RESEARCH PAPER | International Journal of Agricultural Engineering | Volume 10 | Issue 2 | October, 2017 | 488-495
e ISSN–0976–7223 ■ Visit us : *www.researchjournal.co.in* ■ **DOI: 10.15740/HAS/IJAE/10.2/488-495**

Mechanization planning to bridge the mechanization gap for different farm operations to meet fodder and crop production in region, Pusa, Bihar, India

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Received : 14.07.2017; **Revised :** 22.08.2017; **Accepted :** 07.09.2017

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■ **ABSTRACT :** The present study deals with purpose mechanization planning to bridge the mechanization gap for different farm operations for sustainable farming in Pusa region. The results obtained from survey conducted to list out the machineries available as well as gap to the farm, the mechanization planning was suggested on the available field conditions to bridge this gap. Grassland-based cattle farms are highly dynamic systems that are difficult to manage, mostly because of their sensitivity to uncontrollable environmental factors such as weather. The results obtained from the survey conducted in the cattle farm of Dr. Rajendra Prasad Central Agricultural University situated in Samastipur was noticed 70 hp (~0.87 hp/ha) utilization of farm power in terms of available machinery for farm operations which was calculated lower than reported a value of power utilization as 1.5 hp/ha for successful farm operation through mechanization. Mechanization of agriculture to meet the growing demand of population, productivity of land has to be enhanced. This can be done by timely application of improved technology. For good retaining the quality as well as nutritional aspects of green fodder, it is essential to harvest fodder with taking minimum operational time. Nutritious green fodder is required to enhance the quality of milk in terms of vitamin A, D, E, and K. To enhance the productivity, to reduce seed losses and to facilitate interculturing activities, it is necessary to perform sowing operation properly. Maximum production of fodder is required to meet the fodder requirement production as well as to enhance the quality of milk. Mechanization is also essential to understand the importance of maintaining the health and to aware the different initiatives being undertaken by cattle farm farmers to protect and enhance the environment.

■ **KEY WORDS :** Farm mechanization, Farm power, Cattle farm, Status of farm, Milk quality, Mechanization planning

■ **HOW TO CITE THIS PAPER :** Kumar, Dheeraj, Kumar, Manoranjan and Kant, Rajni (2017). Mechanization planning to bridge the mechanization gap for different farm operations to meet fodder and crop production in region, Pusa, Bihar, India. *Internat. J. Agric. Engg.*, **10**(2) : 488-495, **DOI: 10.15740/HAS/IJAE/10.2/488-495.**

Dairy farming represents one of the most important agricultural practices in India, and rank first with about 18.5 per cent of world production as mentioned in economic survey 2015-16. The 146.3 million tones annual milk production was achieved during 2014-15 as compared to 137.69 million tones during 2013-14

(web source) whereas, the Food and Agriculture Organization (FAO) has reported a 3.1 per cent increase in world milk production from 765 million tones in 2013 to 789 million tones in 2014. Dairy farms are mostly dependant on green fodder availability. Dairy farming holds great secure in providing sustainable income and employment to a large mass of rural population. Dairy is presently the top ranking commodity in India, which is nearly equal to the combined production value of rice and wheat. Agricultural mechanization represents technology change through the adoption of non-human sources of power to carry out agricultural operations such as seed bed preparation, water pumping, spraying, interculturing, harvesting etc. Adoption of mechanization by farmers is an evolutionary process induced or influenced by a set of country specific agro-climatic factors, social conditions and economic factors for which the government's policy choices have impact. Across the different regions of the country, there is a significant diversity in dairy farms for structural characteristics, technical performance and economic results including management. The mechanization approach allows managing a large farm area in simplified manner. There is a limited knowledge regarding the actual mechanization level and the operational characteristics of dairy farming systems. This information would lead to better understand the energy demands of the milk production systems that directly depend on fodder quality. The energy related aspects are assuming, highly important in agricultural and livestock systems (Edens *et al.*, 2003; Jakel, 2003; Ludington and Johnson, 2003). Unavailability of land that possibly will be put to fodder production, feeding green fodder and dry fodder is indeed a difficult job. In case of cattle farm of Dr. Rajendra Prasad Central Agricultural University situated in Samastipur, the cattle farm posses 96 ha land including both cultivable as well as uncultivable. The cattle farm governs the 96 ha land so power required is 144 hp for performing the operation. But at cattle farm there is only 70 hp power is available for different field operations. Hence, a deficit was observed in farm power source for different fodder production operation. It was about 74 hp. The major issues are related to the efficiency of the energy uses (Grisso *et al.*, 2004; Institut de l'Elevage, 2009; Rossi and Gastaldo, 2012), the environmental impact due to utilization of fossil fuels as energy sources in agriculture (Rotz *et al.*, 2010) and to optimize the energy operating costs of milk production.

