

Power availability & tractor density

Power availability in selected districts have been analyzed and given in Table 2. Highest power availability of 2.05 kW/ha was found in Raisen followed by Mandla (1.91 kW/ha), Seoni (1.83 kW/ha), Ashok Nagar (1.76 kW/ha) and Dewas (1.75 kW/ha). Average power availability was observed 1.80 kW/ha. Contribution of mechanical power to the total power was found highest in Raisen (95%) followed by Ashok Nagar (88%), Mandla (85%) and Khandwa (83%). Average share of mechanical power was analyzed 85% of the total power. Tractor density was found highest in Raisen (36.27/1000 ha) followed by Khandwa (29.77/1000 ha), Ashok Nagar (19.81/1000 ha) and Seoni (19.21/1000 ha).

Economic evaluation of major crops

Economic evaluation in terms of total cost, gross return, net return, benefit cost ratio (BCR) and yield (kg/ha) was analyzed for the major crops grown in selected districts was analyzed and presented in Table 3.

Table 2: Power availability & tractor density

(Power available, kW/ha)								
Power source	Khandwa	Raisen	Mandla	Seoni	Chhindwara	Dewas	Ashok Nagar	Overall
Human	0.02	0.02	0.03	0.02	0.03	0.03	0.03	0.03
Animal	0.26	0.09	0.26	0.32	0.30	0.29	0.17	0.24
Tractor	0.71	1.00	0.74	0.76	0.37	0.56	0.72	0.70
Electric motor	0.58	0.87	0.79	0.61	0.95	0.74	0.75	0.76
Diesel engine	0.05	0.08	0.08	0.12	0.05	0.12	0.09	0.08
Total power	1.63	2.05	1.91	1.83	1.70	1.75	1.76	1.80
Mechanical power	1.35	1.95	1.62	1.49	1.37	1.42	1.56	1.54
Share of mechanical power to total power, %	83	95	85	81	80	81	88	85
Tractor density, no/000 ha	29.77	36.27	17.61	19.21	8.82	14.94	19.81	20.92

Soybean

Soybean yield was found highest in Raisen (1170 kg/ha) followed by Seoni (1050 kg/ha), Dewas (1024 kg/ha) and Khandwa (973 kg/ha) while average yield of soybean was observed 992.83 kg/ha. Average total cost of cultivation worked out ₹ 22256.25/ha while it was highest in Raisen (₹ 25435.65/ha) followed by Khandwa (₹ 22345.42/ha) and Dewas (₹ 22230.60/ha). Average net return was found highest in Raisen followed by Seoni (₹ 7990.10/ha) and Khandwa (₹ 7331.08/ha). Overall net return was ₹ 7075.46. Overall BCR was 1.32 while found highest as 1.37 in Seoni and lowest as 1.28 in Chhindwara.

Paddy

Highest paddy yield as 3256 kg/ha was found in Khandwa district followed by Mandla (2875 kg/ha) and Chhindwara (2860 kg/ha) while overall productivity was 2941.75 kg/ha. Overall cost of cultivation was ₹ 26793.50/ha ranged between ₹ 28637.67 kg/ha (Khandwa) to ₹ 25432.30/ha (Seoni). Highest net return of ₹ 15318.33/ha was realized in Khandwa district followed by Mandla (₹ 12054/ha) and Chhindwara (₹ 11120.50/ha). Overall net return in paddy cultivation was ₹ 12391.23/ha with BCR of 1.46.

Maize

Overall maize productivity was 1610 kg/ha ranged between 1760 kg/ha (Mandla) to 1480 kg/ha (Chhindwara). Highest cost of cultivation was ₹ 20458.22/ha in Mandla followed by ₹ 19576.80/ha in Chhindwara and ₹ 19536.55 in Ashok Nagar while overall cost of cultivation was 19615.39/ha. Net return realized by the farmers was very poor (₹ 2119.60) due to the heavy rain in beginning of the crop season resulted poor yield. Overall BCR was only 1.11.

Wheat

Wheat is the main crop of Madhya Pradesh grown during Rabi season in all the selected districts of Madhya Pradesh. Overall yield was found 2710.30 kg ranked highest in Raisen (3282.20 kg/ha) followed by Ashok Nagar (2879.60 kg/ha) and Mandla (2642.30 kg/ha). Cost of cultivation was highest in Raisen (₹ 28975.80/ha) followed by Ashok Nagar (₹ 26440.80/ha) and Mandla (₹ 25980.25/ha). Overall net return was realized ₹ 19096.14/ha ranged between ₹ 25180.50/ha (Raisen) to ₹ 21072.60/ha (Ashok Nagar). BCR ranked first in Raisen (1.87) followed by Ashok Nagar (1.80) and Seoni (1.77) while overall BCR was 1.74.

