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Performance of potato on mechanical planter with diverse irrigation method

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Abstract

Efficient planting techniques combined with appropriate irrigation methods play a crucial role in maximizing potato yields and ensuring sustainable agricultural practices. A field experiment was conducted Regional Agricultural Research Station, Jashore, Bangladesh, spanning the seasons of 2022-2023 and 2023-2024. The experiment employed the Bangladesh Agricultural Research Institute (BARI) developed potato planter for mechanized planting, compared with manual planting under three irrigation methods: i) Farmer practice (irrigation in both furrows), ii) Alternate furrow irrigation, and iii) Drip irrigation. The experiment was arranged in a split plot design with three replications. Among the irrigation methods tested, drip irrigation demonstrated superior performance, achieving higher yields while conserving approximately 48% of irrigation water compared to farmer practice. Additionally, the study found that mechanized planting using the potato planter resulted in higher yields compared to manual planting, reducing labor requirements by about 92%. Specifically, drip irrigation combined with mechanized planting using the potato planter yielded the highest tuber production, followed by alternate furrow irrigation combined with mechanized planting. This research underscores the efficacy of combining mechanized potato planting with drip irrigation for maximizing yields and optimizing resource use in potato cultivation systems.

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Introduction

Potato is widely grown around the world because of its rich nutrition, ease of cultivation, and high yield (Wang *et al.*, 2020). In Bangladesh total potato production is 104.31 million M. Ton from 4.56 million hector of land with (BBS, 2023). The national average yield of potato in Bangladesh is less compared to other potato growing countries, like France, Germany, UK, USA and Netherlands. Potato yield will be increased due to using high yielding varieties with proper management practices. Generally in Bangladesh potato is planted manually that is costly, labor-intensive, and time-consuming. Technological advancements have led to enhanced potato yields.

The research reported that mechanization of potato planting is most important component of potato production. Mechanized planting is vital for improving production efficiency and reducing labor (Raigond *et al.,* 2020). Bangladesh Agricultural Research Institute (BARI) developed power tiller operated potato planter is an advance technology for planting potato that reduce labor requirements, especially during the peak potato planting season.

The mechanization of potato planting has proven effective in enhancing potato yields. In recent years, the development and adoption of mechanized potato planters have revolutionized planting processes, offering advantages such as precise seed placement, optimal spacing, and efficient use of inputs.

The choice of irrigation method significantly influences potato growth, yield, and water use efficiency. Traditional methods such as furrow irrigation have been commonly practiced, but their effectiveness in water conservation and yield enhancement is increasingly scrutinized amidst concerns over water scarcity and environmental sustainability. In contrast, modern irrigation techniques like drip irrigation have gained prominence for their ability to deliver water directly to the root zone, minimizing losses due to evaporation and runoff while potentially enhancing nutrient uptake and crop productivity.

Understanding how different irrigation methods interact with mechanized potato planters is essential for optimizing potato cultivation practices. This study explores the performance of potato cultivation under diverse irrigation methods when using a potato planter. It aims to assess yield outcomes, water use efficiency, and overall agronomic benefits associated with each irrigation technique. Such insights are pivotal for informing agricultural decisions aimed at achieving higher yields, conserving water resources, and promoting sustainable potato production systems in diverse agro-ecological settings.

Materials and methods

Experimental site description

The field experiment was conducted in a farmer's field located in Jashore, Bangladesh over the period from 2022-2023 and 2023-2024. Soil bulk density (0–40 cm) 1.11 g cm–3, field capacity 30%, soil pH 6.3 were recorded at the sowing time. Climatic parameter like temperature and rainfall are also recorded in growing period (Fig. 1).

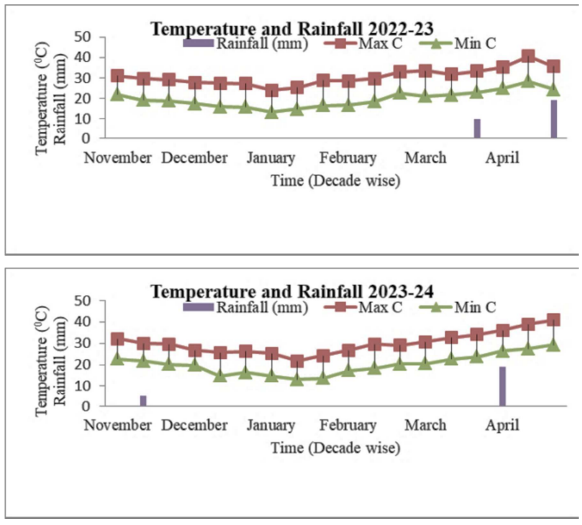

Fig. 1. Rainfall and temperature of growing period

Experimental design

Whole tuber potato seeds ('A' grade seed) size of 28-40 mm are planted by using Bangladesh Agricultural Research Institute (BARI) developed potato planter maintained a 25cm gap between seed to seed and row to row spacing of 60 cm and also manually planting system with three irrigation method like i) Farmer

practice (irrigation with both furrow), ii) Alternate furrow irrigation and iii) Drip irrigation. The study was organized in a split plot design with three replications, where planting systems were designated as the main plot and irrigation methods as the subplot. The tested variety of potato was BARI Alu 72 which life span was 95 days.