Mechanization, resulting in reduced energy expenditure (Dimitri *et al.*, 2005; Laningham-Foster *et al.*, 2003) and the rational use of energy is mainly focused to mechanization level, to the equipment's efficiency and to the style of farms management. Family labour regarded to be more intensively used on small farms in the absence of efficient labour markets due to difficulty in supervising and monitoring hire labor, which, in turn contributes to the inverse relationship between farm size and crop yield (Benjamin and Brandt, 2002; Berry and Cline, 1979; Chen *et al.*, 2009 and Feder, 1985). As Otsuka (2013) analyses, increasing real wages (and transformation of occupational structures in labour market) challenge Asian agriculture in which the major part of farmers are small land holders, of the increasing need (i) to reduce the labour force in agriculture (as the opportunity cost of labour increases), (ii) to increase the average farm size (to reduce labour use by introducing labour saving production methods) and (iii) to generate enough income to retain parity with non-agricultural workers. The ability of their foliages to remain green and uphold their protein content makes them potential sources of protein and energy (Olafadehan, 2013). Forages have many advantages and are important part of any farming system suitable for the hill ecosystem to provide green fodders for livestock (Ghosh *et al.*, 2009), diminish runoff (Saha *et al.*, 2012) and get better soil quality (Choudhury *et al.*, 2013). The planning of mechanization and managing the fodder flow is not only one of the most critical of all management functions; it can also be one of the most satisfying financially, psychologically and aesthetically. Having a thorough knowledge of the mechanization of dairy farms could address towards new management strategies in order to reduce energy consumptions, to make farm operations timely and improve the efficiency of milk production. The objective of this study focused on the mechanization planning to bridge the mechanization gap for different farm operations for sustainable farming in Pusa region. Through such mechanization planning, small land holding farmers as well as large farms can stay viable in agricultural production.

METHODOLOGY

Project area:

The study was conducted in Dr Rajendra Prasad

Central Agriculture University (Dr. RPCAU) cattle farm which is located in main campus of university at Pusa farm on the embankment of Gandak river. The study area situated between $25^0$42' and $26^0$52' North latitude and $45^0$42' and 86^0 02' east longitudes.

Data collection and analysis:

The data were collected based on cropping pattern, agricultural practices, mechanization gap and available farm mechanics. The obtained data were encompassed main information regarding inventory of implements, machinery distribution for each hectare of crop land, availability of power source, land utilization pattern and irrigation structure. In addition, survey was also conducted to get information regarding cattle family description, farm machinery, cropping pattern and operation wise power utilization. Total gross cultivable area (GCA) was calculated as suggested by Bardhan (1973). The difference between fodder production and consumption was estimated. If the consumption was found higher than production then available machinery and un-utilized crop area was checked. Finally, suitable implementation of farm machinery and utilization of un-utilized land to enhance the fodder production to meet the annual demand of fodder was suggested.

Field measurement :

The main observations were taken at the time of tractor and bullock operation, area covered and time taken along with human power used.

Field capacity:

The field capacity was calculated on the basis of area covered in a specific time for a particular operation. The field capacity was calculated as under:

$$\text{Theoratical field capacity} = \frac{S \times W}{10}; \text{(ha/hr)}$$

where, S is linear speed of travel of tractor (Km/hr), W is effective width of implement (m)

$$\text{Theoratical time} = \frac{\text{Field area}}{\text{Theoratical field capacity}}$$

$$\text{Number of Turns} = \left(\frac{\text{Field width}}{W} - 1\right)$$

Turning time = Numbers of turns × Time loss per turn

Actual time was calculated as sum of all time spent during operations and given as:

Actual time = Theoretical time + Turning time + Seed filling time + other losses

Where, other losses directly associated with time losses during operations such repair work, maintenance etc.

Now, efficiency (η) is calculated as

$$\eta = \frac{\text{Theoretical time}}{\text{Actual time}} \times 100$$

In other way, efficiency, actual field capacity and theoretical field capacity are also related as

$$\eta = \frac{\text{Actual field capacity}}{\text{Theoretical field capacity}}$$

Tillage operation data:

Knowing the field capacity and number of times the operations performed on different crops, the total hours of use for each implement were determined.

Sowing operation data:

Knowing the total area covered in sowing/transplanting operation and all power source in valued, in terms of hours total human and animal hours were calculated.

