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Sustainable approach of mechanization in rice-potato cropping sequence: Redefining the need in Assam

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ABSTRACT

In Assam, small and marginal farmers are large in number (86%) with fragmented land holding resulted more dependence on power-tiller driven operations. However, records show the increase of power-tiller numbers in Assam is not so prominent with merely increase of numbers from 24701 in 2012 to 40000 in 2017, whereas tractor numbers have increased from 10610 to 41310 in the same period with approximate area covered by 30.9% in 2017. Currently, the usage of machines for agricultural operations are getting attention of farmers to increase productivity. This study will throw some light on government schemes on promotion of farm-mechanization along with an overview of commercially available advanced farm-machines used in paddy and potato cultivation. Moreover, it will try to provide critical review of the use of such machines in field operations to ensure sustainability of farm operation in a composite of new and old practices for both paddy and potato.

***Keywords*:** Combine harvester, mechanization, paddy transplanter, potato, potato harvester, potato planter and rice

The selection of right crop in the dry/*rabi* season (*Boro*) and the use of suitable short/medium-duration rice varieties with improved management practices (crop establishment, nursery, nutrient, weed, water, insect-pest and disease) in the wet/*kharif* season (*Sali*) are central to bridge yield gaps and enhancing farmers' profitability through system intensification in rice-based cropping systems in Assam. Because of the rainfed nature of farming, and high risks associated with the aberrant monsoon, farmers' investments in improved crop management (irrigation water, fertilizer, weed, insect-pest and disease management) are minimal . Sustainable farm mechanization in paddy-potato system contributes a substantial role for execution of timely low-cost operations and get maximum efficiency utilization of seed, fertilizers pesticides, water, and manpower. It enhances the production (both qualitative and quantitative), system productivity and reduces drudgery in agricultural operations. Day-to-day agriculture has gone through many changes and improvements. However, the transfer and adoption of advanced technologies in agriculture and allied sectors in Assam are far below national average. It is also important to note that agriculture and allied sectors employ major share of population (60% of India's rural population in 2013-14) and therefore, its modernization is appropriate method for sustainable socio-economic upliftment to create mass employment opportunities. According to projections compiled by Indian Institute of Rice Research, Hyderabad (2020), rice demand is expected to grow from present production of 120 million tonnes (2020) to 156 million tonnes by 2030. With declining natural resources, declining input efficiency, and growing labour shortage, the target of 156 million tonnes seem to be a little daunting. Mechanization will help in attaining this number, by minimizing risks, reducing labour constraints, increasing the timelines of field operations, reducing drudgery for women, and attracting youth for involvement in farming; all these factors collectively lead to improvements in farm productivity and profitability. The availability of farm power per unit area ($kWha^{-1}$) has been considered as one of the parameters for expressing level of mechanization. The usage of farm machinery depends on the farm power available for various tractive and stationary operations.

Constantly, agricultural productivity has a correlation with farm mechanization, and it plays a key role in enhancing the productivity by improving efficiency of inputs. In the context of agricultural development, the relevance of farm technology is inevitable when it comes to the economic prosperity of a developing state like Assam. For example, Assam needs its farm sector to upgrade for its increased economic gain. Currently, the farm power in India has achieved a decent growth with a Compound Annual Growth Rate (CAGR) of 3.3% from average farm power availability of 0.25 kW ha^{-1} in 1951 to about 2.02k W ha^{-1} in 2017 (Govt. of India, 2018). Assam out of other 8 states of North-East Region (NER)

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have the largest cultivable plain agricultural land and farm power availability for mechanization is 0.40 kW ha^{-1} (2006-07) increased to 0.97 kW ha^{-1} (2016-17) which is still about half of the National average of 2.02 kW ha^{-1} (MoA&FW, 2018). In 2012, there were 3.78 tractors per 1000 ha of net sown area in Assam, whereas these numbers increased to 14.75 in the year 2017. A system approach of farm mechanization for rice- potato cultivation would be a better option for increasing cropping intensity, enhancing system productivity with special focus on reducing turn around period from harvesting one crop and sowing the next crop, reducing drudgery in farming operations.

