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Research Article

BULLOCK DRAWN IMPROVED IMPLEMENT PACKAGE FOR SOYBEAN CROP CULTIVATION IN MALWA PLATEAU OF MADHYA PRADESH

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Abstract- Animal drawn improved implement package consist of improved bakhar, three row seed-cum-fertilizer drill and sweep cultivator were evaluated at farmers' field in village-Bhuriyapura of Dewas district in Malwa Plateau of Madhya Pradesh. The seed bed preparation, seed sowing, interculture and spraying operations were considered to finalize the implements package for soybean crop cultivation. During the study, field performances of the improved implements were compared with conventional implements used by the farmers. In seedbed preparation, improved bakhar was found more effective than conventional bakhar. It saved 17.6% labour, 16.7% cost of operation and 18.5% time of operation over conventional bakhar. In seeding, the three row seed-cum-fertilizer drill has 13.5% increased field capacity and saved 10.5% labour over locally used Tifan. In case of interculture, use of two row sweep cultivators increased 13.7 % weeding efficiency and 0.04 ha/h field capacity in comparison to Dora which leads to saving of 49.8% of weeding cost as compared to Dora and 94.5% labours over manual weeding. In spraying operation, the operational cost knapsack sprayer was ₹ 285/ per ha.

Keywords- Soybean crop, improved bakhar, seed cum fertilizer drill, Dora.

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Introduction

Soybean is a major crop of Madhya Pradesh grown in 56.69 lakh hectare area thus contributing area-wise share of 79% with respect to area under cereals, pulses and oilseed crops respectively [1]. In world scenario, country ranks fifth in soybean production after USA, Brazil, Argentina and China [2]. Major production comes from Madhya Pradesh (53%), followed by Maharashtra (34%) and Rajasthan (8%) [3]. To mechanize the farm operations tractor drawn machineries have been promoted since two decades. However, rising cost of diesel and electricity have showed significant increase in the cost of operation of power operated machinery. Small and marginal farms, except for primary tillage operations, all other farm operations can be economically carried out by animate power. It is estimated that 55% of net sown area of the country is sown by draught animals [4]. Traditionally the draught animal power has been the main source of farm power. At present there are nearly 56 million draught animals in the country (19th Livestock Census 2012). For small land holders, animal traction is the best option as it is affordable, sustainable, profitable and environment friendly solution in most ecological systems. Small and marginal farmers constitute 84.97% of the land holdings which are less than 2 ha [5]. This area is within the command area of a pair of bullocks. States like Odisha, Madhya Pradesh, West Bengal, Manipur, and Tripura have 2.5 – 5.0 ha per animal power [6]. Various organizations like ICAR-Central Institute of Agricultural Engineering, Bhopal, Centers of All India Coordinated Research Project on Utilization of Animal Energy has developed improved implements for different farm operations. The utilization of draught animal power and appropriate farm mechanization technology address seasonal labour shortage, raising productivity and profitability of smallholder. In India, bullock drawn (Animal power) implements are still widely used in many regions, especially by small and marginal farmers. These farmers are using traditional implement made by local artesian based on local needs. They are not aware of improved implement developed by various research organizations. A locally available implement has lower field capacities and poor performance. These are also lacking in adjustments and calibration. Inputs like seed and fertilizer cannot be applied at constant and uniform rate across field. All these leads to irregular germination and untimely operation, which resulted into lower productivity and production at higher input cost. Keeping in consideration all the points, a package of animal drawn implement was finalized for soybean crop cultivation and same was evaluated in Bhuriyapura village of Dewas district of Madhya Pradesh during kharif seasons of year 2014 and 2015.

Materials and Methods

Based on survey conducted, Bhuriyapura village was selected for the study,as it used animal power as major source of farm power. Soybean is the main cash crop grown in kharif which plays a vital role in the economy of the village. Based on the cropping pattern and discussed with ICAR-KVK, Dewas and State government officials a package of animal drawn implement as given in [Table-1] and shown in [Fig-1] was formulated and given to the selected farmers.

