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Effect of Different Tillage Practices on the growth and yield attributes of Potato (*Solanum tuberosum* L.)

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ABSTRACT

An experiment was conducted in Randomized Complete Block Design (RCBD) with 8 replications and three treatments viz. [T_0 = Conventional Cultivation (Control), T_1 = Zero Tillage Potato and T_2 =Raised Bed Potato). All the growth attributes (plant height, leaf area and plant cover area) recorded were significantly higher in case of conventional cultivation as compared to zero tillage and raised bed planting. However, the yield obtained was significantly higher for zero tillage potato (327.42 q/ha) in comparison to conventional cultivation (216.03 q/ha) and raised bed planting (283.98 q/ha). Thus, it can be concluded that zero tillage method of potato cultivation is better as compared to raised bed planting and conventional potato cultivation both in term of economical and environmental aspect. Economically, maximum B:C ratio of 3.63 is obtained under zero tillage potato and environmentally, it is an option for residue management and emits no harmful gases into the atmosphere due to no machinery use. Also, the benefits of mulching is additional in zero tillage system rendering better soil health in the long run.

Keywords: Zero tillage, Raised Bed, Residue management, Mulching, Conventional cultivation, leaf area, plant cover.

1. INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the major crops contributing to food requirement of the world. Currently, potato is the fourth most important food around the world after rice, wheat and maize [5]. Potato production is associated with different practices that significantly disturb the soil environment with heavy machinery. Crop intensification, minimum input use and maximum possible output is the new requirement in Agriculture today. Zero tillage potato cultivation is one such promising technology for cropping system intensification in the rainfed or low land areas where mono cropping has been practiced on a larger scale till date. There is a need to increase the cropping intensity to increase the yield as well as the economic return from the farm. Potato can be successfully grown using the Zero tillage cultivation system just after *Kharif* rice. This Zero tillage farming technique involves planting potatoes without tilling the soil or using traditional plowing methods. Instead, after harvesting their rice crop, farmers use strip tillage to sow potato seed after without

disturbing the soil structure and the natural habitat of microorganisms. The potato seeds are mulched with rice straw and manure.

There are numerous benefits to reduced-tillage potato cultivation. It helps maintain the soil's health. By reducing soil disturbance, farmers can preserve the soil structure, which prevents erosion and helps to maintain the natural balance of nutrients and microorganisms in the soil. By maintaining the natural structure of the soil, farmers can provide the ideal conditions for the growth of the potato crop. Reduced-tillage potato cultivation requires less labour, fuel, and equipment than traditional plowing methods. This results in cost savings for farmers without sacrificing yields.

Studies have shown that, compared to the traditional ridge and furrow method, reduced-tillage potato cultivation produces higher, net returns, and a benefits-cost ratio. Farmers today can adopt the Zero tillage potato cultivation practice as this system can give higher yield with limited labour and water use thus making the whole production system a lot more economic. Straw mulching is a convenient mulching method in potato cultivation in regions where straw resources are locally available [2] and [6]. Mulching practices directly and indirectly exert positive impacts on micro-climates and crop yield. Mulching can protect soil from water erosion and thus reduce soil and water loss in arable lands. Mulching reduces nitrogen leaching and increases nutrient availability, thereby improving soil quality.

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Mulching suppresses weed growth and reduces competition with weeds for water and nutrients [1]. As a result, mulching leads to increases in yield and water-use efficiency [7].

This study consequently performed to evaluate the effect of different tillage practices on some growth parameters of potato such as (Plant height, leaf area, Plant cover area, per cent weed growth and per cent Disease infestation), yield parameters such as (tuber numbers / plant, tubers weight/ plant and total productivity) and economics of different methods of potato cultivation in a sandy loam soil. And to determine as well the relationship between the tillage types and their effect on the studied parameters.

