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Research Article

Performance Evaluation of 4-Wheel Tractor Driven 3-Rows Semi-automatic Sugarcane Planter

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A B S T R A C T

Sugarcane is major cash and industrial crop grown in Nepal and second prioritized crop of Madesh Pradesh after rice. Planting sugarcane is a very laborious job which involves considerable human drudgery compared to rice, wheat, maize and potato crops. Cost of mechanized sugarcane planting is less compared to traditional methods. It also reduces drudgery involved in unit operation of sugarcane planting. Therefore, this station procured an Indian made 3-rows semi-automatic sugarcane planter (Cost = NRs. 300,000) and conducted its field testing and demonstration at National Sugarcane Research Program, Jeetpur, Bara. This machine completed 8 operations of sugarcane planting in a single pass using by 55 hp tractor and has 3 units. The field capacity of the machine was 0.3 ha/hr. in sandy loam soil with field efficiency 81 % at effective working width of 2.25 m (row to row distance = 0.75 m) with a forward speed of 1.62 km/hr (3rd Low gear). The seed rate was 5.80 ton/ ha., having sett length 30 cm metre with average overlap of 6.25 cm and planting depth = 25-35 cm (adjustable). The planter saves about 90 % labour requirement and 70% of time as compared to conventional method. The planted sugarcane was free of any damage of buds. Sugarcane growers of Nepal found this unit acceptable. The crop germination was about 96%. The cost of operation per ha was in the range of Rs. 7700 as compared to Rs. 17400 manually. The planter planted sugarcane yield was 85.0 ton/ha, (variety-Co 0118) while the sugarcane yield planted by local method was 74.26 ton/ha. The cost of operation reduced by 56% and yield increased by 14.46 %. This planter has shown better utilization of resources and quality work performance resulting in better production and productivity.

Keywords: Mechanization, Semi-Automatic Sugarcane Planter, Field Capacity, Yield, Cost of Production

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Introduction

Sugarcane, the world's largest crop by production, has total production 1.9 billion tonnes in 2020, with Brazil accounting for 40% of the world total. A fully mature sugarcane stalk generally has composition of about 11–16% fibre, 12–16% soluble sugars, 2–3% no sugar carbohydrates, and 63–73% water content. That is why Chaudhary and Mishra (2021a&b) always focus on agricultural economy for development of Nepal.

Sugarcane, an important cash crop of Nepal, ranks 41st in global sugarcane production scenario (Neupane et al., 2017) and has been prioritized as 2nd major crop of Madesh Pradesh after rice. Sugarcane contributes 2.1% to Agricultural Gross Domestic Product (AGDF) of the country. (MoALD, 2019a)

The cultivation of sugarcane is done in 41 districts of Nepal; however, only 14 districts of terai region produces sugarcane commercially (MoALD, 2019). In 2018/2019, the annual sugarcane production was 3.6 million tonnes, with average productivity of 49.67 tonnes per hectare (MoALD, 2019). The food products like sugar, fructose, syrups, and jaggery is produced using sugarcane which is rich source of carbohydrate (Dotaniya et al., 2016, Mandal & Maji, 2008). In Nepal, only 60% of sugar demand is fulfilled by domestic production of sugarcane (NSMA, 2018). Around 100,000 commercial sugarcane farmers in Nepal produce sugarcane in total area of 71.6-thousand-hectare land (Chhetri, 2018; MoALD, 2023). Table 1 shows the status of sugarcane cultivated area along with its production in past few years in Nepal.[1]

Table 1. Status of Sugarcane in relation with production and area in different Fiscal year of Nepal

Fiscal Year	Area (ha.)	Production (metric)
2018/19	71,625	35,57,934
2019/20	68,565	34,00,176
2020/21	64,354	31,83,943

(Source: Moald, 2023)

In 2020/2021, the area, production, and productivity of sugarcane in Nepal were 64.35 thousand hectares, 3.18 million MT, and 49.47 Mt/ha, respectively. Among the major crops grown in Madhesh province, sugarcane ranks fifth position in the area and first in production which is tabulated in Table 2. It is commercially cultivated in four provinces of Nepal namely Koshi, Madhesh, Lumbini, and Sudurpaschim. In 2020/21, the share of Mahesh province in the area and production of sugarcane was 67.7 and 65.2%, respectively (MoALD 2022) as mentioned in Table 3.

