

Variable Rate Fertilizer Applicators: A Modern Approach to Agriculture

Vasu Kumar¹, S. A. Kanade¹ and Rahul Yadav²

¹Research Scholar, Department of Farm Power and Machinery, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra

²Project Associate-II, CSIR-CMERI Centre of Excellence for Farm Machinery, Ludhiana, Punjab

SUMMARY

Variable rate fertilizer applicator offers a promising solution to the dual challenge of increasing agricultural productivity to meet future food demands while safeguarding the environment and natural resources. This technology epitomizes the advancement toward a more efficient, precise and sustainable approach to nutrient management in agriculture.

INTRODUCTION

The global population is expected to reach 10 billion people by 2050 (FAO, 2017). This places a significant demand on the agricultural sector to enhance crop production and yield per unit of land. Modern agriculture is confronted with the dual challenge of meeting the escalating global demand for food, driven by an ever-expanding population, while also minimizing its environmental footprint. Traditional agricultural practices often involve uniform application of fertilizers across entire fields, which can lead to inefficiencies, wastage, and negative environmental consequences such as nutrient runoff and water pollution. In response to these challenges, precision agriculture has emerged as a vital paradigm shift, aiming to optimize resource utilization and reduce environmental impact. One pivotal innovation within the precision agriculture is the development of Variable Rate Fertilizer Applicators (VRFA), a technology designed to revolutionize nutrient distribution in line with specific field conditions and crop requirements.

Traditionally, uniform fertilizer application is done in the field by the farmers assuming the homogeneity of nutrient status in the field. The conventional method of applying fertilizer uniformly fails to consider the varying productivity potentials of different zones within the field. As a result, certain areas receive insufficient fertilization while others are excessively fertilized. Crop yield generally increases up to an optimum level by increasing the rate of fertilizer, but further application of fertilizer is less utilized or mobilized. This excessive use of fertilizers is a major source of pollution in the form of nitrite (NO_2), nitrate (NO_3) and ammonia (NH_3) which can cause hazard to human health. Excessive use of fertilizers also leads to soil and water pollution. Additionally, reducing fertilizer usage negatively affects crop growth and consequently overall yield.

The VRFA is a cutting-edge technological solution that seeks to address the pressing demands of modern agriculture by tailoring fertilizer application to the unique needs of different areas or zones within a single field. VRFA offers an effective way to apply precise fertilizer at different sites within a field as per the site-specific information and reduces the adverse impact of excess fertilizers on the environment (Kumar & Deshmukh, 2022). This innovation represents a significant departure from conventional uniform fertilizer application methods, ushering in a new era of precision and efficiency in agriculture. This technology empowers farmers to optimize nutrient delivery, thereby enhancing crop yields, minimizing input waste, and mitigating negative environmental impacts.

Variable-Rate Fertilizer Application Methods:

There are two types of variable-rate fertilizer applicators:

- Map-based VRFA
- Sensor-based VRFA

Map-based VRFA adjusts the application rate based on an electronic map, also referred to as a prescription map. By utilizing GPS receiver-derived field coordinates and a desired rate prescription map, the input concentration is adjusted as the applicator traverses the field. Fig. 1 illustrates the process for creating a strategy to implement map-based variable rate fertilizer application for a particular field.

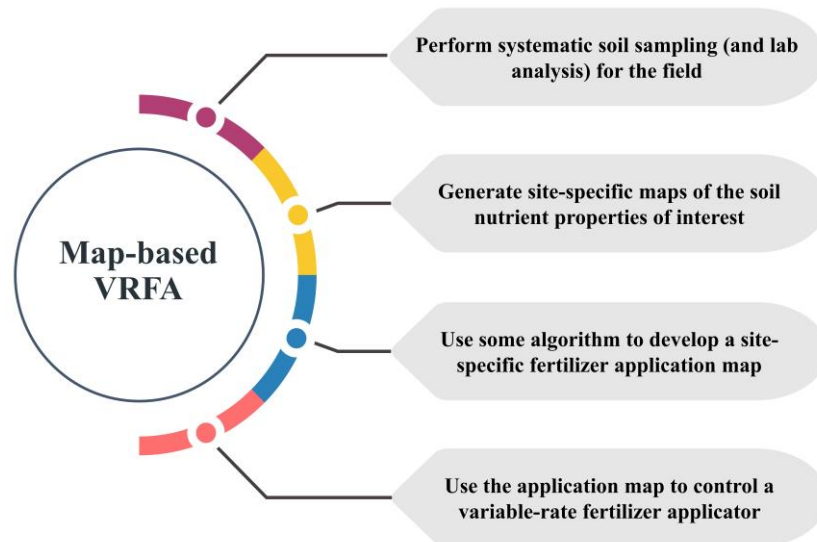


Fig. 1 Plan for map-based variable rate fertilizer application

During the sampling and application steps, a positioning system is employed to continuously track or record vehicle location in the field. The most commonly utilized positioning devices are Differential Global Positioning System (DGPS) receivers. Fig. 2 illustrates the process of map-based variable-rate fertilizer application.

