Agri Articles

(e-Magazine for Agricultural Articles)

Volume: 03, Issue: 03 (MAY-JUNE, 2023)

Available online at http://www.agriarticles.com

©Agri Articles, ISSN: 2582-9882

Smart Seeding Technology: Revolutionizing Agriculture with Precision and Efficiency

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Abstract

Smart seeding technology in agriculture offers an intelligent and data-driven approach to seed placement and crop yield optimization. By integrating sensor technology, data analysis, variable rate technology, and precision planting equipment, this technology enhances precision, efficiency, and resource utilization. Real-time data collected from sensors, such as soil moisture and weather sensors, informs decision-making processes through advanced algorithms and machine learning techniques. Variable rate technology allows for customized seeding rates based on field conditions, optimizing plant population and minimizing waste. Precision planting equipment ensures accurate seed placement and uniform spacing, contributing to improved crop yield and quality. Smart seeding technology also promotes healthier soil and reduces environmental impacts by minimizing chemical inputs and soil erosion. Additionally, it saves time and labour through automation. The applications of smart seeding technology span various agricultural sectors, including row crops, specialty crops, and conservation agriculture. Overall, smart seeding technology holds promise in revolutionizing modern agriculture and meeting the challenges of food production.

Introduction

The global population is rapidly growing, and the demand for food production is increasing. To meet this growing demand, farmers need advanced technologies that enhance and sustain agricultural production. Low productivity, poor quality, high cost, utilization of resources and adverse environmental are limitations in traditional seeding systems. Advanced technologies in agriculture includes automation, robotics, information services, and intelligence that combines information and communication technologies (ICT), robotics, artificial intelligence (AI), big data, and the internet of things. One such technology is smart seeding, which leverages precision and efficiency to optimize seed placement, seedling development, and crop yield. This article aims to explore the concept of smart seeding technology, its components, and the potential benefits it offers to modern agriculture.

Definition and Components of Smart Seeding Technology

Smart seeding technology refers to an intelligent and data-driven approach to planting seeds in agricultural fields. It encompasses a range of interconnected components that work together to enhance precision and efficiency:

a. Sensor Technology: Smart seeding systems utilize various sensors such as GPS, soil moisture sensors, weather sensors, and imaging devices to gather real-time data on soil conditions, weather patterns, and crop health. This data serves as the foundation for informed decision-making.

b. Data Analysis and Decision-Making: Advanced algorithms and machine learning techniques analyze the data collected by sensors. These algorithms consider multiple factors such as soil type, moisture levels, temperature, and plant growth patterns to optimize seed placement, spacing, and timing.
c. Variable Rate Technology (VRT): VRT allows farmers to adjust the seeding rate according to specific field conditions and requirements. By customizing the seed rate, farmers can ensure optimum plant population, minimize wastage, and maximize yield potential.
d. Precision Planting Equipment: Smart seeding systems integrate with precision planters that utilize technologies such as automated seed meters, singulation systems, and pneumatic downforce control to ensure accurate seed placement, uniform spacing, and proper seed-to-soil contact.

Benefits of Smart Seeding Technology

Smart seeding technology offers numerous benefits that can revolutionize modern agriculture:
a. Improved Yield and Crop Quality: By optimizing seed placement and population density, smart seeding technology enables farmers to achieve higher crop yields and enhanced crop quality. Precise seed placement helps reduce competition among plants, resulting in better access to nutrients, water, and sunlight.
b. Resource Optimization: Smart seeding technology minimizes input waste by precisely allocating seeds and fertilizers where they are needed most. This leads to a more efficient use of resources, reducing costs and environmental impacts.
c. Enhanced Soil Health: By considering soil conditions and tailoring seed placement accordingly, smart seeding technology promotes healthier root development and reduces soil erosion. This improves soil structure, nutrient uptake, and overall soil health.
d. Reduced Environmental Impact: Smart seeding technology promotes sustainable agriculture practices by reducing the need for excessive chemical inputs. By optimizing seed placement and timing, farmers can minimize pesticide and fertilizer usage, resulting in reduced environmental contamination.
e. Time and Labour Savings: Automated processes and precise seed placement offered by smart seeding technology reduce the need for manual labour, saving time and effort for farmers. This allows them to focus on other critical farm operations.

Applications of Smart seeding technology

Smart seeding technology is being actively employed in various agricultural sectors:
a. Row Crops: Corn, soybeans, cotton, and other row crops greatly benefit from smart seeding technology. By optimizing seed placement, spacing, and timing, farmers can achieve better stand establishment and uniform crop growth.
b. Specialty Crops: High-value crops such as fruits, vegetables, and ornamental plants can benefit from precise seed placement and customized seeding rates. This technology helps optimize yield, quality, and uniformity in specialty crop production.
c. Conservation Agriculture: Smart seeding technology aligns with the principles of conservation agriculture by promoting minimum soil disturbance, permanent soil cover, and diverse crop rotations. It enables farmers to adopt sustainable practices while maintaining or improving crop productivity.

