International Journal of Advanced Trends in Engineering and Technology (IJATET)
Impact Factor: 5.965, ISSN (Online): 2456 - 4664
(www.dvpublication.com) Volume 8, Issue 2, 2023

TESTING AND EVALUATION OF 4-WHEEL TRACTOR DRAWN SEMI-AUTOMATIC 2-ROWS POTATO PLANTER AND DIGGER FOR MECHANIZATION OF POTATO CULTIVATION

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Cite This Article: Sachin Kumar Mishra, Shreemat Shrestha, Sanjeet Kumar Jha, Shiv Kumar Jha, Bikash K C, Mukti Nath Jha, Manoj Joshi, Dwarika Chaudhary & Sunil Sahani, "Testing and Evaluation of 4-Wheel Tractor Drawn Semi-Automatic 2-Rows Potato Planter and Digger for Mechanization of Potato Cultivation", International Journal of Advanced Trends in Engineering and Technology, Volume 8, Issue 2, July - December, Page Number 26-30, 2023.
DOI: https://doi.org/10.5281/zenodo.10371977

Abstract:

This study covers the laboratory and field performance of a recently imported 4-wheel tractor operated 2-rows semi-automatic potato planter and digger. The planter was calibrated to find out the optimum seed size and was able to plant cut/flat tubers also. The variety used was Khumal Seto. The planter has two units i.e.; seed box and fertilizer box. The graded potato tubers were fed into the seed box and granular fertilizer DAP into fertilizer box. The ridge formation and planting of graded seeds and calibrated fertilizer all were done in a single operation. The field experiment was carried out at Agriculture Implement Research Station, Ranighat, Birgunj, consisting of five treatments with three replications in RCB design. The actual field capacity of the planter was 0.2 ha/hr with field efficiency of 70% at effective working width of 1.30 m and forward speed of 1.95 km/hr. The crop was harvested after 95 days of planting with tractor drawn digger. Its actual field capacity was 0.23 ha/hr with uniform digging and very less missing of tubers. The biggest size of tuber harvested was 200 gm, medium size was 50 gm and smallest size was 10 gm. The missing of small size tubers (10-15 gm) in the field during harvesting was 7 kg/ha. The average maximum tuber yield recorded was 12.95 ton/ha with machine planting at 15 cm depth and 20 cm plant to plant spacing while the minimum tuber yield recorded was 6.1 ton/ha with machine planting at 15 cm depth and 25 cm plant to plant spacing. The total operating costs (Fixed + Variable cost) of semi-automatic potato planter and digger were NRs. 1111.28/ha and NRs.1100.13/ha respectively. The total cost of sowing and digging of planter and digger were NRs.5689.75/ha and NRs.4705.00/ha respectively. There was net savings of 47% and 78% of labor cost and 70% to 60% of time saving, respectively compared to farmers' practice of potato planting and digging.

Key Words: Farm Mechanization, Field Capacity, Semi-Automatic Potato Planter, Potato Digger, Seed Rate, Yield, Economics

Introduction:

Nepal is an agricultural country known for its diverse agricultural resources, and research in agriculture is an ongoing process to improve productivity and sustainability (Chaudhary, K. K., & Mishra, A. K., 2021a&b). Potato farming holds significant economic importance for Nepal. It is considered an important cash crop, contributing to the country's economy by addressing food insecurity and reducing poverty among smallholder farmers. The production and productivity of potatoes in Nepal have been reported to be substantial, with a high yield potential and significant demand. In addition, potato farming contributes to the country's Gross Domestic Product (GDP) and Agricultural Gross Domestic Product (AGDP), with a contribution of 6.57 percent to AGDP and 2.17 percent to GDP. Furthermore, potato farming has been found to be a major source of income for rural communities, directly impacting their livelihoods. The cultivation of potatoes has also been shown to have a positive impact on the economy and livelihoods of rural farmers, making it a vital component of the country's agricultural sector (Subedi, S., Ghimire, Y. N., Gautam, S., Poudel, H.K. and Shrestha, J 2019). Therefore, the significance of potato farming for the economy of Nepal is evident, as it not only contributes to food security and poverty reduction but also plays a crucial role in the overall economic development of the country. Several studies attempted on maize such as Coltheart, M., Curtis, B., Atkins, P., & Haller, M.(1993), Seidenberg, S. P., & McClelland, J. M. (1993), Bamboriya et al.(2020), Gao et al.(2016) Yang, L., Zhang, R., Liu, Q., Yin, X., He, X., Cui, T., & Zhang, D. (2016), Seidenberg, S. P., & McClelland, J. M. (1993), Sah, G., Manandhar, G. B., Adhikari, S. K., & Tripathi, J. (2007), Madhukumara, D. M., & Mathew, M. (2017).,and so

on though potato is not focused much relatively. Irrigation performs may enhance value of potato in GDP (Mishra, A. K., Yadav, P., &Aithal, P. S. 2021: Mishra, A. K., &Aithal, P. S 2022).

