Research Article OPEN ACCESS

Volume-9 | Issue-4 | Oct-Dec-2023|

Check for updates

VEETHIKA-An International Interdisciplinary Research Journal
E-ISSN: **2454-342x**
Double Blind Peer Reviewed Journal
URL: https://veethika.qtanalytics.in

Performance Evaluation of 4-Wheel Tractor Drawn 3-Rows Precision Maize Planter for Mechanization of Maize Farming in Nepal

Sachin Kumar Mishra[1*], Shreemat Shrestha[2], Sanjeet Kumar Jha[3], Anand Mishra[4], Bikash K.C.[5], Mukti Nath Jha[6], Dwarika Chaudhary[7], Sunil Sahani[8]

[1,5,7, &8] Agriculture Implement Research Station, Ranighat, Birgunj, Parsa, Nepal Agricultural Research Council, Nepal.
[2,3, &6] National Agricultural Engineering Research Centre, Khumaltar, Kathmandu, Nepal Agricultural Research Council,
[4]Directotrate of Agricultural Research, Madesh Pardesh, Parwanipur, Bara, Nepal Agricultural Research Council, Nepal.

**Corresponding Author* Email: Sachin_bau33@yahoo.com

Received: 20 November, 2023, ***Revised:*** 2 December, 2023 ***Accepted:*** 8 December, 2023, ***Published***: 12 December, 2023

ABSTRACT: Hybrid winter maize is gaining popularity in the Terai region, as traditional maize growing practices are resource-consuming and labor-intensive. High inputs and labor costs have been a burden for hybrid maize growers. This study aimed to evaluate a Chinese-made 2BMZJ-3 model tractor-drawn 3-rows precision maize planter in actual field conditions and on-farm, comparing it with farmers' practices. The planter was hitched with 3-point linkages at the rear of a 35 hp tractor and could be operated in both tilled and no-tilled conditions. The seed rate was about 20 kg/ha, with a germination of 98% and an average of 4-5 plants/m² of length of row. The actual field capacity was 0.38 ha/hr in clay loam soil with an initial moisture of 26.11% and a bulk density of 1.18 g/cm³. The total cost of sowing was NRs 4050/ha, while the planting cost for farmers' practices was around NRs 7500/ha. The planter reduced the planting cost by 46% and increased the grain yield per unit area compared to farmers' practices. It is concluded that the maize planter not only reduces the planting cost but also increases grain yield per unit area.

KEYWORDS: Farm Mechanization, Precision Maize Planter, Field Capacity, Seed rate/ placement, Yield, Economic Analysis

1. INTRODUCTION

Nepal is an agricultural country and it is known for its diversity so research in agriculture on different aspects is continuous process (Chaudhary & Mishra, 2021a, b). Maize is a significant crop globally, with nearly 1147.7 million MT produced by over 170 countries from an area of 193.7 million ha, with an average productivity of 5.75 t/ha (FAOSAT, 2020). The global consumption pattern of maize is feed-61%, food-17%, and industry-22% (MOAD, 2022). Maize is an industrial crop, with 83% of its production used as fodder, starch, and bio-fuel, which influences the economy of any country. In Nepal, maize is the second most important crop after rice, with a total area of 9,79,776 ha and a production of 29,97,733 MT in 2022, contributing about 26.96% of total cereal production (Coltheart et al.,1993). Maize is emerging as an industrial crop in accessible areas of Nepal, with

DOI: https://doi.org/10.48001/veethika.2023.09.04.003

the main maize growing area being the Terai and hilly regions. There is a great demand for maize as food for people living in the hilly area for feed and fodder. However, traditional maize growing practices are resource-consuming and labor-intensive, with high inputs and labor costs being a burden for hybrid maize growing farmers. Repeated tillage, poor crop establishment, lower resource use efficiency, lower yields, and low net return are the major constraints of maize-based crop production systems (Seidenberg, S. P., & McClelland, J. M. ,1993). Hybrid winter maize after rice is gaining popularity in the Terai region, but farmers have less time for sowing, and there is a great scarcity of labor during the peak time of sowing. Therefore, mechanization in maize plantation is necessary to boost the country's economy and improve the living standards of farmers (Bamboriya et al., 2020). The performance evaluation of a specific machine, such as the Chinese-made 3-rows precision maize planter, can reduce the cost of operation and increase the yields of maize crops (Gao et al., 2016).