Description of potato planter

In this study we use BARI developed power tiller-operated potato planter for mechanized potato planting (Fig. 2). This planter consisting of a frame, furrow opener, seed metering unit, ridger, and V-shaped soil compactor (Wohab *et al.*, 2004). Power tiller operated potato planting machine is small in size and easy to use. There are 24 tine are connected by rearranging the rotating tines of the power tiller where 12 of which are arranged from left to right and 12 from right to left. A rotary plough cultivated the land and produces furrows.

Fig. 2. Field operation of BARI

This planter consists of 10 pairs of cup which sizes are 40 mm and the distance between two cups is 110 mm. The metering device picks up one potato and places it at a specified distance; the bed maker makes the bed and covers the potato seed and simultaneously planting potatoes and making beds. This planter operates on a simple yet effective principle to mechanize potato planting. It consists of a mechanism that digs furrows in the soil at specific intervals. Potatoes are then placed into these furrows at set depths and covered with soil, all in a single pass of the planter. This process is typically driven by a power tiller operated system, ensuring consistent planting depth and spacing, which are crucial for optimal potato growth. The planter's design aims to reduce labor intensity, improve planting accuracy, and ultimately enhance crop yields for farmers, particularly in regions where potato cultivation is prevalent.

Planting system

We used two potato planting methods like mechanized and manually. In mechanized potato planter planting method, specialized cups extract seeds from the hopper, pass them over an opening in the furrow, and precisely drop them into the furrow at the required 25 cm spacing, while simultaneously forming a raised bed. In contrast, in the manual planting system, potato seeds are planted by hand, and the raised bed is created manually.

a. Irrigation with both furrow

b. Alternate furrow irrigation

c. Drip irrigation

Fig. 3a-c. Irrigation methods

Irrigation method

In irrigation treatments applied 3 irrigations at 25 DAP, 40 DAP and 60 DAP at farmer practice and alternate furrow irrigation methods. After planting the potato tubers, drip irrigation systems were placed the intervals of drip tape is 25 cm with an emitter flow rate of 4 litters per hour (Fig. 3a, 3b and 3c). Field capacity of soil was measured by count the amount of water retained in a saturated soil after 2–3 days of gravity drainage. Soil moisture was also calculated using gravimetrically. Amount of irrigation (IR) water was calculated with the following formula.

$$IR = \left[\frac{(FC - MC\ before\ irrigation)\% \times Root\ Depth(mm)}{100}\right] \times Ploat\ area\ (m2) \times (wetted\ soil)\%$$

Where, FC and MC denoted field capacity and moisture content, respectively. Soil samples were taken from 0–20 and 20–40 cm depths with a soil digger for measure the field capacity. During the crop season, negligible amount of rainfall was occurred (Fig. 1).

Data collection and statically analysis

Foliage coverage (%), plant height (cm) at 60 days after planting (DAP), number of stems per hill, number of tubers per hill, tuber weight per plant, and ultimately tuber yield were measured for potatoes. The yield and yield contributing parameters were analyzed using R software. In addition, operational speed, theoretical field capacity, effective field capacity, field efficiency, and the percentage of missing seeds were recorded to assess the performance of the potato planter machine.

Results and discussion

Effect of planting method on potatoes

Number of labor required for potato planting using planter and manual methods are recorded (Table 1). Therefore, potato planting by planter saved about 92% labor compared to the conventional method that lead to decreased planting cost.The reduction in labor and time requirements in mechanized potato planting is a significant advantage for large-scale potato farming. The mechanized approach not only reduces the physical strain on laborers but also speeds up the planting process, allowing for timely planting and potentially extending the planting window. Planting by potato planter gave higher tuber yield compare to manually planting due to make sure accurate and homogeneous spacing between potato seeds during planting (Table 2). From the results, mechanized potato planting system is effective high yield planting method. Besides this offer to make high quality seed bed has a direct impact on soil water storage capacity, improve soil permeability, create suitable conditions for early sprout and seedling growth, and facilitate the standardization of field management later. The mechanized planting ensures uniform planting depth and spacing, which promotes better plant growth and tuber development. However, mechanized planting improve drainage and reduce waterlogging, which can adversely affect potato crops. Additionally, the better moisture retention helps in sustaining the crop during dry periods, reducing the need for frequent irrigation. Missing seeds are also recorded about 4% that was not bad. Sun *et al.* (2017) reported that missing seeding of the improved potato planter is still beyond 5%.

