Int.J.Curr.Res.Aca.Rev.2024; 12(5): 1-6

International Journal of Current Research and Academic Review

ISSN: 2347-3215 (Online) Volume 12 Number 5 (May-2024)

Journal homepage: http://www.ijcrar.com

doi: https://doi.org/10.20546/ijcrar.2024.1205.001

Development and Analysis of Reciprocating Seed Metering Mechanism for Groundnut

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Abstract

Precision agriculture is the application of technologies and principles to manage spatial and temporal variability associated with all aspects of agricultural production for the purpose of improving crop performance and environmental quality. Success in precision agriculture is related to how well it can be applied to assess, manage, and evaluate the space-time continuum in crop production. This theme is used here to assess the manual capabilities in precision agriculture. The cam mechanized system in the machine helps in proper metering of seeds and thus further reduces the losses. The precision planters of different crops is progressing in the country, however we are preparing a new mechanism for groundnut. The physical properties of groundnut were found by using the vernier calliper and electrical balance. The measured properties are length, width, thickness, sphericity, bulk density etc and its values are 13.4 cm, 8.02 cm, 8.14 cm and 0.69, 686.671 kg/m^3 respectively. Based on physical dimensions of groundnut, the metering plate was made up of wood in a rectangular shape with a length of 8cm, thickness of 1.5 cm and width 5 cm. The metering plate has drilled holes with a diameter of 1.5 cm. The metering shaft was made up of stainless steel with the thickness of 0.5cm and length of 22 cm which was drilled to the metering plate. Attach the spring to the metering shaft with a voucher of 0.5 cm diameters. The seed metering machine have a metallic frame of 52 cm×35 cm attached to the ground wheel of diameter 39 cm with a shaft of 1.5 cm thickness having a cam connected to the shaft will push the metering shaft which were having a spring and drilled to the metering plate which was made up of wood. The Metering plate will move in a metering box by the action of cam. The cam will move by the rotation of ground wheels and that wheels will move by a manually operated. However, a missing index of 10% was noted, suggesting room for improvement in seed distribution consistency. Overall, groundnut seed damage amounted to 14% of its total weight, slightly higher than in comparable mechanisms. The size of groundnut seeds notably influenced this damage.

Article Info

Received: 10 March 2024
Accepted: 18 April 2024
Available Online: 20 May 2024

Keywords

Seed Metering Mechanism, Multiple Index, Missing index, Vernier Calliper, cell dimensions.

Introduction

India is one of the leading countries in groundnut production globally, standing second only to China, which contributes 34 percent to the world's groundnut output. In 2021, India accounted for approximately 19 percent of the global groundnut production. Nigeria holds the third position, contributing 9 percent to the world groundnut production, according to data from indiastat.com. According to the National Agricultural Cooperative Marketing Federation (NAFED), Gujarat leads in groundnut production, contributing 36 percent of the total, followed by Rajasthan at 17 percent and Tamil Nadu at 7.5 percent. Andhra Pradesh contributes 5.13 percent, and Telangana contributes 3.23 percent to the total groundnut production.

In Andhra Pradesh, groundnut production occupies 82.3 percent of the total oilseed acreage and 18.7 percent of the production. However, there is a shift among farmers towards oil palm cultivation due to incentives provided by the state government, such as announcing remunerative prices. Consequently, in 2021-22, oil palm production contributed 79 percent to the total oilseeds production, resulting in a decreased share of groundnut in total oilseeds production. In terms of total oilseeds, groundnut covers 18 percent of the area and contributes 26.8 percent to the production in India.