2. STATEMENT OF PROBLEM

Maize is the second most important crop after rice in Nepal, with the Terai and hilly regions being the main maize growing areas. However, traditional maize growing practices are resource-consuming and labor-intensive, with high inputs and labor costs being a burden for hybrid maize growing farmers. Repeated tillage, poor crop establishment, lower resource use efficiency, lower yields, and low net return are the major constraints of maize-based crop production systems (Koirala et al., 2021: Koirala et al., 2020: Paudel et al, 2022). Hybrid winter maize after rice is gaining popularity in the Terai region, but farmers have less time for sowing, and there is a great scarcity of labor during the peak time of sowing. Mechanization in maize plantation is necessary to boost the country's economy and improve the living standards of farmers (Madhukumara & Mathew, 2017). The performance evaluation of a 4-wheel tractor drawn 3-rows precision maize planter can reduce the cost of operation and increase the yields of maize crops (Gao et al., 2016). Therefore, the problem addressed in this research is to evaluate the performance of the 4-wheel tractor drawn 3-rows precision maize planter for mechanization of maize farming in Nepal, with the aim of improving the efficiency and productivity of maize cultivation (Mishra & Aithal, 2022: Mishra, &Aithal, 2021).

3. OBJECTIVE OF THE RESEARCH

The overall research objective is to assess the efficiency and effectiveness of a 4-wheel tractor-drawn 3-rows precision maize planter in the mechanization of maize farming in Nepal, with the aim of improving the productivity and sustainability of maize cultivation in the Terai region.

STUDY LOCATIONS

The performance evaluation of the machine was done in actual field condition in on-station, Birgunj, Parsa. This station is situated at an altitude of 85 meter above sea level. It lies 27° 1' 22" north latitude and 85° 52' 40" east longitude. This region is represented by rainfed upland, partially irrigated mid low land and irrigated low land agro eco-zones with rainfed and irrigated domain. The area falls under sub-tropical climate with hot and humid summer and cool dry winter. Summer is very hot and maximum temperature reaches up to 45˚C and in winter temperature goes down to 4˚C with long spell of cold wave and foggy weather. The average annual precipitation is about 1550 mm.

4. MATERIALS AND METHODS

The Chinese made 4-wheel tractor drawn 3-rows precision maize planter was procured by the station in the fiscal year 2018/19. The performance evaluation of the machine was tested/ evaluated and verified in actual field condition (in on-station, in about 0.2 ha.) as well as in the farmer's fields (in on-farm, in about 17.0 ha.) in Outreach site, Jeetpur-Simara sub-metropolitan ward no.-11, Khesraul, Bara. The laboratory and actual field tests were performed for two fiscal years in on-station viz. 2018/19 & 2019/20 and then the technology was recommended/ verified in on-farm in fiscal year 2020/21 up to till date. The economy of different planting methods as well as farmers 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, seed breakage, seed rate, no. of seeds per hill whereas actual field test include soil type, initial moisture content, bulk density, plant population (germination percentage) and spacing, 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.

DOI: https://doi.org/10.48001/veethika.2023.09.04.003

Laboratory Testing

The planter was operated in the workshop of station for calibration of seed and fertilizer. The other laboratory test was also performed. The machine was operated in 2nd low gear at 1500 rpm. The test codes and procedures described in ANTAM Test Codes (for field capacity, calibration etc.) and Procedures for farm machineries were followed.

Calibration of planter

The calibration of planter was done to get desired seed rate and dose of fertilizer for distribution in a certain area of land. This process was done by collecting seed and fertilizer in the plastic bags through respective openers while travelling tractor for a fixed distance. Then calculation was continued until and unless the planter was able to meet the desired seed rate and fertilizer doses respectively through their openers. The process will be terminated when planter achieved the recommended seed rate and fertilizer rate and then planter was ready for trial.