Different farm machineries of paddy and potato in Assam

1. Mechanical paddy transplanter

Mechanical transplanter can be used to complete the transplanting of rice in a very short period with reduced cost, time and minimum use of labour. Timely establishment of rice seedlings facilitates timely harvesting and seeding of the succeeding crop, thus enhancing cropping intensity and overall system productivity. In Assam, traditionally rice is manually transplanted, which is labour- intensive and time-consuming. Mechanical transplanter with the mat-type nursery is a viable option for change from the practice of manual transplanting.

Mechanical transplanting of rice is the process of transplanting young rice seedlings raised in a mat-type nursery, using a self-propelled rice transplanter (Fig. 1 and 2). The transplanter may be a riding type or walk-behind type. Due to small and fragmented fields with high bund height, walk-behind type transplanter is more preferred in Assam. The labour requirement in conventional manual transplanting is approximately 250-300 person-hour/ha, which is roughly about 25% of the total labor requirement during the crop growing period (Samal *et al*., 2020; Shivashenkaramurthy *et al*., 2020). However, if a self-propelled rice transplanter is used, 40-50 person-hour/ha can transplant up to 1.5 hectares in one day. In the mat-type nursery, a thin layer of farmyard manure (FYM) or compost mixture mixed with soil, is placed on a perforated polythene sheet to raise the nursery. The polythene sheet helps in creating dense mat by proper root growth and prevents the roots from penetrating the underlying soil of raised bed. The mat-type nursery is a pre-requisite for machine transplanting which can be cut into desired sizes to fit into the trays of the transplanter. Seedlings are ready for planting within 14-18 days after seeding (DAS).

Advantages of mechanical transplanting

- Maintain the optimal age of seedlings (14-18 days) for transplanting
- Maintain uniform spacing of 26-28 hills $m^{-2}$and optimum plant density with 2-3 seedling per hill
- Increased productivity by 0.5-0.7t ha^{-1} compared to the traditional method, where plant spacing, and density may not always be consistent

2. Combine harvester (Mini track type)

About 89% of rice in Assam is grown as rainfed in the basins of Brahmaputra and Barak rivers receiving heavy rainfall. In *Boro* season, harvesting period of rice coincides with pre-monsoon rainfall in May/June and sometimes uncertain rainfall during harvesting stage of *Sali* season paddy in the month of November/December, makes manual harvesting difficult in wet fields. Therefore, owing to prevailing aberrant and unpredicted weather conditions, the farmers are forced to reschedule their harvesting operations, the delay in harvesting results in over-ripening of crop, leading to severe shattering and bird losses, and early harvesting results in more chaffy grains. Farmers lose the crop, both qualitatively and quantitatively. Shortage of labour during this peak demand months add an extra burden on farmers with higher labour wages and delayed harvesting of the crop. So mini-combine harvester is a better viable option for reducing cost and timely harvesting of paddy crop in Assam condition (Fig. 3) with following major advantages:

i. The provision of a track-type wheel system in this machine makes it easy to operate in a wet field where a full-feed combine harvester is unable to operate
ii. By using this type of mini-combine harvester, farmers have an option to get the full-length straw just like manual harvesting, which gives additional monetary support to the farmer
iii. The half-feed threshing system in this combine harvester also has two additional benefits, such as:
    a) Less impact force on the grain results in <1% broken grains in threshed paddy (The full-feed combine harvesters generally have 10-12% broken grains).
    b) Straw is smooth and easy for chewing by the cattle.
    c) Besides paddy, it can be used for harvesting, threshing, and cleaning of wheat and barley also.