Field data was analyzed using following standard formulae;

$$D=P.\cos\Theta$$

Where,
D=Draft, N
P=Pull exerted by implement, N
Θ=Inclination of beam, degree

Operation	Conventional implement system	Improved implement system
Seedbed preparation		
	Conventional Bakhar, 450mm blade	Improved Bakhar, 500mm blade
Seeding		
	Tifan	Three row seed cum fertilizer drill
Interculture		
	Dora, 15mm blade	Sweep cultivator, 15*2mm blade
Spraying		
	Knapsack sprayer	

Fig-1 Operation wise selected implements for soybean crop cultivation

Table-1 *Improved implement package and conventional system for soybean crop cultivation*

Operation	Conventional implement system	Improved implement system
Tillage	Desi plough	Improved bakhar, 500 mm
	Blade harrow, 325 - 450 mm	Patela harrow, 1200 mm (situation based)
Stubble collection (Soybean)	Manual picking	Patela harrow, 1200 mm
Seeding/planting	Tifan and chaufan	Three row seed cum fertilizer drill
Interculture/ weeding	Single Dora or double Dora (150 mm each)	Three tyne sweep cultivator
Spraying	Knapsack sprayer	Knapsack sprayer

Theoretical field capacity (TFC) = Width (m) X speed (m/h) /10000 = A / (Tp + Ti)
Where,
A=Area covered, ha
Tp = Productive time
Ti=Non-productive time, h
Effective field capacity (EFC) is the actual area covered by the tool, implement or machine, based on its total time consumed and its width.

Soil moisture = [(weight of the wet soil sample, gm - weight of oven dry soil sample, gm)/ (weight of oven dry soil sample)] X 100
Bulk density of soil sample=M/V
Where,
M=Mass of the oven dried core soil sample, gm
V=Volume of cylindrical core sample, cc
For weeding and intercultural, a three-row sweep cultivator was used by the farmers. However, during the operation operator found difficulty in managing the third row. Therefore, implement was modified by removing one tine from three tyne to become two rows sweep cultivator. The following formula was used for calculating weeding index of the implements.

Weeding index, % = (W1-W2/W1) X 100
Where,
W1 = Number of weeds before weeding
W2 = Number of weeds after weeding
Based on the field data, the cost of using different equipment's in weeding like hand khurpi, Dora, sweep cultivator and improved bakhar were computed in terms of Rs/h and Rs/ha.

Final plant stand was calculated by using standard square frame technique. The number of plants in a square meter area was counted to calculate the final stand. Three replications were taken to calculate the final plant stand.

Various operations like land preparation, sowing, weeding/interculture and spraying were conducted in farmers field with traditional and improved implements. The data in both the cases were compared to assess the benefits of improved implement system.

Results and Discussion

Land Preparation: In traditional and improved method, seedbeds were prepared with two passes of conventional bakhar and improved bakhar. Field observations of conventional bakhar and improved bakhar are shown in [Table-2]. Drafts of the traditional bakhar and improved bakhar were497 and 516N respectively. Increase in width of operation increased the draft by 19 N. But increase in width of cut of improved bakhar leads to22% increased field capacity, 16.7% saving in average operational cost and18.5 % operational time as compared to traditional bakhar.

Table-2 *Field observations of conventional bakhar and improved bakhar*

Particulars	Year 2014		Year 2015	
	Conventional implement	Improved implement	Conventional implement	Improved implement
	Bakhar (T1)	Improved bakhar*	Bakhar (T1)	Improved bakhar*
Field/soil condition				
Area, ha	2.5	1.8	0.8	0.8
Moisture content, %	20.5	18.7	20.7	21.7
Bulk density, gm/cc	1.20	1.15	1.17	1.13
Machine Parameters				
Width, mm	450	500	450	500
Weight, kg	40	45	40	45
Performance results				
Depth of operation, mm	58	63	70	66
Speed, km/h	2.5	2.44	1.91	1.95
AFC, ha/h	0.0625	0.0818	0.086	0.098
Labour required, man-h/ha	16	12.3	11.63	10.2
Cost of operation, Rs/h	83.17	84.33	83.17	84.33
Cost of operation, Rs/ha	1331	1035	967	861
Savings in cost when compared to treatment T1, %	---	22.2	---	11
Saving in time when compared to treatment T1, %	----	25	---	12
* Improved bakhar was used without roller				

Seeding: Three row seed cum fertilizer drill gives a space for quick lateral adjustment of tyne to compensate with desired row spacing as well as seed sowing uniformity throughout the field. Whereas, tifan does not have any row to row spacing adjustment; hence the row spacing for soybean crop in traditional method of drilling was 275 mm, gave the 825 mm width of operation as against 900 mm (300 mm tyne spacing) for three row-seed-cum fertilizer drill [Table-3].

