**Original Research Article**

**MECHANIZATION OF GROUNDNUT CULTIVATION FOR SMALL HOLDER FARMING COMMUNITY**

# Abstract

Groundnut also known as peanut is one of the world’s fifteen leading food crops and cultivated throughout the world. It is consumed in many ways such as vegetable cooking oil, kernels, roasted nuts, salted nuts, milk, butter, cheese, bakery products etc. Groundnut can be cultivated in kharif, rabi and summerseasons. Well drained loose and friable sandy loams and sandy clay loam soils are preferable.Optimum soil temperature for good germination is about 300C.Sowing is the prime operation in cultivation practice of any crop which directly affects production and timely sowing is essential for utilizing available sources of power. Power tiller operated machines may play vital role in groundnut cultivation for small scale farming system as the average holding size is close to 1 ha and more than 86% of India’s farming community are small and marginal farmers. Present efforts were carried out for the development and testing of power tiller operated strip-till multi-crop planter for the mechanization of groundnut cultivation insmall holder farming community.With increasing the level of mechanization by adopting appropriate matching implements for groundnut cultivation in small farming community, the production and productivity could be increased by reducing cost of cultivation and increasing input use efficiency. Efforts are being made to adopt conservation tillage practices with power tiller operated matching implements for small holder farming focusing on groundnutcultivation. The developed planter was tested under three different tillage practices as conventional tillage (CT), strip tillage (ST) and zero tillage (ZT). Three types of rotary blades viz. L-type, J-type and C-type were used in strip-tilling operation. The developed machine was evaluated in terms of field capacity, fuel consumption, draft, seed germination and crop yield. Average groundnut yield in ST was maximum (1.87 t ha-1) followed by CT (1.83 t ha-1) and ZT (1.76 t ha-1). The cost of cultivation was maximum for CT followed by ZT and ST.

**Key words:** Groundnut; Mechanization; Power tiller; Matching implements; Farm operations; Sowing; Conservation tillage; Strip tillage; Zero tillage

**1. Introduction**

Groundnut (*Arachis Hypogaea* L.) is an oilseed crop found throughout the world for its economic and nutritional importance. It is considered to be the poor man’s cashew and has been widely accepted for replacing expensive nuts such as almonds, cashews and pistachio as an urban snack. Groundnut is an important edible oilseed crop. These nuts are used as oil crops and grain legume crops. One can get good cash return and is widely grown in all tropical and subtropical regions of the world for its food value, oil and high protein content. About 80% of the world groundnut production comes from seasonally rain fed areas. Ground nuts are grown during warm season. They need abundant sunshine and warm climate to thrive. The plant requires adequate moistures during its growing seasons and also distinctive dry seasons during pod ripening and maturity. They are adaptable to a wide range of climatic conditions. India occupies second rank in the world, in respect of area (69.52 million ha), production (56.17 Mt.) and productivity (808 kg ha-1) of groundnut. The yield of groundnut has been steadily decreasing for decades as a result of lack of organized breeding program to address production constraints. Disease, insects, and drought are the widespread constraints of groundnut production (Banla *et al*., 2018). Crop dependency has made producers vulnerable to losses because of the lower prices paid for the pods and kernels (Nautiyal, 2002).

Groundnut is largely cultivated in India during *Kharif* season (June to October) under rainfed conditions with low input use and high pressure of insect-pests including weeds leading to low productivity. In *Rabi* season (October to March), the crop is grown on residual moisture with protective irrigation or in riverbed areas. Summer groundnut (Feb-May) grown under assured irrigation is generally practiced with high input application and low pressure of insect-pests attributing to higher productivity. Five states namely Andhra Pradesh, Gujarat, Karnataka, Rajasthan and Tamil Nadu account for about 80% of the total groundnut area and production of the country. Gujarat alone contributes about 35% of the total production of groundnut.