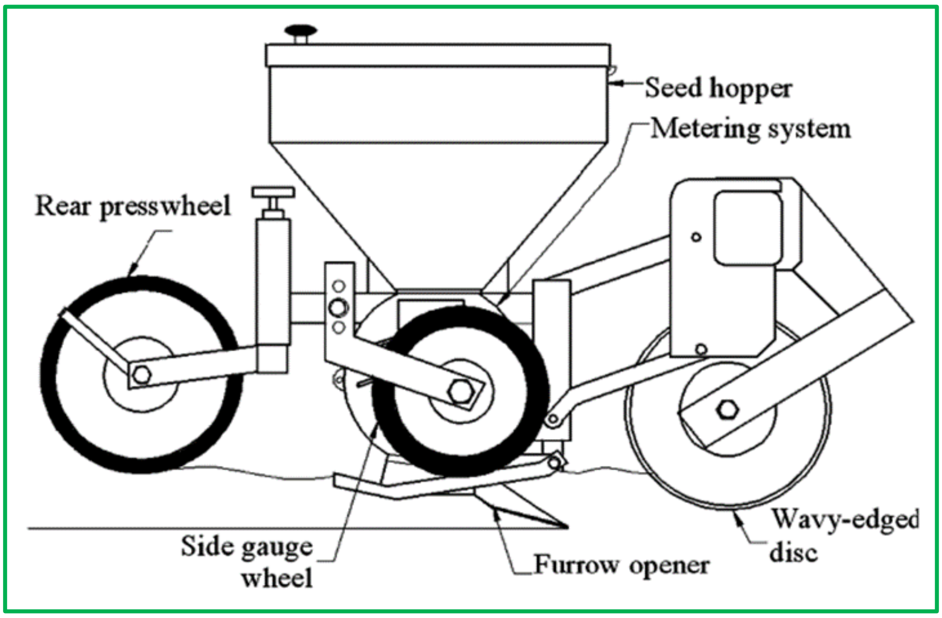
Examples of smart seeders

Mechanized seeding of plug trays and sowing of the seedlings: (Gaikwad and Sirohi 2008)
The most labor-intensive step in planting a plug tray is placing a single seed in each cell. It takes around eight men eight hours to sow 100 plug trays and raise 9800 seedlings. The majority of vegetable nurseries can only produce so much because of this. This issue is

resolved by automated seeders. A vacuum nozzle seeder has been created by researchers for the mechanical sowing of large fruit, vegetable and rootstock seeds. A 50–100 plug-tray/h capacity tray-type vacuum seeder and dibber for small vegetable nursery growers. Gaikwad and Sirohi in 2008 have developed a low-cost pneumatic tomato seeder with an output capacity of 38,800 cells per hour and a potential of 60,000 cells per hour for plug trays with 2412 cells. At the time, the precision plug seeder's entire anticipated cost was 22000 rupees. The seeder was able to increase vegetable nurseries' productivity while reducing labour expenditures. Another crucial factor was that the seeder could be produced locally for a lot less money than seeders that were imported. It could also be modified to work with various seeds by altering the suction pressure and nozzle size.

Precision Plug seeder (Gaikwad and Sirohi 2008)

Mechanized Seedling transplanting: An efficient planting technique frequently used in vegetable production to encourage crop growth and boost vegetable yield is plug seedling for transfer. But plug seedling transplantation is a labor-intensive, inefficient process that heavily relies on manual labour. For bare-root seedlings and plugs, tractor-mounted semi-automatic vegetable transplanters have been created as a solution to this issue. Depending on the plant to plant spacing and operator expertise, Manes et al. (2010) created a tractor-operated vegetable transplanter suited for tomato seedlings and recorded just 2-3 percent lost plants while working at a pace of 0.8-1 km/h. For tomato seedlings in paper pots, researchers also created a walk-behind hand-powered vegetable transplanter that moves at an average forward speed of 0.9 km/h. There are some shortcomings in the traditional transplanting such as low productivity, poor quality, high cost and also sometimes farmers face problems to raise tomato seedlings in time due to adverse environmental conditions. This technique has the potential to use in adverse condition and ultimately facilitates the production of vegetable seedlings in time with low cost, high productivity and good quality seedlings.



The modified precision vacuum seeder for no-till sowing (Karayel 2009)

No-till seeders or precision maize planters: Giannini *et al*. (1967) published a thorough discussion of the need for precision sowing and discussed the development of a very successful precision seeder that used vacuum principles for singulation. Compared with the standard bulk metering seeder, this vacuum seeder used 90% less seed, thus reducing thinning time and resulting in improved yields.

a. Kinze 3500 series b. Kuhn MAXIMA2 series c. DEBONT 2605

No-till precision planters (Source: Li *et al*., 2016)

Conclusion

Smart seeding technology represents a significant advancement in agriculture, harnessing precision and efficiency to optimize seed placement, seedling development, and crop yield. By leveraging real-time data, advanced algorithms, and precision planting equipment, this technology offers substantial benefits such as improved yield, resource optimization, enhanced soil health, reduced environmental impact, and time savings. As smart seeding continues to evolve, it holds great promise in transforming agriculture and meeting the challenges of food production in the 21st century.

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