The paddy fields in Assam are smaller in size and this mini-combine harvester can easily move in these small size fields compared to other bigger versions of the combine harvesters. During the harvesting stage of *Boro* paddy some of the low-lying fields have standing water up to 1.5-2.0 feet, where the farmers usually use boats to harvest their matured paddy fields. This mini-combine harvester worked very effectively and efficiently, when demonstrated to harvest the crop in

Fig. 1: Mechanical transplanter

Fig. 2: Mat-type nursery, a prerequisite for mechanical transplanter

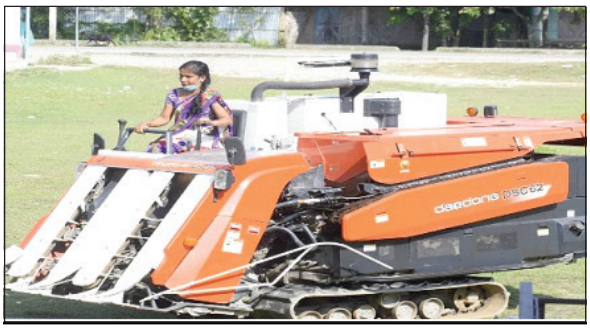

Fig. 3: Mini-combine harvester

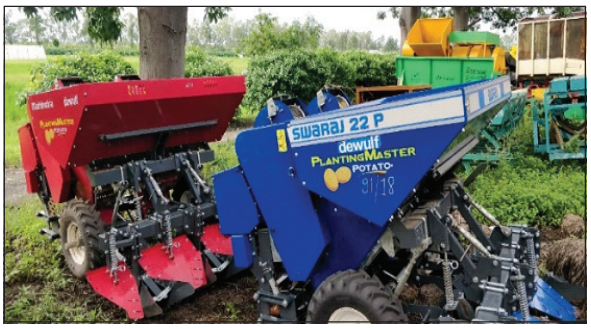

Fig. 4: Automatic potato planter in Assam

Fig. 5: Operation of potato harvester in Assam

Fig 5a: Manual transplanting of paddy in Assam

Fig. 5b: Manual potato planting in traditional cultivation at Gingia Biswanath, Assam

Fig 6: Spreading of straw in a Combine harvester field

standing water of the fields. It brought a smile on farmers' face as they were facing many problems to harvest paddy, especially in the *Boro* season.

3. Automatic potato planter

Basically, the state farm sector is powered by farm labour, animals, tractors and power tillers. Apart from these, advanced level of machineries like combine harvester, transplanter, ridger, potato planter (Fig.4), potato harvester, weeder *etc*. have entered very recently in the farm sector of Assam.

Potato planter performs the functions of furrow opening, seed metering, seed placement at proper depth and formation of ridges to cover potato tubers. Two, three or four row semi-automatic potato planters have been developed, commercialized and are being used by the farmers. The capacity of such machine is low (0.15 ha h^{-1}) because of slow speed of operation as feeding of potato is done manually. Automatic potato planters with picker wheel type mechanism are commercially available with field capacity of 0.25 ha h^{-1} (Dixit *et al*., 2015).

Bhardwaj and Sharma (2020) and Zheng *et al*. (2021) revealed many benefits of automatic potato planters which are given below

- Uniform planting depth and spacing
- Reduce the labour cost and help in timely planting
- Furrows made by potato planter facilitate uniform irrigation
- Improve production of uniform size tubers
- Reduce post-harvest losses particularly greening of the tubers etc.

4. Potato harvester

In Assam, potato harvesting is labour intensive, time consuming operation, causing lot of fatigue, so the use of mechanization can reduce the input expenditure, increase work efficiency and generate additional income. The potato harvester is a viable option to address these aforesaid challenges and can be operated by a tractor of 35hp. In potato harvester the power to the gearbox is transmitted by a telescopic shaft from the tractor-PTO. Soil-potato mass is picked up and lifted by the chain conveyor. Two agitator sprockets oscillate the conveyor chain rod, which helps to separate the soil. Potato tubers with no or very little soil/clods are dropped on the ground behind the digger. Thus, the tubers are completely exposed which helps in speedy manual picking.