2. MATERIALS AND METHODS

2.1 Study Area

The research was conducted in Patepur Block of Vaishali district of Bihar (26.7768 latitude and 85.53635 longitude) where eight (8) progressive farmers working with Climate Resilient Agriculture (CRA) technologies were selected randomly and the trails were conducted in their respective field at eight different locations of the block. These 8 trials conducted in the field of farmers were treated as one replication each. The trial was conducted in the rabi season of the year 2022-23 when the maximum temperature was 34.2°C and the minimum temperature was 4.5°C. There was no rain shower during the entire cropping season. The variety used by farmers was Kufri Khyati. The experiment was conducted under Climate Resilient Agriculture (CRA) Program running in Krishi Vigyan Kendra, Vaishali with the technical support of BISA, Pusa, Bihar.

2.2 Experimental Design

The experiment was laid out in randomized complete block design (RCBD) with eight (8) replications (in 8 farmer's field as mentioned above) and three (3) treatments [T_0 = Conventional Cultivation (Control), T_1 = Zero Tillage Potato and T_2 = Raised Bed Potato).

In conventional method, potato tubers were treated with carbendazim @ 2g/kg of seed and sown in ridges and furrows prepared manually at a distance of 60 cm × 20 cm. In case of zero tillage method, potato was laid down on the soil surface at a distance of 60 cm × 20 cm after the harvest of paddy with any kind of land preparation. Vermicompost (5t/ha) was applied around each potato tuber and a thick layer of straw (15-20cm) was used to cover the entire field to create a layer over the potato tubers and provide them a medium to proliferate over the soil. Potato planter was used for sowing potato in raised bed method where ridges of about (35-50) cm height and (15-20) cm width were created, tubers dropped and covered with soil in a single run of the machine. A seed rate of about 22q/ha was used in all three types of potato sowing method. The details of input used in all the three different methods from sowing till harvesting is presented in Table 2.



Fig. 1, Fig. 2, Mulching with paddy straw in Zero Tillage Potato Field



Fig.3 Zero tillage potato field

Fig. 4 Scientist of Krishi Vigyan Kendra visited Zero Tillage Potato Field at Patepur

2.3 Data Collection

Five plants were selected randomly from each treatment which were used for collection of required data. The growth parameters viz. plant height (cm), leaf area (cm²), plant cover area (cm²) and yield parameters viz. tuber/plant (nos) and mean tuber weight (g), were recorded at the time of harvesting. The plant height was measured from the base of the plant to the tip using centimeter scale. The leaf area was calculated by measuring the length and width of the leaf using centimeter scale and by multiplying the length and width values. The plant cover area was worked out using the principles of rope-and-compass method [5]. In case of yield parameters, tuber/plant was recorded by counting the total number of tubers produced from a single plant at the time of harvesting from each of the five randomly selected plants and by calculating the average of the values. Mean tuber weight was recorded by working out the average of the weight of tubers of different sizes from each of the five plants using weighing balance. The total number of irrigations in each treatment during the entire cropping season, weed incidence (%) and disease infestation (%) was also recorded. An quadrant of 1m² area was used for detecting the percentage of weed growth and disease infestation.

3. RESULTS AND DISCUSSION

The total number of irrigations provided during the entire cropping season for potato crop grown under different methods of cultivation is presented in Table 1. It is evident from the table that only 2 irrigations have been provided for zero tillage method (T_1) of potato cultivation which is lesser as compared to other two methods i.e. Conventional cultivation (T_0) and Raised Bed Potato (T_2) in which 5 irrigations were provided. Thus, the total number of irrigations required in zero tillage potato is 60% less than the other two methods which is probably because a thick layer of paddy straw was spread on the soil as a mulching material resulting in reduction of moisture loss from the soil. These findings are in accordance with the findings of [8] where a reduction of 37% in irrigation water requirement was observed in zero tillage potato cultivation as compared to conventional ridge sowing methods. This thick layer of mulch is also required in Zero Tillage Potato for the potato tuber to grow and develop in dark so that greening does not occur due to chlorophyll formation which renders the potato bitter in taste and toxic for health.

The data recorded on weed growth (%) revealed that the highest weed growth was observed in conventional cultivation method (T_0) followed by Raised bed potato planting (T_2) and lowest in Zero tillage technology (T_1) i.e. 32.82 %, 12.54% and 4.35 % respectively. Straw Mulching suppressed weed growth and reduced competition with weeds for water and nutrients [1]. As a result, mulching resulted in lower weed growth and increased yield and water-use efficiency [7].