Potato is the fifth major crop after rice, maize, wheat and finger millet. It occupies fifth position on area coverage (982600 ha), second position on total production and consumption (2508044 mt.) and first position on productivity (13.73 mt./ha) compared to major crops. It can be easily cultivated in all regions of Nepal up to an altitude of 4700 m. It acts as alternative food option especially in high hills and Himalayan region and can play major role in food and nutritional security. It is one of the important commodities in increasing vegetable farming and provides good market value to the farmers. It can be cultivated in various cropping system and help increase cropping intensity due to its short growing season.

Farm mechanization may be viewed as package of technology to ensure timely field operations, increased productivity, reduced crop losses and improved quality of grain or product. Farm machines have not only increased the mechanical advantage, but also helped to reduce drudgery while performing the different agricultural operations. The contributions of agricultural mechanization in various stage of crop production could be viewed as saving in seeds (15-20%), saving in fertilizers (15-20%), saving in time (20-30%), reduction in labor (20-30%), increasing in cropping intensity (5-20%) and higher productivity (10-15%). Potato planting and harvesting are very labor intensive jobs and involve considerable drudgery. Cost and time of potato planting and digging by mechanical method is very less compared to traditional methods. It also reduces drudgery and number of labors required for potato planting and digging. Thus, recently developed potato planter and diggers have very good acceptance amongst potato growers. Generally, proper planting of any crops is very much important as far as growth and yield is concern (Tewari et al.; 2012). The absence of seed pieces due to mechanical deficiencies in potato planters has been cited as a major cause of reduced yields of potatoes. Misener (1979) conducted field experiments to evaluate different cup and pick type potato planters and concluded that the pick type planter was slightly more effective than the cup type planter. The range of skips for the cup planter was 3 (3.2%) to 22 (14.7%) and for the pick type planter, from 3(3.0%) to 19 (12.1%) per 30.5 m of row length. Capacity and accuracy of plant spacing are the main parameters of machine performance. High accuracy of plant spacing results in high yield and a uniform sorting of the tubers at harvest (McPhee et al., 1996; Pavek & Thornton, 2003).

Due to migration of rural youths to the foreign countries and in the cities, labor forces are not easily available in the villages. If available, they charge very high wage rate. In order to address labor scarcity problem and reduce cost of production of potato, Agriculture Implement Research Center, Birgunj has introduced and evaluated 2-rowssemi-automatic potato planter and digger operated by 4 wheel tractor.

Statement of the Problem:

The mechanization of potato cultivation is a significant area of interest in agricultural research, particularly in the context of Nepal. The traditional methods of potato planting and digging are labor-intensive and time-consuming, leading to considerable drudgery and high labor requirements. In contrast, the adoption of mechanized methods for potato cultivation has been shown to significantly reduce labor intensity, improve working efficiency, and ensure seeding quality (Pushpitha, N. P. G., Weerasinghe, K. D. N., & Maier, D 2018). However, the suitability and performance of specific mechanized equipment, such as tractor-drawn semi-automatic potato planters and diggers, in the context of Nepal's agricultural and environmental conditions, have not been extensively studied. Therefore, there is a need to evaluate the performance of such equipment in the local context to assess their potential for addressing the challenges associated with traditional potato cultivation methods. This evaluation should consider factors such as field efficiency, field capacity, and the impact on labor requirements, with the aim of providing evidence-based recommendations for the adoption of mechanized potato cultivation methods in Nepal. The existing literature provides valuable insights into the design and performance of mechanized potato planting and digging equipment, but there is a need for specific evaluations tailored to the unique conditions of potato cultivation in Nepal. Therefore, this study aims to address this gap by conducting a comprehensive assessment of the 4-wheel tractor-drawn semi-automatic 2-rows potato planter and digger, with a focus on its suitability for the mechanization of potato cultivation in Nepal.

Objective of the Research:

The overall objective for the testing and evaluation of the 4-Wheel Tractor Drawn Semi-Automatic 2-rows Potato Planter and Digger for the mechanization of potato cultivation is to assess its performance in reducing labor intensity, improving working efficiency, ensuring seeding quality, and addressing the challenges associated with traditional potato cultivation methods, particularly in the context of Nepal.