Benefits of the potato harvester were compiled by Bhardwaj and Sharma (2020) and Zheng *et al*. (2021) as follows

- Reducing labor cost
- Low tuber bruising and damage
- Time saving, ease of operation with increased efficiency
- Reducing post-harvest losses

While demonstrating the new technologies, the cost of their introduction and operational cost should be taken into consideration. Farmers will adopt only those technologies which are easy to use, cost effective, accessible and have local service provisions. Accordingly, economics of new technologies has been worked out and their analysis is given in Table 1.

The rice-potato rotation is dominant cropping pattern in some parts of Assam. Current production practices require labour, water and energy which results decrease in profitability and hence lacks intensification. So, to attain sustainable intensification, the use of mechanization is very important in rice-potato cropping system. Advances in using and increasing appropriate equipment can help in reducing the potential yield gap in rice-potato cropping system. Thus, demand for machinery increases which, in principle, leads to more skilled employment opportunities and higher incomes. Apart from increasing demand for machinery, intensification additionally offers opportunities to boost the involvement of women and youth in agriculture for the state of Assam through different schemes which are described below.

Schemes to promote farm mechanization

Many government schemes have been instrumental in bringing innovative technological interventions in the Indian farm sector. Government of India launched the central sector scheme – Sub-Mission on Agricultural Mechanization (SMAM) in the year 2014-15 under the aegis of National Mission on Agricultural Extension and Technology in all states to promote the usage of farm mechanization and increase the ratio of farm power to cultivable unit area up to 2.0kW ha^{-1}.

Assam, a North-eastern state of the country has about 73% population engaged in agricultural activities, but it is still lacking in industrial development of farm machinery. Although the major economic share of the state comes from agriculture, even though farm productivity of the state is quite low compared to many other states in the country. In this context, improvement in farming operations is of utmost importance to incentivize the people engaged in agriculture and also, to check migration of people to urban areas and other states in search of livelihood. The average farm land holding is only 0.63 hectare in the state. In such situation, low productivity due to poor farm practices compel the younger generation to opt for other options to sustain their livelihood. Normally, manual potato cultivation in the state costs about 45% of total cost of production.

Table 1: Economics of selected machines

Parameters	Mechanical transplanter	Combine harvester	Automatic potato planter	2-row potato harvester
Tractor power source required (hp)	NA	NA	e≥40	e≥42
Cost of machine's operation (₹ ha^{-1})	5,063	7875	5,858	7,163
Cost of operation with manual method (₹ ha^{-1})	9,000	12,000	10,500	10,500
Hiring rate (₹ ha^{-1})	7,500	11,250	7,500	9,000
Saving over manual (₹ ha^{-1})	3,938	4,125	4,643	3,338
Labor requirements with manual method (man-days ha^{-1})	30	40	35	35
Labor requirements with machine (man-days ha^{-1})	4	2	8	12
Increase of yield in mechanized over manual method (%)	10-15	-	10-12	-
Reduction in post-harvest losses in terms of quality	-	2-5	-	8-9
Cost of machine (000' ¹)	260	1,500	160	130
Command area of one machine in one year (ha)	42	133	38.4	30
Net benefit in one year with one machine (000' ¹)	165.4	548.6	178.3	100
Payback period (years)	3.1	3.5	2.5	2.9
Return on investment over manual	1.78	1.52	1.79	1.5

Nevertheless, Government of Assam has put in a lot of resources to upgrade the traditional farming practices, to increase the productivity and reduce the cost of operations. The efforts are not just restricted to mere production increase, but also on improving the post-harvest sector along with processing and value-added products. While promoting such an environment, the focus is on modern farm technologies. As a result, many initiatives have been launched to enrich such an advance level of farm sector.