The Zero tillage technology recorded minimum disease infestation (12.5%) while maximum disease infestation was observed in conventional cultivation method (45%) followed by raised bed potato cultivation (42%) as presented in Table 1.

Table 1: Growth and yield parameters of potato grown under different methods

Treatments	Number of irrigations provided	Weed Growth (%)	Disease Infestation (%)	Plant Height (cm)	Leaf area (cm ²)	Plant cover area (cm ²)	Tubers/plant (No./plant)	Mean Tuber weight (g/tuber/plant)	Tuber yield (q/ha)
Conventional Cultivation (Control) (T ₀)	5	32.82	45	35.33	644.45	2401.11	6.25	59.08	216.03
Zero Tillage Potato (T ₁)	2	4.35	12.5	27.57	481.02	1553.82	11.28	125.18	327.42
Raised Bed Potato (T ₂)	5	12.54	42	31.05	492.12	1897.23	9.77	82.45	283.98
SEm±	-	-	-	0.14	0.79	2.81	0.05	0.24	0.16
CD (P=0.05)	-	-	-	1.63	9.01	31.95	0.57	2.72	1.84

From Table 1., significant differences were observed in all the growth parameters of potato *viz.* plant height (cm), leaf area (cm²) and plant cover area (cm²). Conventional cultivation (T₀) of potato resulted in significantly highest plant height (35.33 cm) followed by raised bed potato (31.05 cm) (T₂) and zero tillage potato (T₁) (27.57 cm). This is because the growth and development was more in potato crop sown after tilling the soil as tillage boosted the vegetative development of the crop. [4] also reported that plant height increased with the depth of tillage compared to no-tillage treatment. Similar results were seen in case of leaf area and plant cover area (cm²) where maximum leaf area of 644.45 cm² and plant cover area of 2401.11 cm² was found in conventionally cultivated potato (T₀) which was significantly higher as compared to raised bed potato (T₂) (492.12 cm² leaf area and 1897.23 cm² plant cover area) and zero tillage potato (T₁) (481.02 cm² leaf area and 1553.82 cm² plant cover area). Potato grown under tillage manipulation of soil has resulted in significantly higher values of growth parameters. [9] also recorded higher leaf area of 434.7 cm² in ridge tillage method of potato cultivation as compared to lesser leaf area of 314.2 cm² in case of zero tillage potato in an experiment conducted in Jos Plateau State of Nigeria. In the same experiment, it was also found that the plant cover area was higher in case of all the methods of potato cultivation *viz.* ridge tillage (2818.7 cm²), mound tillage (2147.0 cm²) and flat tillage (4503.3 cm²) in comparison to zero tillage method (1592.0 cm²) as recorded during the 10th week of growth.

Yield attributes *viz.* tubers per plant (No./plant), mean tuber weight (g/tuber/plant) and tuber yield (q/ha) were observed in this trail. The highest mean number of tubers per plant was recorded in Zero tillage method (11.28) followed by raised bed potato cultivation (9.77) and lowest tuber per plant was found in conventional cultivation (6.25). The data recorded on mean tuber weight (g/tuber/plant) showed that the maximum mean tuber weight *i.e.* 125.18g was found in zero tillage practices while minimum in conventional cultivation *i.e.* 59.08g. The tubers under Zero tillage occurred within the layers of paddy straw. Since the tubers harvested from Zero tillage method of cultivation have less moisture content as compare to traditional one for not directly being in contact with soil, thus have better and longer storage quality. Similar finding were also recorded by [3].

The results indicated that highest yield (q/ha) was observed in zero tillage treatment (327.42 q/ha) followed by raised bed potato cultivation (283.98q/ha) and lowest potato yield was observed in conventional cultivation (216.03 q/ha). This is probably because of the fact that the growth parameters recorded were significantly lesser in zero tillage potato as compared to other two methods which indicates that in case of zero tillage method of potato cultivation, less energy was used in the vegetative growth diverting more part of the energy in tuber formation resulting in more yield. The tuber yield under Zero tillage technique increased by 51.56 % as compared to conventional cultivation treatment. Similar results were also showed by [3] and [8].