Inter culturing operation data:

Inter culturing operation consumes large amount of human power by knowing the total area covered by total number of man or women in specified time total human hours were calculated.

Harvesting operation data:

Harvesting is one of the main operations in valued in fodder and crop production which consumes a large amount of human power. Knowing total human's hours were calculated.

Threshing operating data:

The total grain production was calculated by multiplying the average yield of grain and area cropped under maize napier, *Jowar*, jai, barseem etc.

Following expression was used to compute total time required for thresher.

$$\text{Hour of threshing} = \frac{\text{Total wheat/Paddy production}}{\text{Output of thresher}}$$

Hours of threshing were estimated by considering

all the threshing operation to be completed by tractor, electric motor and diesel engine etc.

Pumping operation data:

Cattle farm used electric meter and diesel engine for pumping operation were considered to obtained the pumping hours(In terms of discharge, output) and total area irrigated. The equation used to estimate hours of pumping is written as:

$$\text{Hour of pumping } Z \frac{\text{Area irrigated (ha) x Depth of irrigation (m)}}{\text{Discharge (output)}}$$

Farm power availability:

Farm power availability from different sources of power such as human, animal, mechanical and electrical were analyzed and power available per hectare cultivable area is given as

$$\text{KW/ha } Z \frac{\text{Total power (kw)}}{\text{Cultivable area (ha) x No. of } \frac{\text{Crop}}{\text{Year}}}$$

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Land utilization pattern of the projected area:

The total land area of Dr. RPCAU cattle farm is 96 ha in which 16 ha are under bund having 250% cropping intensity and rest 78 ha are undulatiny, full of shrubs and tree and under the teeth of river Gandak. Out of 78 ha of land in Dhab area only 24.24 ha are cultivable that also having only 100% ensured cropping intensity in *Rabi* season.

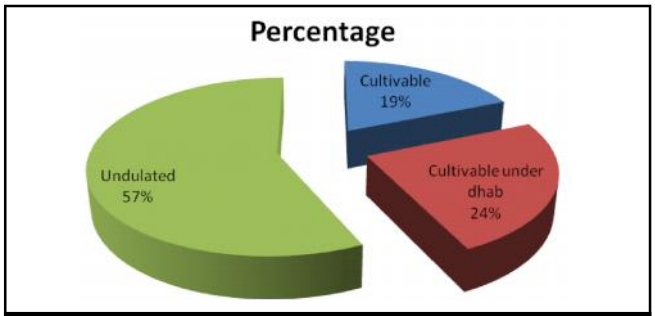

Fig. 1 : Land holding pattern of the projected area

Land utilization pattern of the projected area as obtained from official record of Dr. RPCAU cattle farm is presented in Table 1.

Table 1 : Utilization cropping pattern of the projected area in year 2013-2014

Sr. No.	Season	Crop	Net cultivable area (ha)
1.	*Rabi*	Barseem	8.484
		Jai	30.704
		Napier	0.606
	Kharif	Maize	6.06
		Jawar + Maith	34.34
	Total gross cultivable area = 80.194		

Table 2 shows annual production, consumption and requirement of fodder. In year 2010-2011 the fodder production in cattle farm was 16650 quintal, consumption 41213.35 quintal and deficit was 24563.29 quintal. In year 2011-2012 the fodder production in cattle farm was 23106.32 quintal, consumption 40610.56 quintal and deficit was 17504.24 quintal. In the year 2012-2013 the fodder production in cattle farm was recorded 25352.55 quintal, consumption 38028 quintal and deficient was found 12675.45 quintal. In year 2013-2014 the fodder production was recorded as 18216.57 quintal, consumption 32770.04 quintal and deficit was 14553.47 quintal. The quantity of fodder varied because the cattle farm also taking care of cattle from local farmers, and the cost of caring is either milk produce by cattle or payment in terms of rupees. Due to continuous deficit of fodder in the farm, which will be only fill up by timely operation and moderate use of available cultivable area. It will be carried by mechanization.

Table 2 : Annual fodder production and consumption

Sr. No.	Year	Production (q)	Consumption (q)	Requirement (q)
1.	2010-2011	16650.06	41213.35	24563.29
2.	2011-2012	23106.32	40610.56	17504.24
3.	2012-2013	25352.55	38028	12675.45
4.	2013-2014	18216.57	32770.046	14553.47

Increasing the cropping intensity cattle farm power source must be about 1.5 hp per hectare. Farm power is needed on the farm for operating different implement and during various farm operations, while mobile power is used for doing different field jobs. The mobile farm power comes from human, draft animals, power tiller and self propelled machines. There was absence of sowing implement at cattle farm.

