



A Key Input for Reducing of Mechanization Cost in Smallholdings: Mini Tractor Drawn Multi Task Toolbar

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Authors' contributions

This work was carried out under ICAR Extramural Project collaborative between both authors. Author CR designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author NR managed the analyses of the study. Both authors read and approved the final manuscript.

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ABSTRACT

The present study aims to determine the key input for reducing of mechanization cost in smallholdings: Mini tractor-drawn multi task toolbar. Farm power and mechanization are essential inputs agricultural production system and will raise the labour and land productivity. Inadequate equipment and practices can damage severely natural resources. A focus on only one aspect, primary tillage (or) seeding (or) tilling (or) spraying results in low utilization rate which is not profitable to small holder farmer. Hence the attempt was made and developed "multi-task tool frame" that can house all the components required for a variety of operations such as seeding, fertilizing, weeding, tilling, spraying and transportation thereby reducing investment, operating cost, time and fuel for operation. The use of multi-task tool frame could reduce the cost of sowing and fertilizer application reduced from Rs. 3800/- to Rs. 1674/- per ha through developed machine planting. Moreover, the man hour requirement came down from 152 hour to 3 hours. Combining the

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spraying and weeding operation found to be good in 1st speed ie 1.8 kmph over the 2nd speed 3.2 kmph. However, the cost of reduction was 71 percent in machine operation when compared to manuel weeding & spraying and 44 percent over independent machine (spraying weeding) operation, moreover and saving in man-days about 48 man days per hectare. Fuel-saving of 8.15 Lha⁻¹ which amounts to 47.8% due to combining the two operations like tilling and spraying compared to independent operations.

Keywords: Tractor; machine planting; weeding; primary tillage.

1. INTRODUCTION

India is having 18% small farmers and 67.3% marginal farmers with land holding of less than 2 ha and 1 ha respectively. These 86% of the farmers are resource-poor with fragmented small pieces of land and lack of financial strength to afford machines for crop production. In addition, due to urbanization and other created petty works in rural India agricultural workforce came down to 5.5% from 15.4% (in 1970) and the very important farm power source of Indian farms, draught animal power source also came down from 45.4% to 5.1%.

Under power dearth situation, farmer is under a confused state of mind and forced to attempt with available farm power tractorization (tractor with cultivator) and in turn, loosing productivity. Farm mechanization is only an option and opportunity to increase yield and reduce loss in addition to lowering the cost. But due to poor economic status of farmer resorted to tractor services available in the region. Most tractor services focused only on tillage and remained unused after ploughing [1].

Increasing productivity requires more intensive agriculture. More intensive agriculture cannot happen without more power availability to perform work [2] Farm productivity is directly related to the farm power available and significant increases in agricultural production can only be achieved through increasing power based mechanization [3]. A complete mechanized system approach, including not only tillage, but planting, spraying, weeding delivered to the smallholder farmer, need to be considered to better understand the opportunity for smallholder mechanization in crop production [4]. The proper choice and use of mechanized inputs into agriculture have a direct and significant effect on the achievable level of land productivity and labour productivity. The smallholder farmer also needs farm power and mechanization needs to be raised to stimulate the product value chain

and activate input supply to raise the productivity of their land and labour and to see the improvement in farm family lively hoods [5].

Moreover in India, green revolution improved productivity through intensive agriculture and appropriate input use, but a sudden increase in power demand due to higher productivity was met with tractorization for tillage and threshing the crop. Most of these machines are suitable for big farms and designed only for row cropping. The remaining operations such as sowing, weeding and chemical spraying were met from animal or human power source. But these power sources came down (animal and human both together) to 10.1% in 2017 from 63% 1970, which caused severe dearth of power availability for Indian farmer in general and smallholder farmer in particular. Due to the shortage of labour availability, some of the essential but labour intensive operations like intercultural operations (weeding, tilling) and chemical spraying operations are skipped and compromised with yield deterioration which in turn affected the productivity levels. Moreover, focus on only one aspect, primary tillage, resulted in poor equipment utilization and tractorization becomes unprofitable.

New technologies and mechanization are a must for smallholders to achieve sustainable increase in production. Trends in mechanization worldwide showed that there were strong correlations between economic growth and mechanization [6]. Advent tractorization farmer compromised with certain labour intensive operations like weeding tilling versatile and to be useful for carrying out various operations like sowing fertilizer application, tilling & weeding, chemical sparing and hauling. The tool frame was mounted with a special gearbox (uniquely designed) to multiply the power take-off units and complete certain operation simultaneously in a single to which saves time energy and more importantly natural resource fuel oil. Since the process in accommodating multi operations in a

one go and carryout 4 tasks with single investment and moreover can save fuel consumption & cost of operation. The economic feasibility of the combination tool designed for small holdings mechanization was tested independently as well as in combination to evolve best combination.