###### One of the important legume crops of tropical and semiarid regions is groundnut, major source of edible oil and protein. Groundnut kernels contain 47-53% oil and 25-36% protein (Sunandini and Devi, 2020; Banla *et al*., 2018; Taru *et al*., 2008). The major producers of groundnut are India, China and USA, which together account for over two-thirds of global output. India ranks first in the production of groundnut among the major edible oilseed crops (Rai *et al*., 2016). Groundnut is a most sensitive crop to moisture stress. Distribution of rainfall plays a greater role than the quantum of rains received during the crop season. Longer dry spell at the time of peg formation/penetration and grain filling is most injurious to both the yield and quality of groundnut. Therefore, protective irrigation at the time of peg formation/ penetration and grain filling has a significant role in yield improvement. Warm and moist conditions are highly congenial for groundnut cultivation. Temperature, light intensity, rainfall and humidity significantly influence the productivity of groundnut. Optimum temperature of 25 - 35°C is required for good germination, flowering and pod formation. Sandy-loam soil rich in organic matter is considered best for the crop.

Mechanization for groundnut cultivation is done for land preparation only and for the rest, traditional methods are followed. Marginal and small land holders are not able to use mechanization leading to poor seed plantation, lack of plant protection and inefficient post harvesting methods. Kumar and Karmakar (2024) studied the performance of various power tiller operated matching implements for different farm operations in conservation agriculture for various crops.

Awadhwal and Babu (1994) developed a multi-row bullock drawn planter and tested for sowing groundnut and dryland corps. Results showed that the planter performed very well in sowing groundnut, chickpea, pigeon-pea and sorghum. The field efficiency of the planter was 0.33 ha h-1 and draft requirement varied from 70-80 kg.

Padmanathan *et al*. (2006) developed a groundnut combine harvester and tested in the field. Results showed that the maximum harvesting efficiency was 92.3%, threshing efficiency 82.3%, cleaning efficiency 72.3% and minimum percentage of broken pods was 4.43%. The operation of groundnut combine harvester resulted in 39 and 96% saving in cost and time respectively, when compared to conventional method of manual digging and stripping. Optimum plant density is among the critical crop management practices for obtaining a high groundnut yield and profitable economic returns (Howlader *et al*., 2009; Minh *et al*., 2021).

Laxman *et al*. (2018) developed tractor drawn aqua planter for groundnut and performance evaluation was carried out. Results showed that the field capacity of the planter was 0.145 ha h-1 with field efficiency 88.9% at 2.72 km h-1 forward speed. Seed rates for the groundnut was 105.47, 108.46, 118.55 kg ha-1 with vertical, inclined and horizontal plate seed metering mechanisms, respectively.

Anitha *et al*. (2022) conducted an experiment to evaluate the performance of mini tractor-mounted sensor-based groundnut aqua planter developed for low moisture content soil. The dropped seed from the metering mechanism of planter can be detected by an infrared sensor and activate the solenoid valve to discharge water close to the dropped seed. This increases the moisture content of soil and sustainability of seed for germination. The water can be applied along with the seed at the targeted location which helps the farmers to plant the crop even under low rainfall conditions.

Verma *et al*. (2024) studied the mechanization level for groundnut cultivation in Junagadh district of Gujarat. They found that the farmers are using different types of farm machinery for various agricultural operations of groundnut cultivation. Mean mechanical energy for different operations such as seedbed preparations, sowing, interculturing, plant protection, harvesting and threshing were found to be 4419.5, 1543.20, 348.49, 131.98, 1072.33 and 658.62 MJ ha-1 respectively. The survey represented that the mean farm power was 45.05 hp and farm mechanization level was 13.92 hp ha-1.

###### **2. Materials and Methods**

**2.1 Development of strip-till multi-crop planter**

Power tiller operated strip-till multi-crop planter was developed which consists of furrow opener, seed and fertilizer boxes, seed metering mechanisms, seed and fertilizer tubes, ground drive wheel, furrow covering unit, strip-tilling unit, chain & sprockets, set of bevel gears etc. The power tiller VST Shakti 130DI was used as the prime mover.