Table 2: Input details and Economics of potato grown under different methods

Parameters	Conventional Cultivation		Zero Tillage Potato		Raised Bed Potato	
	Input (/ ha)	Cost (Rs/ha)	Input (/ ha)	Cost (Rs/ha)	Input (/ ha)	Cost (Rs/ha)
Manpower (Sowing, Spraying, Interculture operations etc.)	102	30600	85	25500	66	19800
Seed rate (q)	22 q	44000	22 q	44000	22 q	44000
Irrigation	5 times	12500	2 times	9000	5 times	12500
Tillage/ Other machinery use	4	12000	0	0	5	15000
Manure/ Fertiliser	195 Kg DAP, 250 Kg Urea, 200 Kg MOP	13390	110 Kg DAP, 55 Kg	4840	195 Kg DAP, 250 Kg Urea, 200 Kg MOP	13390
Pesticides	Fungicide	1400	Fungicide	1400	Fungicide	1400
Cost of cultivation (Rs/ha)	-	113890	-	84740	-	106090
Gross Return		258900		392904		340776
Net Return		145010		308164		234686
B:C Ratio		1.27		3.63		2.21

Table 2 represents the details of inputs used in different methods of potato cultivation and cost of individual component. The overall economics including cost of cultivation, gross return, net return and B:C ratio for the three different methods in also presented in the same table. From the table, it is observed that the total number of manpower required in machine sown raised bed potato was lowest as no labour was used for field preparation and potato sowing as well. On the other hand, zero tillage potato involved manpower in the spreading of mulch material and in placing seed potatoes at fixed distance over the soil surface. The cost incurred in irrigation was also less in zero tillage as compared to other as explained above. The machinery cost in zero tillage is totally nil as because no machinery was used in zero tillage while in conventional cultivation, there were few rotations of tractors and in case of raised bed planting, machines were involved in field preparation as well in the sowing of potato tubers. Rest of the inputs were more or less similar in all the methods.

All the above mentioned factors resulted in lowest cost of cultivation in zero tillage potato (T_1) (Rs. 84740 per ha) followed by conventional cultivation (T_0) (Rs. 113890 per ha) and raised bed planting (T_2) (Rs. 340776 per ha). The gross return was Rs. 392904 per ha for zero tillage (T_1), Rs 340776 per ha for raised bed planting (T_2) and Rs. 258900 per ha for conventional method (T_0) of potato cultivation. Zero tillage potato (T_1) resulted in highest B:C ratio of 3.63 followed by B:C ratio of 2.21 for raised bed potato (T_2) and lowest B:C ratio of 1.63 was recorded with conventional potato cultivation (T_0). Since, the cost of cultivation involved in zero tillage potato cultivation (T_1) was lowest and the yield obtained was highest (327.42 q/ha), thus this resulted in maximum net return and B:C ratio when compared to the other two methods of potato cultivation.

4. CONCLUSION

In the above experiment conducted, all the growth attributes (plant height, leaf area and plant cover area) recorded were significantly higher in case of conventional cultivation as compared to zero tillage and raised bed planting. However, the yield obtained was significantly higher for zero tillage potato (327.42 q/ha) in comparison to conventional cultivation (216.03 q/ha) and raised bed planting (283.98 q/ha). Thus, it can be concluded that zero tillage method of potato cultivation is better as compared to raised bed planting and conventional potato cultivation both in term of economical and environmental aspect. Economically, maximum B:C ratio of 3.63 is obtained under zero tillage potato and environmentally, it is an option for residue management and emits no harmful gases into the atmosphere due to no machinery use. Also, the benefits of mulching is additional in zero tillage system rendering better soil health in the long run.

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6. FUTURE SCOPE OF STUDY

Climate change is possibly the most intricate and challenging concern in today scenario, thus researches aimed at mitigating the impacts of climate change in a country like India is very important in the present situation and will continue to be so in the future. Thus, development climate resilient technologies for cultivation of potato can be a component of future focus in these type of studies.

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