Groundnut sowing is a critical aspect of groundnut cultivation. Typically, seeds are planted approximately 5 cm deep using either a country seed drill or sown behind a country plough. Another method involves dibbling seeds, maintaining a spacing of 60 cm between rows and 10 cm between plants for spreading types, while for bunch types, the spacing is adjusted to 45 cm x 10 cm. This approach not only helps conserve seeds but also boosts yields by ensuring sufficient space for optimal plant growth and development. Mechanized sowing plays a significant role in groundnut farming. The selection of a suitable metering system is crucial for efficient groundnut planting. Various types of planters and seed drills have been developed to facilitate mechanized sowing. However, the choice of metering system remains an important consideration in the advancement of groundnut planting. Various types of planters and seed drills have been developed, but the problem still persists, like the missing of seeds, over filling, etc. Planters can give different types of distribution and precision pattern, depending on the machine that is being used (Abdalla, 2007). Some researchers have worked on row planters (Ashoka *et al.,* 2012) the twin or two-row groundnut planter and the 48-row planter by John Deere (Koley, *et al.,* 2017). As our population continues to increase, it is necessary that we must produce more food, but this can only be achieved through some level of mechanization. It is therefore necessary to develop a low-cost planter that will reduce drudgery and enable small holder farmer to produce more foods (Sedara *et al.,* 2020).

Sukhbir S and Sharma (2004) compared the performance of traditional methods of sunflower sowing i.e. Dribbling on ridges, kera and broadcasting with manual planter. Statistical analysis showed significantly higher grain yie1d under manual planter as compared to Korea and broadcasting. Ghosal and Pradhan (2013) developed a low cost manually operated multi crop seed drill with cup feed metering mechanism for small and marginal farmers. The actual field capacity and field efficiency of the seed drill were 0.063 ha/h and 78.75 % respectively. Cao Cheng Mao *et al.,* (2014) designed a multi-line metering device for seeding of wheat and rice with ring groove push movement. The working principle of the multi- line metering device and force on dropping seed were analysed, and the theoretical maximum speed of the metering plate was investigated. The experimental results showed that a linear increase was observed with increasing rotation speed. Performance evaluation were done based on five parameters viz., average spacing, multiple index, missing index quality feed index and seed rate were determined (Kachman and Smith, 1995). Separation efficiencies of different grader and overall grading efficiency vary based on different feed trough angles with different RPM (Kumar *et al.,* 2018).

The present study was aimed at developing and optimizing parameters for a low-cost groundnut planter's seed metering mechanism. Additionally, the study sought to create a test rig for evaluating the planter's performance under laboratory conditions.

Materials and Methods

Physical characteristics of groundnut seeds like length (L), width (W), thickness (T) and sphericity were analysed by using the standard method which was helpful to design the seed collecting cell in the metering mechanism. The mass of 200 groundnut seeds where randomly selected groundnut seeds were weighted by using the electronic balance with a least count of 0. (fig. 1). This information was crucial for calculating the bulk density of groundnut seeds, following standard procedures. The bulk density calculation aided in designing an appropriate seed storage area within the test rig.

Development of seed metering mechanism

On the basis of physical dimensions of groundnut, the metering plate is made up of wood in a rectangular shape with a length of 8 cm, thickness of 1.5 cm and width 5 cm. The metering plate has drilled holes with a diameter of 1.5 cm. The metering shaft is made up of stainless steel with of 0.5 cm diameter and length of 22 cm which was drilled in the metering plate as shown in Fig.2.

Attach the spring to the metering shaft with a stopper as shown in Fig.3. Metering box is made of metal sheet of 3mm thickness having dimensions 12.5 cm x 5.5 cm x 1.8 cm. This box type structure made beneath the seed hopper and both sides of the box were open. Metering box acts like a frame, and the reciprocating motion of the plate was enabled inside the box. Seed hopper is made up of metal sheet having a height of 15cm, top opening of 12 cm x 8.5 cm and bottom opening was 3cm x 3cm. Cam is made up of iron having a base circle diameter of 3 cm and limit circle was 5.5 cm. A hole of 0.65cm radius was drilled on cam for fixing on the wheel shaft and vertical distance of 5.5cm as shown in Fig.4.

Working of seed metering mechanism

The seed metering mechanism has a metallic frame of 52 cm×35 cm attached to the ground wheel of diameter 39 cm (fig.4). A cam is fixed on wheel shaft of 1.5 cm diameter to push the metering shaft which is having a spring loaded and it is connected to a metering plate.