The Table 4 is discussed to fill up the mechanization gap in cattle farm. Based on field capacity and field efficiency of implements, the numbers of required implement can be easily calculated and hence the gap is estimated. For minimizing seed losses and proper seed germination, it is necessary to deliver the seed at specified seed-rate and place seed in certain pattern. Hence, one seed cum fertilizer drill with field capacity 0.50-0.55 ha/hr and one inclined plate multi crop planter with 0.52-0.55 ha/hr is required. There was enough irrigation facility hence requirement is nil. The harvesting is performed manually, which takes more time so affect the quality of green fodder which ultimately affects the quality of milk hence one green fodder harvester with trolley is required. It was critically observed that there is need to level the undulated land and hence land leveler is essentially required. There are surplus implements available for primary tillage, but there is a big problem associated with repair and maintenance of these implements. For secondary tillage purposes there is need of one rotavator with field capacity 0.65 to 0.70 ha/hr and field efficiency 68%. To maintain the land level there is need based requirement of land leveller time to time. Present scenario says there is no any sowing implement is found at cattle farm. To enhance the productivity, to reduce seed losses and to facilitate intercultury activities, it is necessary to perform sowing operation properly. It is possible with the help of one 11 tine seed cum fertilizer drill having field capacity0.64-0.62 and field efficiency 65% and one inclined plate multicrop planter with field capacity 0.62-0.71 ha/hr and field efficiency 65%. Irrigation facility is sufficient enough to irrigate the cultivable area. For retaining the quality as well as nutritional aspects of green fodder, it is essential to harvest fodder with taking minimum operational time. Therefore, one green fodder harvester is recommended with field capacity 0.3 to 0.4 ha/hr and field efficiency 70%. For maize cultivation, maize thresher with 80 to 100 kg/hr threshing capacity and 72% efficiency is recommended to fill up the gap.

Operation wise implement planning for fodder production:

The cattle farm governs the 96 ha land out of this 78 ha land is undulated. The primary consideration for land levelling is important. Hence, land leveller is suggested. To enhance production it is necessary to cover more area available. The main preparatory activity for production is seed bed preparation. The farm posses less power source and matching implement. Hence, high power tractor 45 hp and one power tiller is recommended.

Table 3 : Status of farm power available, gap and requirement

Sr. No.	Name of power source	Available		Requirement	Total gap
		Capacity	Condition		
1.	Tractor	35hp Massy forgushan Model No 1035 35hp Massy forgushan Model No 1035	Functional	One 145 hp Tractor	62hp
2.	Power tiller	Nil	Nil	12 hp	12 hp
3.	Electric motor	1hp 15 hp	Functional	Nil	Nil
4.	Generator/diesel engine	5 hp 5 hp	Functional	Nil	Nil

Table 4 : Planning for filing the gap

Sr. No.	Field operation	Demand of existing type machine/ implement	Additional implement out of existing one	Remarks
1.	Tillage	MB Plough, Disc Plough, 9 tine Cultivator and Disc-harrow (16 disc)	Rotavator	Since, it is very efficient implement hence required
2.	Sowing	Nil	Seed cum fertilizer drill Inclined plate multicrop planter	Proper sowing is necessary for increasing yield and makes intercultury operation easier
3.	Weeding	Hoe	Peg type weeder	Because it is easier in operation
4.	Harvesting	Nil	Fodder reaper	For small grass like barseem
			Paddy straw chopper	For paddy straw
			Green fodder harvestor	For green fodder harvesting one green fodder harvestor is required