Table 1. Performance of potato planter on the field

Performance parameter	Value
Average operating speed, km/hr	2.5
Planter's width, cm	60
Theoretical field capacity, ha/hr	0.15
Effective field capacity, ha/hr	0.11
Field efficiency, %	73
Average amount of fuel used, lit/hr	1.2
Labor requirement, man-days/ha	3
Labor requirement manually planting, man-days/ha	4
Conventional manual method, man-days/ha	50
Seed spacing, cm	25
Seed missing, %	4

Effect of irrigation method on potatoes

Drip irrigation system not only save water but also to supply immediately desire amount of water to the root system of plants. From the result drip irrigation has been shown to have higher efficiency compared to traditional irrigation methods, like furrow irrigation, due to the targeted application of water directly to the crop's root zone and reduced water loss through

evaporation and runoff. Besides, avoiding the leaf moisture and create a dry environment that reduces the risk of potato blight and other fungal diseases. Drip irrigation provides maximum foliage coverage than other irrigation methods that ensure to cover the ground and improved transpiration efficiency indirectly. However, Drip irrigation method also provides early stolen initiation, sustained leaf growth for new tuber initiation and increased bulking of early tubers that influenced the maximum yield (Table 2). Finally, the result found that drip irrigation method achieved higher yield among the irrigation methods. Smith *et al.* (2022) found that drip irrigation significantly increased potato yields.

Combined effect of planting and irrigation method

The result revealed that foliage coverage, plant height, tuber weight and yield are significantly varied over plating method and irrigation method (Table 2). Drip irrigation method achieved higher yield among the irrigation methods and planting by potato planter recorded higher yield over the manually planting due to ensuring precise placement of seed. The trend of yield and yield contributing parameter of potato are planting by potato planter greater than by manually planting and drip irrigation> alternate furrow irrigation> both furrow irrigation. The potato tuber yields exhibited significant variation in response to different planter and irrigation method. Drip irrigation with planting by potato planter gave higher tuber yield followed by alternate furrow irrigation with planting by potato planter. Second lowest yield were recorded drip irrigation with planting by manually that indicate drip irrigation performance is better than others. Rahman *et al.* (2021) found that using the BARI developed planter in conjunction with drip irrigation resulted in higher potato yields compared to using drip irrigation with conventional tillage.

Table 2. Yield and yield contributing parameter of potato during 2022-23 and 2023- 24 (pooled analysis)

Tillage*Irrigation	% Foliage coverage	Plant height (cm) 60DAP	Stem/Hill	Tuber/Plant	Tuber weight/Plant	Yield
T1*I1	87.00bc	59.00b	4.67	8.66	579.33b	29.21cd
T1*I2	88.00ab	60.67ab	5.33	9.66	585.00b	30.86b
T1*I3	90.00a	62.33a	6.33	10.33	595.00a	32.41a
T2*I1	81.00d	58.33b	4.33	7.67	549.00c	27.96e
T2*I2	85.33c	59.66ab	4.67	8.00	556.00c	28.46de
T2*I3	90.00a	60.00ab	5.00	9.00	557.67c	29.58c
LSD	2.00	2.82	0.88	0.99	8.85	0.60
CV	1.23	2.5	ns	ns	0.82	1.09

T_1=Planting by potato planter; T_2= Planting by manually; I_1= Irrigated by both furrow (farmer practice); I_2= Irrigated by alternate furrow irrigation method; I_3= Irrigated by drip irrigation method

Seasonal water use by different irrigation methods

Water applied by different irrigation methods is shown in Table 3. It is observed from the table that about double amount of water was required in farmers' practice i.e. irrigation in both furrow than drip method. Irrigation water savings by drip and alternate furrow method over farmers' practice were 48.64%, and 28.38% respectively. So, drip irrigation method was found the best water saving technology for potato cultivation. Smith *et al.* (2022) found that seasonal applied water was lowest in drip irrigation compared to furrow and alternate furrow irrigation for potato.

Table 3. Amount of applied water in different irrigation methods

Treatment	Applied water (mm)	Water saving over farmer practice (%)
Drip	190	48.64
AFI	265	28.38
FP	370	-

FP= Irrigated by both furrow (farmer practice); AFI= Irrigated by alternate furrow irrigation method; Drip = Irrigated by drip irrigation method

Conclusion

Potato planting using a planter such as the BARI developed potato planter improves production quality

by enabling precise tilling, sequential and evenly spaced seed planting, and simultaneous earthing up during cultivation. For irrigation, both drip irrigation and alternate furrow irrigation methods are well-suited for potato cultivation.

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