Two holes are drilled throughout in the metering plate which made up of wood to collect the groundnut from the store and deliver to the dropping point. Metering plate will have a reciprocating motion inside the covering box by action on cam. The covering box has one opening at the down side of the hopper for collecting the seeds when it matches with the holes on metering plate. Another opening is away from the hopper which will help to drop down the collected seed tubes in the reverse movement of metering plate. The cam will work by the rotation of a shaft connected to the ground wheels and that wheels will move by a manual pulling. It will push the spring-loaded metering shaft and the connected metering plate attain a forward movement. After that a backward movement of metering plate where attain by the effect of spring on the shaft when the cam released. The holes in the metering plate will move at a distance of 2.5 cm distance inside the cover plate and drop the seeds from the collecting point. The metering plate was placed inside the covering box, and it has reciprocating movement based on the cam rotation. So, the groundnut will collect in the holes in the metering plate from the hopper during its forward movement. The collected seeds in the holes of metering plate will drop the in the reverse movement of metering plate.

For the evaluation of the developed metering mechanism, several parameters were considered (Kachman and Smith, 1995):

Mean Spacing

This parameter measures the average distance between individual seeds in the planted rows. It gives an indication of the uniformity of seed spacing, which is crucial for optimal plant growth and yield.

$$X = \sum x / N \quad \text{--------- (1)}$$

Where,

X = Mean spacing of the seed, cm

$\sum x$ = Sum of the number of observations

N = total number of observations

Multiple Index

The multiple index assesses the occurrence of multiple seeds being dropped at the same position along the planting row. Otherwise, it is the total number of spacing, which are less than 0.5 times theoretical spacing. This parameter helps ensure proper seed distribution and prevents overcrowding, which can negatively impact plant growth.

$$MI = \frac{\psi}{N} \times 100 \quad \text{--------(2)}$$

Where,

MI = Multiple index, %.

ψ = Total number of observations with spacing, which are less than 0.5 times theoretical spacing,

Missing Index

The missing index indicates the frequency of gaps or missing seeds along the planting row. It is the total number of observations with spacing more than 1.5 times theoretical spacing. High value of miss index is mainly due to the failure of seed picking system or, due to lack of positive release of the seeds. High values of the missing index suggest inadequate seed placement, which can lead to uneven plant emergence and reduced yield potential.

$$Ms.I = \frac{\xi}{N} \times 100$$ ----------(3)

Where,

ξ = the total number of observations with spacing more than 1.5 times theoretical spacing,

Quality of Feed Index

This parameter evaluates the overall quality of seed placement by considering factors such as uniformity, accuracy, and consistency in seed spacing. It is the number of observations, which are 0.5 to 1.5 times theoretical spacing. A higher quality of feed index indicates better seed distribution and placement accuracy.

$$QI = \frac{\tau}{N} \times 100$$ ------(4)

Where,

QI = Quality of feed Index, %,

τ = Number of observations, which are 0.5 to 1.5 times theoretical spacing

Damage of Seeds

The evaluation also includes assessing the extent of seed damage during the planting process. Damage to seeds can affect germination rates and overall plant health, ultimately impacting yield potential.

By considering these parameters during laboratory evaluation, it is possible to assess the performance and effectiveness of the developed metering mechanism in accurately and efficiently planting groundnut seeds while minimizing seed damage and ensuring optimal plant spacing and distribution.

Results and Discussion

Groundnut physical characteristics were measured and recorded, showing an average length of 13.4 mm, major diameter of 8.02 mm, and minor diameter of 8.14 mm.