From [Table-3], it is also depicted that average field capacity, labour requirement and cost of operation of tifanfor the kharif 2014 and 2015 were 0.19 ha/h, 5.3 man-h/ha and Rs. 422/ per haand 0.16 ha/h, 6.25 man-h/ha and Rs. 501 per ha respectively. In case of three row seed-cum-fertilizer drill, the concern values were 0.23 ha/h, 4.5 man-h/ha and Rs. 427/ per ha and 0.17 ha/ h, 5.88 man-h/ha and Rs. 567/ per ha. It indicates use of three row seed cum fertilizer drill has more average field capacity, saving in man power by 15 and 10.5% (0.6 man-h/ha). Three row seed cum fertilizer cost was more by Rs. 6800/ than traditional tifan (Rs. 2200/). But increased field capacity leads to reduction in operational cost by Rs. 106 to 300/.

Table-3 *Field observations of sowing of soybean crop*

Particulars	Year 2014		Year 2015	
Implement	Tifan (T1)	Three row seed cum fertilizer drill	Tifan (T1)	3-row seed cum fertilizer drill
Crop				
Crop variety	---	---	IS-8560	IS-8560
Field/soil condition				
Area, ha	1.5	1.2	0.6	0.8
Moisture content, %	21.2	19.3	13.9	14.6
Bulk density, gm/cc	1.07	1.04	1.12	1.08
Machine parameter				
Weight, kg	35-45	50	35-45	50
No. of rows, No	3	3	3	3
Row spacing, mm	275	300	275	300
Beam inclination, ^{0}	NA	NA	21	21
Performance results				
Width of operation, mm	825	900	825	900
Seed quantity, kg	150	70	80	70
Working depth, mm	40 – 60	50-65	43	39
Speed of operation, km/h	3.1	2.9	2.0	1.9
Average pull, kg	NA	NA	NA	59.79
Draft, kg	NA	NA	NA	55.82
FC, ha/h	0.19	0.23	0.16	0.17
Labour required, man-h/ha	5.3	4.5	6.25	5.88
Cost of operation, Rs/h	80.13	96	80.13	96.00
Cost of operation, Rs./ha	422	427	501	565
Saving in time when compared to treatment T1, %	---	15.5	---	6

Final plants stand: Seed germination decides the final plant stand in a unit area. Nevertheless, it is the function of depth of seed placement and proper soil cover and not of the machine. An average depth of seed placement was observed to be in acceptable range for both the implements i.e. 50 and 43 mm and 57 and 39 mm for tifan and three row seed cum fertilizer drill. However, across the field, in case of three row seed cum fertilizer drill, the plant stand was uniform as compared to tifan.

Table-4 *Average final plant stand in 1m² area of soybean crop*

Year	Conventional implement	Improved implement
	Tifan	3 row seed cum fertilizer drill
2014	23.3	21.5
2015	25.7	23.7

Interculture and weeding: Field performance data for Dora, khurpi and two row sweep cultivator were taken at farmers field. The field performance data was recorded for weeding efficiency, field capacity, labour requirement, cost of operation, saving in cost and saving in time [Table-5]. The performance results show nearly 73 to 20% increased weeding efficiency due to use of two row sweep cultivators as compared to conventional Dora. The average field capacity of Dora was 0.04 ha/h, whereas concerned values of two row sweep cultivator was 0.08 ha/h. It means that two sweep cultivator shows increased field capacity of49.8%. In manual method of weeding by using khurpi, nearly 240 man-h/ha were required, whereas in case of animal drawn Dora and two row sweep cultivator labour requirement was 33.4 and 13man-h/ha respectively. Moreover data depicts that labour requirement in manual weeding is 7.2 times than that of animal drawn Dora and 18.5 times two row sweep cultivator. Furthermore it can be concluded that by the use of Dora nearby 79 - 93% labours can be saved, whereas in case of use of two row sweep cultivator 93- 96% labour can be saved in comparison to manual weeding. Cost of weeding with khurpi was estimated to be Rs. 7500/ per ha, whereas cost of weeding with Dora and two row sweep cultivator were Rs. 3867/ and Rs. 1339/ per ha respectively. When the cost of weeding with different methods were compared, the manual weeding required 1.9 times cost of weeding with Dora and about 5.6 time cost of two row sweep cultivator. Due to use of two row sweep cultivator Rs. 6161 and 2528/ per ha were saved when compared to manual weeding and Dora.