**2.2 Performance evaluation of the developed multi-crop planter**

The performance of the developed strip-till multi-crop planter was evaluated in the laboratory as well as in the field with groundnut of variety TAG 24.

**2.2.1 Experimental site**

Field investigations were carried out during the cropping season of 2022-23 at Instructional Farm of Bidhan Chandra Krishi Viswavidyalaya (BCKV), Nadia, West Bengal, India. The research work was a part of the PhD research project named “Power Tiller Operated Strip-till Multi-crop Planter for Conservation Agriculture”. The homogeneous soil of the field was sandy clay loam type. The design of experiment was split plot with three replications and the whole experiments were carried out in accordance to the design. The crop was cultivated according to three different tillage methods viz. conventional tillage (CT), strip tillage (ST) and zero tillage (ZT).

**2.2.2 Experimental details**

The entire field of area 26 x 62 m2 was divided equally into three main plots of 8 x 62 m2 area comprising of 3 different tillage practices as conventional tillage (CT), strip tillage (ST) and zero tillage (ZT). The groundnut (TAG 24) was sown in pre-Kharif or summer season. For field preparation, various tractor drawn tillage implements were used in CT and ST whereas no tillage was done in case of ZT. The crop was sown with the developed power tiller operated strip-till multi-crop planter.

**2.2.3 Crop establishment technique**

The developed power tiller operated strip-till multi-crop planter was used for sowing of groundnut in CT and ZT without strip tilling and in ST with strip tilling. The VST Shakti 130DI was selected as the matching prime mover for the development of strip-till multi-crop planter. The row to row and plant to plant spacing were 40 cm and 15 cm. Inclined plate type seed metering mechanism was used to maintain seed to seed spacing of the crop. The metering plates were designed on the basis of engineering properties of groundnut (TAG 24) seeds. Separate seed boxes were used for rows and row to row spacing was adjustable. The number of rows of the power tiller operated multi-crop planter for groundnut was 3.

 The multi-crop planter was calibrated before sowing operation in the field. The inclined type seed metering plates with cells made on the periphery of the circular plates was used for groundnut seeds. The seed rate was found as 80 kg ha-1.

 The recommended dose of fertilizer (RDF, kg ha-1) was (N:P2O5:K2O) 40:60:40 for groundnut. Urea (46 % N), Di-ammonium Phosphate (DAP) (18 % N and 46 % P2O5) and Muriate of Potash (MOP) (60 % K2O) were used to apply to meet N:P2O5:K2O dose. The amount of nitrogen (N) was calculated from Urea (46 % N) and DAP (18 % N) to meet out required dose. The amount of P2O5 and K2O were calculated from DAP (46 % P2O5) and MOP (60 % K2O) respectively to meet out the required dose.

**3. Results and discussion**

The performance of the developed power tiller operated strip-till multi-crop planter was evaluated in both laboratory and field conditions with groundnut (TAG 24) seeds.The machine was calibrated five times with a fixed number of revolutions of ground drive wheel (5, 10, 15, 20, and 25). The average seed rate was found to be 79.19 kg ha-1.

The sand bed method was used to evaluate the performance of the machine in the laboratory. The average seed to seed spacing, number of multiples, missing hills and visible damage were found as 15.62 cm, 4.0%, 3.33% and 2.67%, respectively.

The field performance of the developed planter was undertaken in terms of field capacity, draft, fuel consumption, seed germination and crop yields.

**3.1 Effective field capacity**

The average EFC at 1.5 km h-1 forward speed for groundnut sowing was 0.107 ha h-1. And when forward speed increased to 2.5 km h-1, the average EFC increased to 0.174 ha h-1 as shown in **Fig. 1(a)**. The percent increase in EFC from 1.5 km h-1 to 2.5 km h-1 forward speed was 62.62%. With the increase in operating depth, the average EFC was decreased for all rotary blades as illustrated in **Fig. 1(b)**.