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.

Materials and Methods:

The semi-automatic 2-rows potato planter and digger operated by 4-wheel tractor manufactured by Satwant Industry, Punjab, India was procured in the fiscal year 2014/15. Its laboratory test was done using different size potato seeds and plant to plant spacing. The field testing of potato planter was done at Agricultural Implement Research Station, Ranighat, Birgunj on November 28, 2015. The machine performance was tested and evaluated in the actual field condition with the following parameters viz. type and texture of soil, moisture content and bulk density, seed rate, theoretical/ actual field capacity, plant population (germination %), uniformity in seed distribution, spacing and depth, yield and cost analysis. This experiment consisted of 5 treatments with 3 replications in RCB Design. The treatments were: (T1)= land preparation & planting at depth (d1)=10 cm & spacing (S1)= 20 cm; (T2)= land preparation & planting at depth (d1)=10 cm & spacing(S2)=25 cm; (T3)= land preparation & planting at depth (d2)=15 cm & spacing(S1)=20 cm; (T4)= land preparation & planting at depth (d2)=15 cm & spacing(S2)= 25 cm and (T5)= Manual seeding & ridge formation using 4-w Tractor-drawn ridger. The plot size was 30 m^2. The fertilizer dose applied was N_2:P_2O:K_2O (150:100:100) and FYM (20 ton/ha). The potato crop was harvested on March 2, 2016 using 4 wheel tractor drawn potato digger. The potato yield, bruised tubers, missing tubers in soil of each plot was recorded. The plot yield was converted to average yield per hectare and reported.

Results and Discussion:

The semi-automatic potato planter and digger have been introduced and evaluated in the country first time and the results are very encouraging.

Potato Planter Specifications:

Height of planter: 1.53 m
Effective width of coverage: 1.3m (adjustable)
No. of rows: 2
Row to row spacing: 65 cm (adjustable)
Plant to plant spacing: 20-25 cm (adjustable)
Depth of seeding: 10-15 cm (adjustable)
Size of ridge: 45 cm (adjustable)
Seed metering: Horizontal belt with cup type planting mechanism, floating type ground wheel drive with lugs.
Planter works efficiently in all type of soil & can able to plant cut/ flat potato tubers
Tractor power required: 35 hp and above.
Weight of machine: 380 kg (approx.)
Cost of machine: NRs. 200000.00
The ridge formation, fertilizer application & tuber placing, all are done in single operation.

Field Performance of Potato Planter:

The appropriate seed size for the machine was 30-50 g. It can also plant small size tubers of 10-25 gm which are generally used by the farmers. The planter was operated by 35 hp tractor hitched with 3-point linkage. Its actual field capacity was 0.2 ha/hr with field efficiency of 70.0 percent at effective working width of 1.30 m and forward speed of 1.95 km/hr. The actual field capacity of the planter maybe varied from 1.5 to 1.7 ha/day depending on the plot size, shape, depth of planting and soil type. The soil type was sand loam having bulk density 1.15gm/cc. The seed rate was about 2500 kg/ha. with no seed breakage. The average germination of tubers was 95 percent recorded after 40 days of planting. The average maximum tuber yield recorded was 12.95 ton/hr with machine planting at 15 cm depth and 20 cm plant to plant spacing while the average minimum tuber yield recorded was 6.1 ton/hr with machine planting at 15 cm depth and 25 cm plant to plant spacing.

Potato Digger Specifications:

No. of rows: 2
Width of coverage: 1.1 m
Length of machine: 1.83 m
Depth of digging: 45 cm (adjustable)
The machine can dig & harvest all size of potato from soil according to the row maintained duringplantation.
Tractor power required: 35 hp and above.
Cost of machine: NRs. 180000.00

Field Performance of Potato Digger:

The crop was harvested after 95 days of planting with tractor drawn digger. The potato digger was operated by PTO of the tractor. Its actual field capacity was 0.23 ha/hr with uniform digging and very less missing oftubers.In heavy soil, the digger could not separate the soil and tubers, thus the harvested tubers were left on the soil surface. The tubers were manually collected and it was observed that 21-man days/ha required to collect machine harvested tubers. The skin injury was observed to be less than 1 percent in bigger size tubers due to impact with conveyor belt. The biggest size of tuber harvested was 200 gm, medium size was 50 gm and

smallest size was 10 gm.The loss of small size tuber in the field during harvesting was 7 kg/ha. Quality of harvested tubers was good (no cut damage).Quantity of harvested tubers may be little more (less missing tubers in the field).