Table-5 *Field observations of intercultural/weeding operation*

Particulars	2014			2015	
	Traditional method		Improved method	Traditional method	Improved method
	Dora* (T1)	Manual weeding by khurpi (T2)	3-Row Sweep cultivator**	Dora (T1)	2-Row Sweep cultivator
Field/soil condition					
Area, ha	1.3	0.2	0.4	0.8	0.8
Moisture content, %	20.8	---	19.6	20.1	20.5
Bulk density, g/cc	1.07	---	1.10	1.08	1.06
Machine parameters					
Weight, kg	13	---	40		40
No. of rows	1	----	2	1	2
Width, mm	150	---	150*2	150	150*2
Performance results					
Pull	NA	NA	NA	NA	8.2
Speed, km/h	2.4	---	2.5	2.2	1.8
Depth of operation, mm	30	---	35	30	2.7
Draft, kg	NA	NA	NA	NA	5.2
Weeding efficiency, %	61.5	---	66	49	59
FC, ha/h	0.020	1 acre/12 men/2 day	0.063	0.06	0.10
Labour required, man-h/ha	50	240	15.87	16.67	10
Cost of operation, Rs/h	77.33	31.25	84.33	77.33	84.33
Cost of operation, Rs./ha	3867	7500	1339	1289	843
Savings in cost when compared to treatment T1& T2,%	---	---	65-75	---	35
Saving in time when compared to treatment T1&T2, %	---	---	68-93	---	40
* Row spacing – 275 mm					
** 3-Row sweep cultivator's one tyne was removed during operation and operated between 300 mm rows					

Spraying: In soybean crop, spraying of chemicals is performed more than two times to control weeds and to increase crop yield. In Bhuriyapura village, trend of chemicals applied consisted; Max Humus (Humic and Fulvic Acids) as a soil supplement, MTS to control/repeal thrips, red and white spiders, leaf curling disease, insecticide or pesticides (Contract)to kill the pests and D-Gold chemical to increase percentage setting fruit and to enhance growth of plant. The availability of bottles sizes and proportion of spray chemicals added in 15 lit of water to make spray solution is given in [Table-6] (information was provided by the farmers). The expenditure incurred on chemicals of soil supplement, crop protectant, insecticide and growth enhancer were Rs. 550/, 4250/, 1890/ and 1800/ per ha per application respectively. The data recorded for knapsack sprayer at farmer's field is given in [Table-7]. The application rate for soybean was900 lit/ha. Mostly the refilling and preparing spray solution requires lot of time, which lowered the field capacity to 0.14 ha/h. The average operational cost and labour requirement of spraying with knapsack sprayer was Rs. 285/ per ha and 8.2 man-h/ha respectively.

Table-6 *Cost economics of spray chemicals*

Name of Chemical company	Max Humus	MTS	Contract	D-Gold
Quantity of chemical used in making 15 lit spray volumes, ml	15	20	15	8
No. of fillings of spray tank required per ha (enquiry)	60	60	60	60
Total chemical quantity required, ml/ha	900	1200	900	480
Available size of bottles, ml	500	250	50	50
Unit rate, Rs.	275	850	105	200
Approximate no. of bottles required	2	5	18	9
Expenditure on one time chemical use, Rs./ha	550	4250	1890	1800
Total expenditure on chemical, Rs/ha	8490/			

Table-7 *Field performance of knapsack sprayer*

Year	2014	2015
Crop	Soybean	Soybean
Type of sprayer	Knapsack sprayer	Knapsack sprayer
Area	0.8	0.8
Weight including spray solution, kg	20	20
Sprayer tank volume, lit	15	15
No. of fillings of spray tank required per ha (enquiry)	60	60
Approximate rows covered, no.	8	6
Operational width, mm	2200	1800
Application rate (60*15), lit/ha	900	900
Total plants (850 mm spacing), no./ ha	---	---
Avg. time required to cover 42m, min	1.4 - 2	---
Average time required for 30 no. plants spraying, sec (min)	---	---
Speed of operation, km/h	1.8	1.9
Total time required in manual spraying, h/ha	---	---
FC, ha/h	0.17	0.10
Labour wedges per day of 8 h, Rs.	250	250
Cost using knapsack sprayer, Rs./ha	185	386
Labour required, man-h/ha	5.95	10.40

Conclusion

The performance of selected implement package was found highly satisfactory and could be recommended for adoption at other locations of animal dominated areas. The field capacity of improved bakhar, three row seed cum fertilizer drill and sweep cultivator were 20, 13.5, and 50% more field capacity in comparison to local bakhar, tifan, Dora and manual weeding. This significant improvement reduces the labour cost by 17.6, 10.5 and 60 % respectively. Timely operation with more precision and less cost will boost the economy of the small farmers dependant on animal drawn implement.

Application of research: The work mentioned in the article is very important for timely operations in soybean crop especially bullock prevailing areas around the study location.

Research Category: Agricultural Mechanization

Abbreviations:
TFC: Theoretical field capacity
EFC: Effective field capacity

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