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| --- | --- |
| (a) | (b) |

**Fig. 1** Effective field capacity at different forward speed and operating depth for different rotary blades

**3.2 Fuel consumption**

It was observed that the fuel consumption decreases with increase in forward speed of the machine for all types of rotary blades used in strip-tilling. The fuel consumption at 1.5 km h-1 forward speed were 11.95, 12.41 and 12.66 L ha-1 for L-type, J-type and C-type rotary blades, respectively. With increase in forward speed to 2.5 km h-1, the fuel consumptions were 10.95, 11.47 and 11.59 L ha-1 for L-type, J-type and C-type rotary blades, respectively as shown in **Fig. 2(a)**. The average fuel consumption at 1.5 km h-1 forward speed was 12.85 L ha-1. With increase in forward speed to 2.5 km h-1, the average fuel consumption decreased to 11.36 L ha-1. The percentage decrease in fuel consumption with increase in forward speed from 1.5 to 2.5 km h-1 was 11.6%. It was observed that with increase in operating depth from 4 to 6 cm, the average fuel consumption was increased for all types of rotary blades as illustrated in **Fig. 2(b)**.

**3.3 Wheel slip**

It was observed that the average slip percentage of power tiller wheel was 8.95±2.41% in groundnut cultivation. The slip percentage was decreased with increase in forward speed as shown in **Fig. 3(a)**. The average slips at 1.5 km h-1 forward speed was 9.78% for groundnut sowing. At 2.5 km h-1 forward speed, the average slip percentage was 7.73%. When the forward speed increased from 1.5 km h-1 to 2.5 km h-1, the slip percentage was decreased by 20.91%. It was found that there is no any perfect relationship between the slip percentage of power tiller wheel and operating depth of strip tilling operation as illustrated in **Fig. 3(b)**. However, the slip percentage at 4 cm operating depth was 8.97%. At 6cm operating depth, the slip percentage was 9.82%. It was seen that the maximum slip percentage was for L-type rotary blade. The slip percentage for L-type blade was 10.68%. The minimum slip percentage was 6.80% for C-type blade.

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| (a) | (b) |

**Fig. 2** Fuel consumption of the machine at different forward speed and operating depth for different rotary blades

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| --- | --- |
| (a) | (b) |

**Fig. 3** Slip at different forward speed and operating depth for different rotary blades

**3.4 Draft**

The draft of the machine was increased with increase in operating depth and forward speed for all types of rotary blades as illustrated in **Fig. 4**. The drafts at 1.5 km h-1 forward speed were 148, 145 and 143N for L-type, J-type and C-type rotary blades, respectively. With increase in forward speed to 2.5 km h-1, the drafts were 202, 248 and 207 N for L-type, J-type and C-type rotary blades, respectively. With increase in operating depth from 4 cm to 6 cm, the draft increases for all types of rotary blades used. The maximum draft (302 N) was found at 6 cm operating depth for J-type rotary blade and minimum draft (113 N) was found at 4 cm operating depth for L-type rotary blade.

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| --- | --- |
| (a) | (b) |

**Fig. 4** Draft of the machine at different forward speed and operating depth for different rotary blades

**3.5 Germination of seeds**

The average germination of groundnut seeds was observed for strip tillage operation with different input parameters (**Fig. 5**). It was observed that the average seed germinations of groundnut were 84.41±2.35, 83.33±3.05 and 82.64±1.86%, respectively for L-type, J-type and C-type rotary blade tilled plots.

It was seen from the **Fig. 5** that with increase in forward speed from 1.5 km h-1 to 2.5 km h-1, the seed germination was slightly decreased for all rotary blades. With increase in operating depth from 4 cm to 6 cm, the seed germination was slightly decreased for L-type and C-type blades but for J-type rotary blade it was slightly increased.