Power tiller is suggested because some land is under shrub and tree where power tiller is suitable to cover area for fodder production. It was observed that there was no any sowing implement at the DrRPCAU cattle farm. Sowing was done by broadcasting manually and some time opening furrows by country plough and dropping seeds by hand, maize is sowing by making holes or slits by a stick or Khurpi and dropping seeds by hand. Under manual seeding it was not possible to achieve uniformly distribution of seeds. Cattle farm may sow at desired seed rates but inter-row and inter-row distribution of seeds is likely to be uneven resulting in bunching and gaps in field. There is poor control over depth of seed placement. It is necessary to sow at higher seed rates. Labour requirements are high because two persons are required for dropping seed and fertilizer. The effect of inaccuracies in seed placement on plant stands is greater in case of fodder sown under dry cultivation. During *Kharif* sowing, placement of seeds at uneven depth may result in poor emergence because subsequent rains bring additional soil cover over the seed and effect plant emergence. Hence, if DrRPCAU cattle farm will posses two sowing, implement one seed drill or seed cum fertilizer drill and another is planter then all type fodder will be sown by two machine and achieve place the seed in the acceptable pattern of distribution in the field, place seed uniformly at the desired depth in soil and ultimately enhance in the yield. It was observed that only one hoe was available but not in proper condition almost all field intercultured by khurpi. Weeding control in the field of fodder under irrigated and rain fed field during *Kharif* is a serious problem and the yield is affected to the extent of 20%-60% if not controlled. The khurpi is most versatile hand hoe for removal of weeds but it takes 300 to700 man-hours to cover one hectare (FIM REPORT). Use of long handle wheel hoe and peg type weeders, reduce this weeding time to 100-125 hours. The sowing practice of fodder in the DrRPCAU cattle farm was found not in raw and wider spacing because sowing was conducting by broad casting of seed. If the sowing will be carried by suggested seed drill and transplanter then weeding may be used by long handle wheel hoe and peg type weeder and reduce in time then area will be covered more. Plant protection equipment was not available at DrRPCAU cattle farm and there no any plant protection insecticides and pesticides are used in fodder production. However, chemical in the form of liquid or power will be directly adverse effect the animal food. The area under fodder production high yielding varieties and per ha consumption will increase the fodder. Irrigation is also most crucial of all the inputs as it ensures fodder crop establishment. Besides *in situ* water conservation of natural precipitation, cattle farm have Budhi Gandak canal water, tube wells water for irrigation.

However, cattle farms prefer assured irrigation which is available by exploiting ground water through irrigation pumps. Harvesting operation is one of the most important operations for Dodder production and it takes more time a labour consuming operation. With the help of mechanization harvesting and post harvesting operation motivated to reduce operational cost as well as losses with retaining product quality. Mechanization also avoids the problem concern with non availability of labour during harvesting period and it ensures timeliness and reducing drudgery in operations. The sickle is the most widely used for harvesting of fodder crops at DrRPCAU, Pusa farm. This is easily available but output is very low. Reaper, reaper cum binder is not useful for fodder harvesting. Fodder harvester is only suitable for the cutting as well as chaffing green fodder for feeding of cattle at DrRPCAU cattle farm.

Conclusion :

The survey analysis examined engagement of different types of mechanized and non-mechanized work and how these related to sustainable dairy farming. The mechanization of farm work has obvious benefits in terms of productivity, its potential effects on cultivation and management must be recognized. The cattle farm governs the 96 ha land so power required is 144 hp for performing the operation. But at cattle farm there is only 70 hp power is available for different field operations and about 74 hp deficit was observed (Kumar and Kumar, 2017). There is need to level the undulated land and hence one land leveler is essentially estimated implement under secondary tillage for maintaining the undulated land to enhance in area for fodder crop production. There are surplus implements available for primary tillage, but there is a big problem associated with repair and maintenance of these implements. For secondary tillage purposes there is need of one rotavator with field capacity 0.65 to 0.70 ha/hr and field efficiency 68%. To enhance the productivity, to reduce seed losses and to facilitate interculturing activities, it is necessary to perform sowing

operation properly. It is possible with the help of one 11 tine seed cum fertilizer drill having field capacity 0.64 and field efficiency 60% and one inclined plate multicrop planter with field capacity 0.62 ha/hr and field efficiency 60%. For good retaining the quality as well as nutritional aspects of green fodder, it is essential to harvest fodder with taking minimum operational time. Therefore, one green fodder harvester is recommended with field capacity 0.3 to 0.4 ha/hr and field efficiency 60%. Fodder reaper and paddy straw chopper are required for timely harvesting of fodder and chopping of paddy straw. The sowing practice of fodder in the DrRPCAU cattle farm was found not in row and wider spacing because sowing was conducting by broad casting of seed. Farm mechanization led to enlarge in inputs on relation of higher average cropping intensity and larger area and greater than before productivity of farm labor. To retain their green leaves and nutrient content during dry seasons, they bridge the gap normally created by decline in the nutritive potentials of natural pastures during this period. The ability of their foliages to remain green and uphold their protein content makes them potential sources of protein and energy (Olafadehan, 2013). The green fodder can be supplied to farm only with the timeliness in operations and it can be possible only with mechanization practices.

Acknowledgement :

Authors are thankful to Ruchi Mehta, College of Fishery, DrRPCAU, Dholi for her timely suggestions and technical helps. Authors acknowledged the AICRP on Farm Implement and Machinery (FIM), Dr Rajendra Prasad Central Agricultural University, Pusa for technical support. Authors are thankful to office of cattle farm for providing the necessary data for successful research.

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