Potato Yield:

The effect of planting depth, spacing and planting methods on potato yield is presented in Table 1 and Table 2. The result indicated that the closure the spacing higher the yield and vice versa. There was clear-cut trend between depth of planting and yield i.e. more depth high yield. The average maximum tuber yield recorded was 12.95 ton/hr with machine planting at 15 cm depth and 20 cm plant to plant spacing while the average minimum tuber yield recorded was 6.1 ton/hr with machine planting at 15 cm depth and 25 m plant to plant spacing.

Table 1: Plant population and potato tuber yield as influenced by different planting methods in Fiscal year 2014/15

Planting Methods	Plant population/30 m^2 (20 DAS)	Plant population/30 m^2 (40 DAS)	Average yield (ton/ha)
Potato planter (10 cm depth and 20 cm spacing)	53	136	8.7
Potato planter (10 cm depth and 25 cm spacing)	81	138	6.7
Potato planter (15 cm depth and 20 cm spacing)	93	169	10.0
Potato planter (15 cm depth and 25 cm spacing)	35	140	6.1
Manual planting	65	178	7.5

Table 2: Plant population and potato tuber yield as influenced by different planting methods in Fiscal year 2015/16

Planting Methods	Plant population/30 m^2 (20 DAS)	Plant population/30 m^2 (40 DAS)	Average yield (ton/ha)
Potato planter (10 cm depth and 20 cm spacing)	110	127	9.8
Potato planter (10 cm depth and 25 cm spacing)	96	112	9.7
Potato planter (15 cm depth and 20 cm spacing)	112	132	12.95
Potato planter (15 cm depth and 25 cm spacing)	89	114	11.60
Manual planting	122	132	12.90

Economics of Planter and Digger:

Any technology must be economically viable. The economic analysis of the semi-automatic potato planter and digger showed that the planting cost with potato planter was around NRs 5689.75/ha which was 47% less than manual planting (farmers practice) and harvesting cost with digger was NRs.4705.00/ha which was 78% less than manual harvesting and 70% to 60% of time saving, respectively compared to farmers' practice of potato planting and digging.

Planter:

Fixed Cost: NRs 108.5/hr. Variable Cost: NRs 2.78/hr.
Total Operating Cost: NRs 111.28/hr.
Total Operating Cost along with tractor: NRs (1000+111.28) =NRs 1111.28/hr.
Total Cost of planting: NRS 5689.75/ha. (<47% of F.P.)

Digger:

Fixed Cost: NRs 97.63/hr.
Variable Cost: NRs 2.50/hr.
Total Operating Cost: NRs 100.13/hr.
Total Operating Cost along with tractor: NRs (1000+100.13)= NRs 1100.13/hr.
Total Cost of Digging: NRs 4705.00/ha. (<78% of F.P.)
Wages, hiring charges of tractor and cost of machines may vary the results**.**

Conclusion and Recommendation:

The study on the testing and evaluation of the 4-Wheel Tractor Drawn Semi-Automatic 2-rows Potato Planter and Digger for the mechanization of potato cultivation in Nepal is a significant contribution. The results of the on-station field testing and evaluation of the potato planter and digger indicate that these technologies are feasible and have the potential to significantly reduce labor costs and time associated with traditional potato planting and digging practices. The net savings of 47% and 78% of labor cost and 70% to 60% of time, respectively,

compared to farmers' traditional practices, demonstrate the potential benefits of these machinery technologies. The favorable reactions of farmers to these machines are anticipated, and their actual responses will be available in the coming potato planting season. However, some modifications are needed in the potato digger for the separation of tubers and soil clods in heavy soils, and an attachment collector (tray/bags) behind the digger is also needed to reduce the labor cost incurred in collecting harvested tubers. The study provides valuable insights into the potential of mechanized potato cultivation methods in Nepal and highlights the need for further research and development to optimize the performance of these technologies in local agricultural and environmental conditions. The needs for further research and development to optimize the performance of these technologies in local agricultural and environmental conditions.

Acknowledgement:

The authors are grateful to Executive Director, Directors, Crop & Hort Research, and Planning & Coordination, NARC for the approval of new research programs and providing fund for the procurement of new machines. They are also thankful to Regional Director, RARS, Parwanipur for providing research advice and other supports to conduct the experiment. Thanks also goesto Co-ordinator, Potato Research Program, Khumaltar, Kathmandu for appreciating this work. The direct and indirect cooperation and support provided by the staffs of this station during the field experimentation is highly acknowledged.

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