A weight of 200 seeds registered at 112.8 g, with an average sphericity of 0.69 and a calculated bulk density of 0.686 g/cc. Subsequently, the developed metering mechanism underwent testing in the laboratory using the sand bed method. The hopper was filled with groundnut seeds, and the machine was manually pulled through the sand bed. Readings such as seed spacing, number of seeds dropped, seed losses in the bed, and damages were recorded after each pass and subjected to analysis. The sand bed experiment demonstrated that the mechanism effectively maintained proper spacing throughout testing. The metering shaft pushed the seed-filled metering plate, traveling a distance of 2.5 cm before each release. The machine achieved an average spacing of 120 mm, indicating successful performance. A quality of feed index of 68% further affirmed the mechanism's effectiveness. However, a missing index of 10% was noted, suggesting room for improvement in seed distribution consistency.

The metering unit was designed for two seeds per hill, but an 8% occurrence of multiple indexes was observed during testing, indicating occasional double seeding. Overall, groundnut seed damage amounted to 14% of its total weight, slightly higher than in comparable mechanisms. The size of groundnut seeds notably influenced this damage. The reciprocating motion of the metering plate caused partial seeds to be crushed within the cell, particularly between the hopper and cell walls. Therefore, it's crucial to carefully select seed sizes that match the cell dimensions when utilizing this reciprocating mechanism to minimize damage.

Figure.1 Measuring the physical characteristics of groundnut seeds

Figure.2 Metering plate with holes

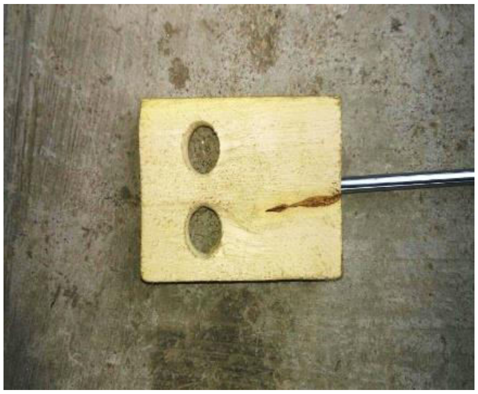

Figure.3 Spring loaded Metring Shaft

Figure.4 Development of seed metering mechanism

Figure.5 Developed test rig for the analysis of reciprocating seed metering mechanism for groundnut

Conclusion

The laboratory experiment titled "Development of a Seed Metering Mechanism for Groundnut" was conducted on a sand bed to assess the operational aspects of a machine and to determine the physical properties of groundnut varieties, including Kadhiri-3. The experiment aimed to design a seed planter mechanism utilizing a cam system. The results revealed the physical characteristics of groundnuts, such as average dimensions (length, width, thickness, and sphericity), as well as a bulk density of 0.686 g/cc. Based on these dimensions, a wooden metering plate with drilled holes of 1.5 cm diameter was constructed. The metering box, made of metal sheet, measured 1.8 cm in thickness, 12.5 cm in length, and 5.5 cm in width.

The seed hopper, also constructed from metal sheet, had dimensions of 15 cm (height), 8.5 cm (width), with top and bottom openings of 12 cm and 3 cm x 3 cm respectively. The cam, made of iron, had a diameter of 4.1 cm, a hole with a radius of 0.65 cm, and a vertical distance of 5.5 cm. Operational parameters included a mean spacing of 18.9 cm and seed damage accounting for 14% of the total seed weight. Quality indices for seed, including missing and multiple indexes, were recorded at 68%, 10%, and 8% respectively.

The current investigation shed light on the advantages and disadvantages of this particular metering mechanism, with the aim of exploring its potential for future applications. It became evident that the mechanism requires further enhancements to mitigate issues such as damage, missing and multiple indexes. There is a clear need for an improved version that boasts simplified components at a lower cost, which would prove particularly beneficial for groundnut farmers.

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How to cite this article:

Edwin Benjamin, Aminul Islam, G. Khaleel, K. Hem Chand and Venkateswararao, M.. 2024. Development and Analysis of Reciprocating Seed Metering Mechanism for Groundnut. *Int.J.Curr.Res.Aca.Rev.* 12(5), 1-6.
doi: https://doi.org/10.20546/ijcrar.2024.1205.001