Actual Field Testing

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

Plant populations (germination %) and spacing

It could plant 3-rows at 60 cm spacing. There were 4 spacing adjustments of 12cm, 18 cm, 20cm, 25 cm for plant to plant. Through testing, it was found that the germination was 98 % and varied due to seed placement at different depth as well as available moisture in the soil for germination(Yang et al., 2016)There was drop in germination percentage when locally available seed was used for plantation of maize as compared with hybrid seed and ways of plantation of seed in the field(Fu et al., 2018).

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. Speed of tractor = d/s

Working width of operation

It is product of no. of tyne and distance between two tynes.

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:

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

Field capacity and field efficiency

The measurement of the effective field capacity and field efficiency of the planter was done by continuous observation and timing of each activity and time losses for turning, filling of seed and fertilizer as well as adjustment if done during time of operation. Two persons were involved in the evaluation, one operated the planter while the second observed and recorded the time taken for the operation (time loss at field ends and time taken for the actual planting operation). The time taken was recorded using a digital stopwatch and the inter-row and seed width measured using a steel tape. The effective field capacities and field efficiencies were calculated using equations:

$Effective\ field\ capacity\ (EFC\ \text{ha. / hr.}) = plot\ area\ (\text{ha})/\ Total\ time\ required\ to\ cover\ the\ plot(\text{hr})$

$Theoretical\ field\ capacity\ (TFC) = \text{working width(m)}\ x\ speed/\ 10$

$Field\ efficiency\ (\text{FE}) = (Effective\ field\ capacity/\ Theoretical\ field\ capacity)\ x\ 100\%$

$or\ Field\ efficiency = (time\ for\ actual\ operation/\ \text{total time taken})\ x\ 100\%$

Component of planter

It consists of frame, fertilizer box, seed hopper, metering unit, multi-groove vertical metering plate having seed hole, furrow openers, 3 ground wheels for operation of fertilizer and seed distribution as well as pressing the soil.

DOI: https://doi.org/10.48001/veethika.2023.09.04.003

The technical specifications of the machine are given below:

Table 1: - Technical specifications of 4-wheeled Tractor Drawn Precision Maize Planter

S.N.	Particulars/Parameters	Required Specifications
1	Model, unit	2BMZJ-3
2	Overall sizes, mm	1700*1200*1100
3	Weight, kg	210
4	Power, hp	35 and above
5	Linkage	3-point linkage
6	Metering mechanism	Vertical metering plate having hole
7	Row space, mm	600-700
8	Plant spacing, mm	120-250
9	Depth of seeding, mm	30-50
10	Overall Working width, mm	2200
11	Transmission	Ground wheel driving

Working principle of precision maize planter

The metering device of both fertilizer and seed was powered by a ground wheel through chain and sprockets and the planter was hitched with 3-point linkage of tractor. To get desired seed rate, various gear ratios were provided by manufacture so that different varieties of available seed can be planted through this planter as well as fertilizer rate can adjusted through screw. Accordingly gap between plant to plant can also be adjusted through gear system and the press wheel of planter press seed in in the soil as required by farmers. During operation, the planter press wheel drives the fertilizer and seeding units dropping seeds and fertilizers at desired row and depth (side by side) followed by the soil coverage and compaction by press wheel which completes the whole operation.

5. RESULTS AND DISCUSSION

The planter can be operated both in tilled and no-tilled conditions of fields without single damage of graded seed with plant to plant spacing=20-25 cm (adjustable) and row to row spacing =60 cm(adjustable). The seed rate was about 20 kg/ha. and the germination was 98 % with avg. no. of plants=4-5/m. length of row. The actual field capacity was 0.38 ha. /hr. in clay loam soil having initial moisture 26.11% and bulk density 1.18 gm/cc with 50% time saving than traditional method. The total cost of sowing was NRs 4050/ha, while in case of farmers' practice, the planting cost came around NRs 7500/ha. (30 labours per hectare @ NRs 250). Thus, this planter lowered down the planting cost by 46%. The highest grain yield recorded was 10.5 ton/ha with the machine whereas farmers' practice yielded 9.5 ton/ha. Thus, it can be concluded that the maize planter not only reduces the planting cost but also increases grain yield per unit area.