2. MATERIALS AND METHODS

Development of multi tool frame was taken up under the research grant of ICAR – Extramural Project on “Productivity improvement and alleviation of drudgery through small farm mechanization” sanctioned to Regional Agricultural Research Station, ANGRAU, Tirupati and work carried out at College of Agricultural Engineering, Madakasira. The developed “multi task tool frame” was selected for study, the evaluation carried out in the farms of ANGRAU at College of Agricultural Engineering, Madakasira. The multi task tool frame was developed with the objective of integrating some of the operated which are still carried out by the animal (or) human energy and mitigating energy requirement, a navigating the smallholder farmer drudgery and increasing productivity through mechanization.

For calculating effective field capacity, the time consumed for actual work and lost for other activities such as turning and filling the tank of spray was considered. Effective field capacity was calculated by following formula.

$$E.F.C. = \frac{A}{TP + Tnp}$$

Where,

E.F.C. = Effective field capacity, ha h⁻¹

A = Area, ha

Tp = Productive time, h

Tnp = Non-productive time, h

Field efficiency: Field efficiency was calculated by taking ratio of effective field capacity to theoretical field capacity. It is always expressed in percentage. It was calculated by following formula.

$$F_x (\%) = \frac{EPC}{TPC} \times 100$$

Where,

F_e = Field efficiency, %

E.F.C. = Effective field capacity, ha h⁻¹

T.F.C = Theoretical field capacity, ha h⁻¹

Development of “Multi task tool frame and testing”:

The multitask tool frame was with basic frame made up of MS angle made into box, made as basic supporting frame and provided with two wheels at either side. The required braces and brackets welded to the frame for housing different gadgets depending up on the utility, like seed sowing and fertilizer applicator (or) tilling and weeding (or) spraying etc., The required components based upon requirement were conveniently be fixed to the braces & brackets provided on main frame. Since the main frame was common only certain components need to be changed at every operations (or) combination of operations that investment on individual equipment can be minimised and all operations also can be mechanized.

Sowing unit: The developed multi task tool was fitted with sowing unit i.e., seed cum ferti drill. The crop chosen was groundnut variety “kadiri 6” seed was placed in the hopper designated for seed and fertilizer in ferti hopper. The conveying tubes were connected to furrow opener. It well prepared field was selected for doing the evaluation time taken was noted for completing entire field and effective field capacity was computed in two tested speeds of 1.8 kmph and 3.2 kmph speed.

Spraying unit: The spraying unit as fixed with chemical spraying unit and tank was fixed after removing seed cum ferti drill unit from the main frame. The drive was given to spraying from central shaft frame of developed gear box. The spraying unit was tested in the ground nut crop sown with the developed unit (seed drill) at a spacing of 30 cm.

Tilling & weeding: The tilling unit was developed on the frame at rear member of the main frame. Three tilling assemblies were selected for evaluation. The height of the wheel (ground) is adjusted and orientation of tilling unit also can be adjusted. The power was connected through flexible shaft by connecting to developed transmission unit without disturbing spraying unit power transmission belt. The unit was operated in two speeds ie 1.8 & 3.2 kmph.

Overall observation: The developed machine was working well in both speeds ie 1.8 kmph and 3.2 kmph for sowing and spraying operations where as tilling (or) combined with spraying the machine performance is better in lower speed i.e 1.8 kmph only and weeding efficiency was found satisfactory.

3. RESULTS AND DISCUSSION

The multi task tool frame was developed and tested in the groundnut during 2016-2018. The trials were conducted at college of Agricultural Engineering, Madakasira, ANGRAU for ground nut crop production and production technologies. The variety chosen was groundnut, kadirri '6' in experimental field of 1000 m² plots. The field was prepared and the developed tool frame was used starting from row sowing and fertilizing intercultural operations tilling weeding and spraying operations were carried out. The developed gadget was independently used and possible combination was also administered. The time spent was rated and fuel consumption for covering the area was computed using standard top pill method.

The cost economics of the developed multi task tool frame was worked out. The total cost of the Multi task tool frame was Rs. 1,25,000/-. The selected prime mover (tractor) cost was Rs. 3,50,000/-. It is also estimated the cost of all the gadgets independently like seed cum fertidrill, spraying unit; rototilling or weeding unit with local available market prizes which amounted Rs. 1,75,000/-. More over the independent equipment usage will be for very short time and need to be kept aside (without use) cost of

operation was estimated and compared with existing practice and independent gadgets in Table 1.

Operational cost per hour of developed unit:

The cost of operation was computed to estimate the operational cost by considering the actual cost incurred for developing the unit and also estimated the cost of spraying and tilling independently for comparison.