**3.6 Yield of groundnut**

The average yield variation of groundnut under strip tillage (ST) plots with forward speeds and operating depths are presented in **Fig. 6**. It was observed from the **Fig. 6(a)** that the groundnut yield decreased with increase in forward speed from 1.5 to 2.5 km h-1. The average pod yield of groundnut was maximum (2082 kg ha-1) under strip tilled plot operated by J-type rotary blade at 1.5 km h-1 forward speed and minimum (1700 kg ha-1) operated by J-type rotary blade at 2.5 km h-1 forward speed.

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| --- | --- |
| (a) | (b) |

**Fig. 5** Seed germination at different forward speed and operating depth for three types of rotary blades

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| --- | --- |
| (a) | (b) |

**Fig. 6** Groundnut yield variation with (a) forward speed and (b) operating depth for different rotary blades

From the **Fig. 6(b),** it has been seen that the average pod yield of groundnut was maximum (1946 kg ha-1) under strip tilled plot operated by L-type rotary blade at 4 cm operating depth and minimum (1764 kg ha-1) operated by C-type rotary blade at 6 cm operating depth.

|  |  |
| --- | --- |
| (a) | (b) |

(c)

**Fig. 7** Groundnut yield variation of strip tilled plot with (a) forward speed (b) operating depth and (c) type of rotary blade and comparison with yield under zero tillage and conventional tillage

The average yield of groundnut pod under strip tillage operation for various input parameters and the yield under conventional tillage and zero tillage are presented in **Fig. 7**. It has been seen from the **Fig.7(a)**, the average groundnut yield of all the strip tilled plots operated at 1.5 km h-1 forward speed was maximum (2034 kg ha-1) followed by conventional tillage plots (1842 kg ha-1) and zero tilled plot (1726 kg ha-1).

From the **Fig. 7(b)**, it was observed that the average groundnut yield of all the strip tilled plots operated at 5 cm operating depth was maximum (1903 kg ha-1) followed by 4 cm (1865 kg ha-1) and 6 cm (1831 kg ha-1) operating depth.

Similarly, from the **Fig. 7(c)**, it was seen that the average groundnut yield of all the strip tilled plots operated by L-type and J-type rotary blades at different forward speeds and operating depths was maximum (1891 kg ha-1) followed by C-type (1818 kg ha-1) rotary blade.

**3.7 Cost of production for groundnut**

From the **Fig. 8**, it has been seen that the cultivation cost of groundnut was maximum under CT (100192 INR ha-1) followed by ZT (89623 INR ha-1) and ST (87339 INR ha-1). The gross return and net return were found as maximum for ST followed by CT and ZT. The B:C ratio were observed as 1.61, 1.35 and 1.24 for ST, ZT and CT respectively (**Table 1**).

**Fig. 8** Cost of cultivation and returns under different tillage practices for groundnut

**Table 1** Cost of cultivation and returns under different tillage practices

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| --- | --- | --- | --- | --- | --- |
| **Crop** | **Tillage** | **Cost of cultivation, INR ha-1** | **Gross return, INR ha-1** | **Net return, INR ha-1** | **B:C ratio** |
| Groundnut(TAG 24) | ST | 87338.93 | 227562.11 | 140223.18 | 1.61 |
| ZT | 89622.57 | 210439.23 | 120816.66 | 1.35 |
| CT | 100192.04 | 224582.31 | 124390.27 | 1.24 |

**4. Conclusions:**

Sowing of seeds is a very crucial and time bound farm operation for better crop production and productivity. With the considerations of small and marginal farm holders, and the advantages of strip tillage (ST) over conventional tillage (CT) and zero tillage (ZT), the present work was carried out to develop a power tiller operated strip-till multi-crop planter for conservation agriculture. Conventional tillage requires large amount of energy as well as high operating cost. The operating time from tillage to sowing is also high in CT as compared to combined tillage and ZT. The loss of natural resources from CT could be minimized with the adoption of reduced tillage or combined tillage. The study shows that power tiller operated strip-till multi-crop planter can be used effectively to compensate conventional and zero tillage practices especially for small and marginal farm holdings.

**Disclaimer (Artificial Intelligence)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (Chat GPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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