Chief Minister Samagra Gramya Unnayan Yojana (CMSGUY) is one such scheme to name among various that strive to achieve growth of agricultural mechanization by providing one tractor unit to each revenue village of the state covering 25 villages in their revenue circle. Tractor is the symbol of agricultural development; it is required for many farm operations. Although, it is a small leap, but the sector will proliferate with innovative technologies in near future. Whatever, small interaction made with end users, it could be assumed that the farmers have been benefited from such initiatives and there are many farmers who are coming forward for such mechanical farm equipment and they are ready to invest. People are also seeing it as a business option by providing farm services to their fellow farmers. The primary reason of machine popularity is their time and cost saving through saving in manual labour. There is no doubt, that people will fall back on such advance technologies for saving of inputs and increased gain in output. But there is a need to rationalize the use of such implements in such a way that addresses sustainability and enrich prevailing farming practices among farmers. To bring such a balance between modern technology and existing practices, it needs practical understanding of the constraints and their remedies.

Let's just take one example, each from rice and potato, in Assam. The climate resilient technologies, transplanting rice with mechanical transplanter and potato production *i.e.,* zero-tillage with paddy straw mulching (ZTRM) became popular practice among farmers in Assam. These two technologies have been widely demonstrated and immediately adopted by the farmers because of their perceived benefits. These two technologies reduced the cost of cultivation up to 30%.

The sequential sowing of potato after rice is quite suitable because Assam is having 2.4million-hectare (Anonymous, 2020) land area under paddy cultivation. Mechanical transplanter and combine harvester provide opportunity for timely transplanting and harvesting, respectively, of the paddy crop. It further facilitates to vacate the fields in time to provide ample scope for the sequential sowing of the potato in a cropping system approach. After paddy harvesting, its straw availability is in abundance, hence promoting zero-tillage potato cultivation became economical. People can easily have the access to this resource (paddy straw) that can be used quite innovatively. This also provides ample opportunity to save the environment, with sustainable crop production.

Nevertheless, the cultural practice save their own values, as a result, the straw after harvest is still not priced. The paddy is harvested by cutting the plant at knee length (40-60 cm from ground) resulting the plant to be cut in two halves. The upper portion goes with the rice panicles and rest of the straw is left unturned in the fields for decomposition and grazing of the cattle. This is a traditional practice of harvesting paddy in Assam.

Once the rice is threshed, the left-over upper portion of the straw is used as fodder for animals and has good market price. It is generally sold at the price of Rs. 6000

per ton. But the other part of the straw which was left in the field could be used as a mulching material for zero-tillage potato cultivation.

Zero-tillage is a useful climate resilient technology for potato cultivation in Assam as the state is hit by flash floods at multiple times every year causing delayed paddy harvesting and ultimately, there is only a narrow window left for potato cultivation between harvesting of rice and land preparation for sowing. But in zero-tillage the time required for land preparation can be bypassed, as in this practice the potato is planted on surface of the ground and paddy straw is used to mulch the crop. Also, the track type combine harvester can help to harvest paddy in limited window of time between two crops and also in wet field conditions with standing water up to 2.0 ft. (Fig. 6). Eventually, the crop gets ample scope of timely sowing in the shortened window and suitable low temperature regime to grow.

CONCLUSION

It seems the technology we are promoting is at crossroad. A redefinition of such initiative with cultural integrity would enrich farm sector in the long run. More capacity building and communication with the value chain actors are important to make them prepare to see the systemic context of a development with more space for customization rather than just being optimistic. People need more awareness on associated benefits for adoption of the rice-potato cropping system. Crop specific inventions are quite acceptable, but it should also address its impact on the system. The innovations should be complimentary to each other rather than just liner in its approach. It also should not attract higher opportunity cost for the end users. Farm mechanization should be increased in system approach for sustainable operations, so that farmers can get more remuneration from the same piece of agricultural land with low inputs, less labour and reduced time. As by using paddy transplanter, combine harvester, potato planter and potato harvester in the farm operations of paddy and potato cultivation, will be a good business proposition in intensifying cropping system from 146% to 170%.

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