Table 2. Status of different crops in Madhesh Province based on area and production in 2020/21

Crop	Area (ha)	Rank
Rice	382275	I
Wheat	178479	II
Oilseed	56428	III
Maize	53201	IV
Sugarcane	43557	V
Potato	25800	VI
Millet	1656	VII
Barley	178	VIII
Crop	**Production (mt)**	
Sugarcane	2076415	I
Rice	1432819	II
Wheat	608228	III
Potato	404382	IV
Maize	185297	V
Oilseed	62745	VI
Millet	1669	VII
Barley	265	VIII

(Source: Moald, 2023)

Table 3. Status of Sugarcane in Different Provinces of Nepal in 2020/21

Province	Area	% share	Production	% share
Koshi	5719	8.9	322556	10.1
Lumbini	8468	13.2	412731	13.0
Sudurpaschim	6198	9.6	357121	11.2
Bagmati	33	0.1	1391	0.0
Gandaki	374	0.6	13695	0.4
Karnali	5	0.0	34	0.0
Madhesh	43557	67.7	2076415	65.2
Total	64354	100.0	3183943	100.0

(Source: Moald, 2023)

Sugarcane planting is a very labour consuming work which involves human drudgery compared to rice, wheat, maize and potato crops. Sugarcane production of Nepal increased from 235.611 tonnes in 1971 to 3.4 million tonnes in 2020 growing at an average annual rate of 6.32 %. But, from Fiscal Year 2020/21, there is drastically reduction in cultivable area of sugarcane farming. One of the main reasons behind this is very delayed payment or no payment of cash to the sugarcane grower farmers by sugar mills along with other reasons such as no new introduction of high yielding varieties of sugarcane causing lower yield, labour scarcity problem in peak season, delay planting, high initial cost of production and low return due to delayed acceptance of crops in the sugar mills.

Hence, there is an serious need of agricultural mechanization in sugarcane cultivation as faces the problem of labor scarcity. Agricultural farm mechanization will help to reduce farm operation, time, thereby providing more opportunity to the farmers to accomplish other necessary works. This will also help to reduce the physical exertion and drudgery of the sugarcane grower farmers working in the field. Testing and evaluation of semi-automatic sugarcane planter will help to generate complete information's (manufacturer, model, efficiency, suitability and economics) regarding sugarcane cultivation and will reduce cost of production and will increase the yield of sugarcane crop. Documentation of such information will help to convince the beneficiaries/ stakeholders or to provide information to the clients as and when required.[2]

Study Location

The performance evaluation of the machine was carried out in actual field condition at National Sugarcane Research program, Jeetpur, Bara. The station is located at 98 meters above sea level and 27° 06' 48" N latitude and 84°57' 07" E longitude. The climate is hot and humid in summer season and cool in winter at studied location. The maximum average temperature ranges between 22.7 to 34.5°C and minimum temperature ranges between 8.5 to 25.9 °C with average annual rainfall of 1550 mm.

Materials and Methods

The 4-wheel tractor driven 3-rows Semi-automatic sugarcane planter manufactured by Moga Engineering Works, Meerut, India was procured by the station in the fiscal year 2017/18 with specification given in Table 4. The performance evaluation of the planter was tested/ evaluated in actual field condition in on-station (National Sugarcane Research Program) in about 0.3 ha. The laboratory and actual field tests were performed for two fiscal years in on-station viz. 2018/19 & 2019/20. The economy of different planting methods as well as sugarcane growers/ farmers/ stakeholders feedback were calculated/ collected. The machine performance parameters were taken. The laboratory tests include calibration of the machine, uniformity of seed in distribution and spacing, bud damage determination, length of sett, overlapping length, quality of cut, seed rate etc. whereas actual field test include soil type, initial moisture content, bulk density, plant population (germination percentage) and spacing, depth of planting, row to row distance, seed rate, speed of the operation, effective working width, wheel slip, theoretical/ actual field capacity, field efficiency, fuel consumption, yield and economic analysis.[3,5]

Laboratory Testing

The planter was operated in the workshop of station for calibration of seed and fertilizer. The other laboratory tests were also performed. The machine was operated in 3rd low gear at 1600 rpm.

Calibration of Planter

The planter was calibrated by attaching it with tractor by three-point linkage system and powered by PTO which was operated in third low gear at 1600 rpm (Shukla et.al., 1978). Total number of setts cut per unit area were counted and weighed. Similarly, fertilizer drop was collected in a polythene bag through their respective openers in order to know the weight of it in a particular area.[6] Then calculation was performed until and unless the planter was able to meet the required seed rate and fertilizer doses respectively through their openers. After achieving the recommended seed rate and fertilizer rate, the calibration of planter was completed.

Node Damage Determination

50 sets were selected randomly and number of node damaged were observed and recorded. The process is repeated and average was calculated to minimize error.