During the field trials, performance of developed machine was observed and field capacities were computed based on the time taken for various operations independently as well as in combination. The results were presented in Table 2.

The cost economics of various operations carried out by the developed unit and was compared with existing practice of manual operation and available machines From the Table 4 for sowing alone need to be treated separately and computed the operational cost and compared with existing practice (or) manual sowing and fertilizer application. The cost of sowing and fertilizer application reduced from Rs. 3800/- to Rs. 1674/- per ha through developed machine planting. More over the man hour requirement came down from 152 hour to 3 hours.

Table 1. Operational cost of developed implement according to existing machines

Name of the machine	Tractor	Multi task tool frame developed machine	Independent existing machines
Cost of the equipment / (Rs. ^{h1})	3,50,000/-	1,25,000/-	1,75,000/-
Fixed cost (Rs. ^{h1})	57.75	51.0	72.0
Variable cost Rs/.hr	270.0	16.0	22.0
Total operation cost Rs/hr	327.0 (A)	57.0 (B)	94.0 (C)
Total operating cost including per mover Rs/hr	-	384.0 (A+B)	421.0 (A+C)

Note: Operational cost was estimated assuming 125 days working 1000 hours per year for tractor 50 days 400 hrs/per developed equipment and existing machinery

Table 2. Determination of field capacity of developed multi task frame for different operation

S. no.	Operation	Speed kmph	No rows	EFC ha h ⁻¹	Time taken to cover one hectare 'h'
1	Seed cum ferti drill	1.8	5	0.229	4.36
	Seed cum ferti drill	3.2	5	0.388	2.58
2	Spraying	1.8	5	0.232	4.31
	Spraying	3.2	5	0.374	2.67
3	Tilling & weeding	1.8	5	0.229	4.37
	Tilling & weeding	3.2	6	0.362	2.76
4	Spraying & Tilling	1.8	5	0.227	4.41
	Spraying & Tilling	3.2	5	0.288	3.47

Table 3. Overall performance of developed machine and its economic implications

S. no.	Operational costs	man days (d ha ⁻¹)	man hours (h ha ⁻¹)	Operational cost (Rs. ha ⁻¹)	machine hours (h ha ⁻¹)	Operational cost of developed machine (Rs.ha ⁻¹)	Operational cost with existing machines for independent operations (Rs.ha ⁻¹)
1	Seed cum ferti drilling	17	136	3400	4.36	1674.0	1835.0
2	Fertilizer application	2	16	400	2.58	991.0	1086.0
3	1 st weeding & tilling	19		3800			
		29	232	5800	4.37	3356.0(twice)	3680.0(twice)
4	2 nd weeding & tilling	20	160	4000	2.76	2120.0(twice)	2324.0(twice)
		49		9800			
5	1 st spraying	2	16	1000	4.31	3310.0(twice)	3629.0(twice)
6	2 nd spraying	2	16	1000	2.67	2050.0(twice)	2248.0(twice)
		4		2000			
Combined operation							
7	Spraying & tilling	29+2		5800+1000	4.41	392.0(twice)	3713.0(twice)
				232+16			
8	Spraying & tilling	20+2		4000+1000	3.47	2665.0(twice)	2921.0(twice)
				160+16			
		53	Total	11,800			

Table 4. Fuel consumption of the developed machine

Operation	Speed	Fuel consumption e/h	Time 't/h(a)'	?
Tilling	1.8	2.04	4.37	8.915
Spraying	1.8	1.91	4.31	8.232
Combination tilling & S(s) praying	1.8	2.04	4.41	8.996

Whereas the cost reduction was maximum when compared with weeding by machine over the traditional practice of manual weeding ie Rs. 9800/-ha to Rs. 3356 ha/- (machine). The machine weeding man hour saving was 488 man hrs per hectare over manual weeding operation. This shows the drudgery on human labour is completely eliminated through machine weeding.

Spraying operation by machine increased operational cost but the risk of exposure to the highly toxic chemical during spraying operation. Combining the spraying and weeding operation found to be good in 1st speed ie 1.8 kmph over the 2nd speed 3.2 kmph. However the cost of reduction was 71 percent in machine operation when compared to manual weeding and 44 percent over independence machine operation

spraying weeding more over and saving in man days about 48 man days per hectare.

Transportation of input and produce: In addition to the above mentioned advantages, farmer can haul inputs from house to farm and produce from farm to house, since the reduction of cattle population (draught animal) in villages farmer is struggling to transport inputs and produce and carrying on heads which can conveniently be completed with developed machine.

4. CONCLUSION

This clearly show that developed "multi task tool unit" machine can significantly reduce the cost of operation and make the operation independent of work force there by reducing drudgery of the

human labour and make farmer comfortable and continue with this agriculture profession.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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