The field efficiency was found to be 70 % with 30% slippage which can be increased if wheel slip is reduced. This shows a good and satisfactory performance within the range of values obtained for planting operation for medium land. The machine performance output was satisfactory when compared with traditional planting. Through direct observation, seed placement from metering system of planter showed no damage of seed without missing. The forward speed of tractor was 2.76 km/ha. and the effective working width was 1.8 m. The fuel consumption was found to be 4 lt./hr. The number of precision maize planter procured by the farmers in Nepal =10(according to machine suppliers data).

Table 2: - Machine preformation parameters measured during operations in the field

S.No.	Particulars/Parameters	Value
1	Types of soil	Clay loam (in on-station)/ sandy loam (in on-farm)
2	Moisture Content, %	26.11
3	Bulk density, gm/cc	1.18
4	Row to row spacing, cm	60 (adjustable)
5	Seed to seed spacing, cm	20-25 (adjustable)
6	Depth of seed placement, cm	3-5 (adjustable)
7	Seed rate, kg/ha.	20
8.	Fertilizer dose (N_2:P_2O_5: K_2O) kg/ha.	150:100:60

Table 3: - Maize Yields data using precision planter in on-station & in-farm in different fiscal year.

Fiscal year	On-Station		On-farm		
	2018/ 19	2019/ 20	2020/ 21	2021/ 22	2022/ 23
No. of farmers	-	-	10	12	15
Adopted area (ha.)	0.2	0.2	7.0	10.0	17.0
Varieties (Hybrid)	P-3522	P-3522	P-3522	P-3522	P-3522
Yield(ton/ ha.)	8.022	8.954	9.056	9.516	10.5

Economics analysis of Maize planter

The economic analysis showed that planting cost of maize by machine was around NRs. 4050/ ha. which was 46% less than manual planting (farmer's practice).

DOI: https://doi.org/10.48001/veethika.2023.09.04.003

Cost of planter(P): - NRs.200000

Life of maize planter: - 10 year

Annual use hour: - 780 hrs.

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

Hiring charge of tractor: - NRs. 1500/ hrs.

Fixed cost: - NRs. 50.06/ hrs.

Variable cost: - NRs. 1.28/ hrs.

Total operating cost: - NRs. 51.34/ hrs.

Total operating cost along with tractor: - NRs. 1551.34/ hrs. (NRs. 1500+ 51.34)

Total cost of planting: - NRs. 4048.99/ ha. ~ NRs. 4050/ ha.

6. CONCLUSION

Considering the results of on-station and on-farm field testing and evaluation of the maize planter, it can be concluded that the technology is adoptable and has the potential to significantly impact maize production in Nepal. Despite the high initial cost of the planter, it can contribute to reducing the cost of plantation of maize, making it more accessible for farmers. The study demonstrated that the seeding depth of the seed was influenced by both the planter depth setting and the downforce applied by the ground wheel, resulting in a satisfactory germination rate compared to traditional methods. The side-to-side placement of fertilizer with the seed provided maximum utilization of fertilizer in the growth of the plant, directly affecting the yield. With slight adjustments to the planter, operators can control the desired plant population throughout the field for higher yields. Additionally, this technology addresses many challenges associated with conventional manual methods in maize, such as poor seed placement, poor spacing management, uneven fertilizer distribution, and labor-intensive tasks. Through the use of this planter, farmers were able to plant and harvest crops in a timely manner, utilizing the time saved for other tasks.

The performance evaluation of the 4-wheel tractor-drawn 3-rows precision maize planter has demonstrated its potential for mechanizing maize farming in Nepal, leading to increased efficiency, reduced costs, and improved yields. Further research and development of this technology could lead to significant advancements in maize production and contribute to the overall economic development of the country.

Acknowledgement

The authors would like to express their sincere appreciation to Nepal Agricultural Research Council management team for all the technical and financial support thought-out the conduction of this research. They are extremely thankful to all the technical and non-technical manpower of Agriculture Implement Research Station, Ranighat, Birgunj, for their continuous effort. This wouldn't have been possible without the kind support & feedback of farmers, our deepest gratitude to them.