Quality of Cut

50 setts were selected at random and nature of cut was observed and noted for three times and average was calculated.

Length of Setts

50 setts were selected and length of each sett was measured and average was taken.

Actual Field Testing

The performance evaluation was done in actual field based on the following indicators/ parameters/ observations.

Depth of Placement

Planter was operated in the field without levelers. Depth of placement of setts in the furrows was evaluated at five different places and average was calculated. Depth of placement of setts was controlled by the hydraulic system of the tractor if required during operation of planter. (Patil et.al, 2004)

Overlap/Gap

In 50 meters length, all setts dropped in furrow were collected. The number of setts were counted and length of each sett were measured to calculate average overlap and gap using following formula. (Shukla et.al., 1984)

Average overlap = {Total length of setts - Distance (50 m.)} / Total no of setts

Average gap= {Distance (30 m.) - Total length of setts} / Total no of setts

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Plant Populations (Germination %) and Spacing

It could plant 3-rows at 75 cm spacing (adjustable). Through testing, it was found that the germination was 96 % and varied due to seed placement at different depth as well as available moisture in the soil for germination.

Speed of Operation

The speed of operation was calculated by using stop watch for time taken (s) and tape for measuring distanced travelled(d). This process was done multiple times to minimize the error. The speed of tractor (km/h) was calculated by following equation. (Mishra et.al., 2023)

Speed of tractor = d/s

Working Width of Operation

It is product of no. of tyne and distance between two tyne. (Gupta et. al., 2017)

Wheel slip

Forward speed of drive wheel within fixed distance under no load (l1) and under load (l2) were measured. The calculation was done by using formula.

Wheel slip (%) = (l1 – l2)/ l2 *100

Fuel Consumption

Total time of field operation (T) in seconds and area covered (A) in square meter was recorded. After completing the operation, the tractor was brought to the same levelled ground, positioned same as to refill the tank. Differences between the initial level of fuel to fill tank after operation will be the fuel consumed. Fuel consumption was calculated as given below: (Sawant et.al., 2018)

FC= L/ T Where, L = Total fuel consumed (litres) and T = Total time taken (hours)

Theoretical Field Capacity (TFC)

TFC = {Theoretical Width (m) x Speed of operation (km/hr)}/10 (Mahmoud, Wael. (2014))

Actual Field Capacity (AFC)

The plot of 0.2 hectare was selected and time taken to cover this area was noted. Time taken for turning, hopper filling and other operational obstructions was also noted.

Field Efficiency

Field efficiency= AFC/TFC* 100

Component of Planter

It consists of frame, fertilizer box with lever for controlling fertilizer, fluted roller type metering unit for fertilizer, seed hopper with 3 boxes, cutter bar metering unit for cutting sugarcane sett, 3 furrow openers, 2-coulter wheel for maintaining depth, two sprayer tanks with nozzles for fungicide (tank with 30 litre capacity) and insecticide (tank with 200 litre capacity) applications and plankers for pressing of soil.[7,10]

Working Principle of Sugarcane Planter

In this machine, sugarcane is fed manually by 3 labors sitting on the machine as shown in Figure 1. The machine cuts sugarcane automatically into pieces (sett of 30-35 cm) before dropping into furrows. It also opens the furrows, applies fertilizer, chemical and fungicide and also covers the sets and presses it automatically. It is operated by 55 hp tractor and has 3 units which is controlled by three-point linkage system. The planter

Table 4. Technical specifications of 4-wheeled Tractor Driven Sugarcane Planter

S.N.	Particulars/Parameters	Required Specifications
1	Manufacturer	Moga Engineering workshop
2	Number of rows	3
3	Furrow opener Row to row spacing	750 mm (adjustable)
4	Sett metering device	Cutter bar type
5	Seed box capacity	100 kg
6	Fertilizer metering device	Fluted roller type
7	Chemicals dispensing device	Brass nozzles fitted to apply fungicides and insecticide of 30 litre and 200 litre respectively
8	Power	55 hp & Above
9	Depth of seeding	25-35 mm
10	Working width	2250 mm
11	Transmission	PTO operated
12	Weight	950 kg
13	Linkage	4-points linkage including PTO

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places fertilizer and sett in 3 rows which can be adjusted between 60 cm to-67.5cm or 75 cm in the furrow at desired rate. The planter cuts the sett cane automatically. At the cutting point, seed is treated with insecticide (seed treatment). Places seed in the rows automatically with end-to-end jointing & regularly or as desired. The planter also sprays pesticide on the seed in the furrows with pressure for soil treatment. The planter covers the furrow after the sett is dropped and finally the closed furrows are levelled with the leveller.[11,13]

Results and Discussion

The semi-automatic 3-rows sugarcane planter have been introduced and evaluated in Nepal for the first time and the results were very encouraging. The visitor farmers responded positively that this planter could save time, labor and money substantially. Sugarcane growers of Nepal (Sugar mills) found this unit acceptable.