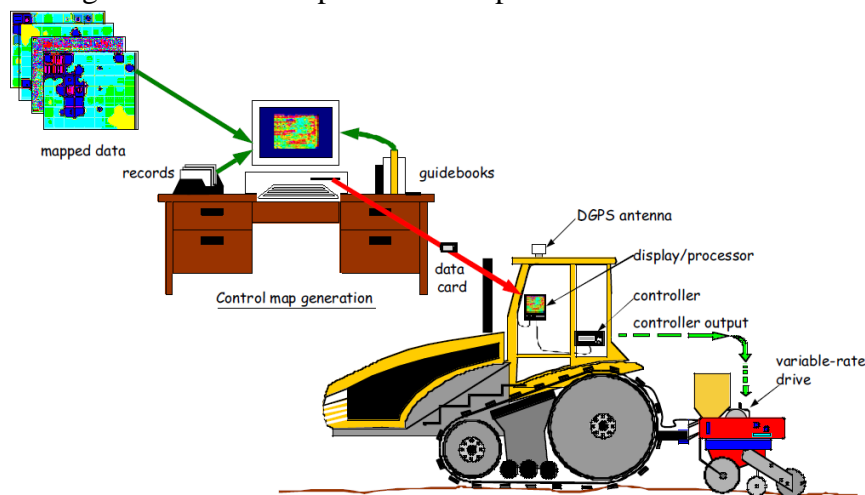


Fig. 2 Map-based VRFA system (Ess *et al.*, 2001)

Sensor-based VRFA employs sensors to assess the desired properties, usually crop characteristics or soil properties, on the go. The data collected by this system is promptly analysed and utilized to control a variable rate applicator (Fig. 3). This alternative approach doesn't necessarily depend on employing a DGPS system, nor does it necessitate extensive data analysis before implementing variable-rate applications.

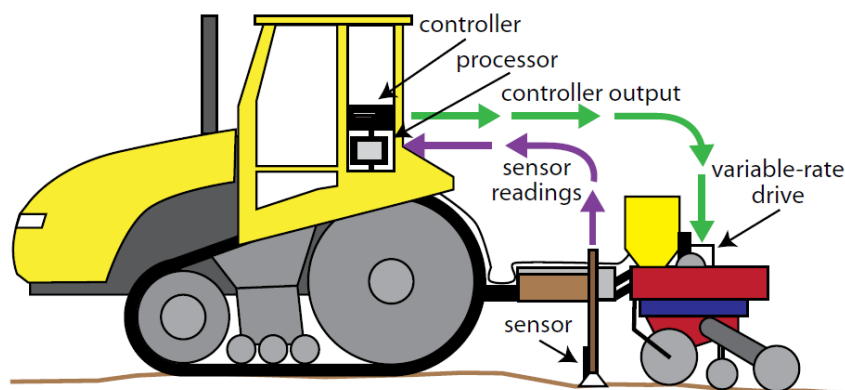


Fig. 3 Sensor-based VRFA system (Grisso *et al.*, 2011)

Advantages of Variable Rate Fertilizer Applicators:

Efficient Resource Utilization: By applying fertilizers only where they are needed, the system reduces fertilizer wastage and minimizes the environmental impact of excess nutrient runoff.

Increased Crop Yields: Precise nutrient application enhances crop growth and development, leading to improved yields and crop quality.

Cost Savings: Efficient nutrient allocation helps reduce over-application of fertilizers, leading to cost savings by minimizing excess usage and lowering input expenses.

Environmental Sustainability: With reduced fertilizer runoff and leaching, variable rate application helps mitigate the risk of water pollution and environmental damage, promoting sustainable farming practices.

Adaptability: The applicator can be adjusted to suit different crops, soil types, and field conditions, making it a versatile tool for various agricultural settings.

Flexibility in Crop Rotation: Different crops have varying nutrient requirements. Variable rate application accommodates changing crops by adjusting nutrient levels accordingly.

Real-Time Monitoring: Many variable rate applicators offer real-time monitoring and adjustment capabilities, enabling farmers to respond promptly to changing field conditions.

Long-Term Soil Health: By avoiding nutrient imbalances and excesses, variable rate application contributes to maintaining soil health over time, promoting sustainable land management practices.

CONCLUSION

The implementation of variable-rate fertilizer application represents a significant advancement in modern agricultural practices. This innovative approach acknowledges the inherent variability within fields, enabling precision agriculture to optimize crop yield while minimizing environmental impacts. By tailoring fertilizer application rates based on comprehensive data analysis and mapping, farmers can address the unique needs of distinct areas within their fields. This not only enhances resource efficiency but also contributes to reduced soil and water pollution, reflecting a sustainable and responsible approach to farming. As technology continues to evolve, variable-rate fertilizer applicators stand as a pivotal tool in achieving the delicate balance between productivity, environmental stewardship, and economic viability within the realm of agriculture.

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