References

ADS. (2015). Agriculture Development Strategy (ADS). Ministry of Agricultural Development Singhdurbar. Kathmandu, Nepal.

Annual reports (2018/19, 2019/20, 2020/21, 2021/22, 2022/23). Agricultural Implements Research Station, Nepal Agricultural Research Council, Ranighat, Parsa, Nepal.

Bamboriya, S., Jat, S., Shreelatha, D., Mahala, D., & Rakshit, S. (2020). Mechanized maize production for enhanced productivity and profitability. IIMR Tech. Bull, 1, 4–46.

Chaudhary, K. K., & Mishra, A. K. (2021). Impact of Agriculture on Economic Development of Nepal using Statistical Model. J. Adv. Res. in Alternative Energy, Environment and Ecology, 8(2), 1-3.

Chaudhary, K. K., & Mishra, A. K. (2021). Analysis of GDP using then-variable Regression Model. International Journal of Management, Technology, and Social Sciences (IJMTS), 6(1), 170-175.

Fu, W., An, X., & Zhang, J. (2018). Study on precision application rate technology for maize no-tillage planter in North China Plain. IFAC-PapersOnLine, 51(17), 412–417.

Gao, N., Fu, W., Meng, Z., Wei, X., Li, Y., & Cong, Y. (2016). Research and Experiment on Precision Seeding Control System of Maize Planter. In D. Li & Z. Li (Eds.), Computer and Computing Technologies in Agriculture IX (Vol. 478, pp. 528–535). Springer International Publishing.

Koirala, K. B., Adhikari, J. B., & Tripathi, M. P. (2021). Maize (Zea mays L.) hybrids for Terai ecological belt of Nepal. Journal of Agricultural Research and Advances, 3, 21-28.

Koirala, K. B., Rijal, T. R., Kc, G., Katuwal, R. B., Dhami, N. B., Acharya, R., et al. (2020).

DOI: https://doi.org/10.48001/veethika.2023.09.04.003

Performance evaluation of maize hybrids under rainfed environments across the middle hills of Nepal. Tropical Agroecosystems, 1, 43-49.

Mishra, A. K., & Aithal, P. S. (2022). Performance Assessment of Irrigation: A Case from Nepal-Asia. International Journal of Management, Technology, and Social Sciences (IJMTS), 7(1), 444-464.

Mishra, A. K., Yadav, P., & Aithal, P. S. (2021). Time and Cost Performance Status of Sikta Irrigation Contract. International Journal of Management, Technology, and Social Sciences (IJMTS), 6(1), 286-305

Madhukumara, D. M., & Mathew, M. (2017). Design, Development and Testing of a Tractor Drawn Semi-Automatic Rhizome Planter for Ginger and Turmeric [PhD Thesis, Department of Farm Power and Machinery].

MOAD. (2022). Statistical information on Nepalese agriculture 2020/2021. Agri-Business Promotion and Statistics Division. Ministry of Agriculture and Development. Singhdurbar, Kathmandu, Nepal.

Paliwal, R. L., Granados, G., Lafitte, H. R., & Violic, A. D. (2000). Tropical Maize Improvement and Production. Plant Production and Protection Series No. 28. FAO, Rome, Italy.

Pereira, D. H. A., & Sain, G. (1999). Adoption of maize conservation tillage in Azuero, Panama. CIMMYT Economics Working Paper No. 99-01. Mexico, D.F.: CIMMYT

Sah, G., Manandhar, G. B., Adhikari, S. K., & Tripathi, J. (2007). Conservation agriculture: a system for sustainable food production. Paper presented at SAS convention – 2007.

Seidenberg, S. P., & McClelland, J. M. (1993). The structure and function of the developing maize kernel. Crop Science, 33(3), 565-575.

Yang, L., Zhang, R., Liu, Q., Yin, X., He, X., Cui, T., & Zhang, D. (2016). Row cleaner and depth control unit improving sowing performance of maize no-till precision planter. Transactions of the Chinese Society of Agricultural Engineering, 32(17), 18–23.

DOI: https://doi.org/10.48001/veethika.2023.09.04.003