This machine completed 8 operations of sugarcane planting in a single pass. It is operated by 55 hp & above tractor and has 3 units. The field capacity of the machine was 0.3 ha/hr. in sandy loam soil. Bahl et al. (2001) reported that sugarcane cutter planter has an effective field capacity of 0.15 hectare per hour. The field efficiency was 81 % at effective working width of 2.25 m (row to row distance = 0.75 m) with a forward speed of 1.62 km/hr (3rd Low gear). The seed rate was 5.80 ton/ ha., having sett length 30 cm metre with average overlap of 6.25 cm and planting depth = 25-35 cm (adjustable). The planter saves about 90 % labour requirement and 70% of time as compared to conventional method. The planted sugarcane was free of any damage of buds. Sugarcane growers of Nepal found this unit acceptable. The crop germination was about 96%. The cost of operation per ha was in the range of Rs. 7700 as compared to Rs. 17400 manually. The planter planted sugarcane yield was 85.0 ton/ha,(variety-Co 0118) while the sugarcane yield planted by local method was 74.26 ton/ha. The cost of operation reduced by 56% and yield increased by 14.46 %. Srivastava (1995) found that, cost of planting sugarcane reduced about 40 per cent less compared with conventional method. This planter has shown better utilization of resources and quality work performance resulting in better production and productivity. The field efficiency was found to be 81 % with 19 % slippage which can be increased if wheel slip is reduced. The machine performance output data as well as soil parameters are tabulated in Table 5. Through direct observation, seed placement from metering system of planter showed no damage of bud without missing. The fuel consumption was found to be 6 lt./hr.[14,16]

Economics Analysis of Sugarcane Planter

The economic analysis showed that planting cost of sugarcane by machine was around NRs. 7700/ ha. which was 56% less than manual planting (farmer's practice).

Cost of sugarcane planter(P): - NRs.300000

Life of sugarcane planter(L): - 10 year

Annual use hour: - 540 hrs.

Salvage value of sugarcane planter(S): - 10% of P

Hiring charge of 65 hp tractor: - NRs. 2250/ hrs.

Fixed cost: - NRs. 108/ hrs.

Variable cost: - NRs. 2.77/ hrs.

Total operating cost (fixed cost + variable cost): - NRs. 110.77/ hrs.

Total operating cost along with tractor: - NRs. 2360.77/ hrs. (NRs. 2250+ 110.77)

Total cost of planting: - NRs. 7696.11/ ha. ~ NRs. 7700/ ha.

Wages, hiring charges of tractor and cost of machines may vary the results. Mishra, A. K., & Aithal, P. S. (2022) and Mishra, A. K., Yadav, P., & Aithal, P. S. (2021) focuses irrigation for smooth function of agriculture in Nepal.[17,20]

Table 5. Soil & machine performance parameters measured during operations in the field

S.No.	Particulars/Parameters	Value
1	Types of soil	sandy loam
2	Moisture Content, %	28.52
3	Bulk density, gm/cc	1.15
4	Row to row spacing, cm	75 (adjustable)
5	Sett length, cm	30 (adjustable)
6	Depth of seed placement, cm	25-35(adjustable)
7	Seed rate, ton/ha.	5.8
8.	Fertilizer dose (N_2:P_2O_5: K_2O) kg/ha.	150:60:40

Field Evaluation Photographs

Figure 1.4- Wheel Tractor Driven 3-Rows Semi-Automatic Sugarcane Planter in Operation along with respective crop at On-station

Conclusion and Recommendation

The on-station field testing and evaluation of the sugarcane planter have demonstrated its potential for adoption. The technology showed a net savings of 90% in labor cost, 56% in the cost of cultivation, and 70% in time compared to traditional manual sugarcane planting methods. This significant cost and time efficiency, along with the ability to address various challenges in conventional manual cultivation, such as poor seed placement, spacing management, and fertilizer distribution, makes the machinery technology highly attractive to farmers. Additionally, the planter enables timely planting and harvesting, allowing farmers to utilize the saved time for other activities. The study on feasibility and economic viability of sugarcane planters (Jaideep et.al.,2018) have been studied in various regions, further supporting the potential benefits of this technology.

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