Gram

Gram is also a major crop of the farmer's of Madhya Pradesh grown in Rabi season in the entire selected district. Overall yield was 1189.14 kg/ha ranged between 1376 kg/ha (Raisen) to 1080 kg/ha in Dewas. Cost of cultivation was highest in Raisen (₹ 23538/ha) followed by Chhindwara (₹ 22456.89/ha) and Khandwa (₹ 21567.60/ha) while overall cost of cultivation was ₹ 21305.60. Highest net return was found in Raisen (₹ 19805.60/ha) followed by Ashok Nagar (₹ 16991.07/ha) while overall net return was ₹ 15623.12/ha. BCR ranked first in Raisen (1.84) closely followed by Ashok Nagar (1.82) with overall as 1.73.

Table 3: Cost of cultivation of crops (₹/ha)

Districts	Crops	Total Cost	Yield,kg/ha	Gross Return	Net Return	BCR
Khandwa	Soybean	22345.42	973.00	29676.50	7331.08	1.33
Raisen		25435.65	1170.00	345150	9079.35	1.36
Seoni		21567.40	1050.00	29557.50	7990.10	1.37
Chhindwara		20545.20	870.00	26317.50	5772.30	1.28
Dewas		22230.60	1024.00	29388.80	7158.20	1.32
Ashok Nagar		21413.25	870.00	26535.00	5121.75	1.24
Overall		22256.25	992.83	29331.72	7075.46	1.32
Khandwa	Paddy	28637.67	3256.00	43956.00	15318.33	1.53
Mandla		26758.50	2875.00	38812.50	12054.00	1.45
Seoni		25432.30	2776.00	36504.40	11072.10	1.44
Chhindwara		26345.50	2860.00	37466.00	11120.50	1.42
Overall		26793.49	2941.75	39184.73	12391.23	1.46
Khandwa	Maize	18890.00	1760.00	23760.00	4870.00	1.26
Mandla		20458.22	1520.00	20520.00	61.78	1.00
Chhindwara		19576.80	1480.00	19980.00	403.20	1.02
Ashok Nagar		19536.55	1680.00	22680.00	3143.45	1.16
Overall		**19615.39**	**1610**.00	**21735**.00	**2119.60**	1.11
Khandwa	Wheat	24987.95	2583.25	42623.63	17635.68	1.71
Raisen		28975.80	3282.20	54156.30	25180.50	1.87
Mandla		25980.25	2642.30	43597.95	17617.70	1.68
Seoni		23680.90	2543.80	41972.70	18291.80	1.77
Chhindwara		24536.60	2480.50	40928.250	16391.65	1.67
Dewas		24765.20	2560.50	42248.25	17483.05	1.71
Ashok Nagar		26440.80	2879.60	47513.40	21072.60	1.80
Overall		25623.93	2710.30	44720.07	19096.14	1.74
Khandwa	Gram	21567.60	1235.00	36432.50	14864.90	1.69
Raisen		23538.40	1376.00	43344.00	19805.60	1.84
Mandla		20675.70	1122.00	35343.00	14667.30	1.71
Seoni		20656.55	1106.00	34839.00	14182.45	1.69
Chhindwara		22456.89	1170.00	36855.00	14398.11	1.64
Dewas		19567.60	1080.00	34020.00	14452.40	1.74
Ashok Nagar		20676.43	1235.00	37667.50	16991.07	1.82
Overall		21305.60	1189.14	36928.71	15623.12	1.73

Mechanization index

The overall mechanization index combined all the crop was 43.76%, even though 85% of the total farm power is contributed by mechanical and electrical power sources. However, not all crops are uniformly mechanized. Crop wise values for mechanization index vary from 36.86% in paddy to a highest value of 57.61% (Table 4) in wheat varied from 52.49% to 68.56% across the districts (Table 5). Technology for mechanization of wheat crop such as tillage, sowing, harvesting and threshing is extensively being used by the farmers. The mechanization index of soybean crop, which occupies the largest area under cultivation during *Kharif* season, is only 40.41% that varied from 35.50% to 45.85% across the selected district.

Although overall mechanization index for soybean crop was 40.41%, but the highest was recorded in Raisen (45.85%) and lowest of 35.50% in Chhindwara. Soybean crop grown in entire state, and mechanical power use is limited to inter culture/ weeding & hoeing and harvesting. Raisen had the highest mechanization index (46.30%) for the gram cultivation followed by 44.53% in Mandla, 44.48%

Table 4: Overall mechanization index (MI) for major crops

District	Crop	Component of the cost of cultivation, ₹/ha			
		Manual	Animal	Machinery	MI,%
Overall	Soybean	6442.4	2784.65	6257.66	40.41
	Paddy	7442.5	3179.4	6200.12	36.86
	Maize	6437.6	2842.5	5546.55	37.41
	Wheat	5567.8	2342.55	10748.60	57.61
	Gram	5872.3	2342.7	6461.46	44.03
	Combined all the crops	31762.6	13491.8	35214.39	43.76

Table 5: District wise scenario of Mechanization Index for major crops

Crop	Khandwa	Raisen	Mandla	Seoni	Chhindwara	Dewas	Ashok Nagar
Soybean	42.10	45.85	38.60	38.60	35.50	39.60	43.30
Paddy	41.35	0.00	34.50	38.20	33.70	0.00	0.00
Maize	41.22	0.00	34.78	0.00	33.70	0.00	40.65
Wheat	57.90	68.56	54.45	52.49	53.65	54.50	60.60
Gram	42.32	46.30	44.53	44.48	41.26	43.28	40.83

in Seoni, 43.28% in Dewas, 42.32% in Khandwa and 41.26% in Chhindwara. Khandwa had the highest mechanization index (41.22%) for the maize production followed by 40.65% in Ashok Nagar and 34.78% in Mandla.

Analysis of resource use efficiency

The resource use efficiency was assessed by comparing marginal value product (MVP) with factor cost of resources. Linear Production function without intercept was used for the analysis and model is given as under:

$$Y = b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + u$$

Where, Y = Gross Return, ₹/ha,

X_1= Crop area, ha

X_2= Human labour, ₹/ha,

X_3= Animal Labour, ₹/ha,

X_4= Machinery, ₹/ha,

X_5= Miscellaneous, ₹/ha,

u = Error term.

The miscellaneous expenditure in the model included the expenditure on seed, manure, fertilizers, agro-chemicals etc.

The estimated production parameters are presented in Table 6. The estimated production function explained 80% variation in soybean output, 97% variation in wheat and gram each due to variation in all the resources put together showing a good fit of the model. Human labour was significantly contributed in cultivation of soybean and gram while machinery contributed significantly in cultivation of wheat. A highly significant contribution was found for miscellaneous inputs (seed, manure, fertilizers, agro-chemicals) in production of wheat and gram. Size of farm also registered a significant role in production of wheat and gram, Table 6.

Table 6: Estimated production function of major crops

Particulars	Production elasticity		
	Soybean	Wheat	Gram
Area	1530.40 (0.160)	43735.36 (1996.4)*	22142.35 (4142.20)*
Human Labour	2.127 (2.053)*	0.14 (0.315)	0.572 (0.413)**
Animal labour	0.634 (0.450)	0.042 (0.135)	0.040 (0.282)
Machinery	2.883 0.562)	0.282 (0.109)*	0.471 (0.239)
Miscellaneous	0.922 (0.689)	0.425 (0.139)*	1.277 (0.507)*
R^2	0.80	0.97	0.97

**Significant at 1%, **Significant at 5%*

Marginal Value Product (MVP) & Marginal Factor Cost (MFC)

To analyse the scope for intensification of selected resources, the marginal value product (MVP) of the resources was compared with the respective marginal factor costs (MFC). The MVP and MFC ratios for different resources was analysed and given in Table 7. The MVP-MFC ratios indicated that there was a scope for increased use of human labour and machinery in soybean & gram cultivation in the short run keeping the use of other resources at a constant level. This was also true for machinery and miscellaneous items as MVP-MFC ratio for these resources was also more than one in cultivation of wheat and gram.

Table 7: MVP and MFC of resources in major crop production

Inputs	Soybean	wheat	Gram
	MVP/MFC	MVP/MFC	MVP/MFC
Human Labour	2.13	1.16	3.01
Animal labour	0.93	1.16	1.02
Machinery	2.89	1.78	1.75
Miscellaneous	0.92	3.50	3.36

CONCLUSION

Farmers are getting better net return from wheat (₹ 19,591/ha) and gram (₹ 18,695/ha) production with a BCR of 1.71 & 1.86 respectively. The BCR from soybean, paddy and maize was found 1.31, 1.41 and 1.15 respectively. Contribution of human labor in the yield was found significant for soybean and gram production while machinery and miscellaneous ((Seed, fertilizer, manure, agro-chemical) were contributed significantly in the wheat and gram productivity. Size of land holding and machinery contributed significantly in cultivation of wheat & gram. Thus, use of machinery showed a positive response with size of holding. Ratio of MVP/MFC for human labour, machinery & miscellaneous were highly sensitive and contributed more than one while animal labour showed a marginal contribution. The mechanization index was found higher in crops like wheat (57.61%) while it was comparatively lower in gram (44.03%) soybean (40.41%), maize (37.41%) and paddy (36.86%). Mechanization level may be increase with adoption of power operated weeder for weeding/inter-culture operation of soybean & maize crop, power operated sprayer/duster for spraying/dusting of agro-chemicals in soybean crop while paddy mechanization may get momentum with the adoption of transplanter, mechanized nursery system for transplanting, power operated sprayer duster for spraying/dusting and track type combine harvester for harvesting.

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