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Application UAV Based Granular Fertilizer Spreader for Paddy

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Introduction:

Rice is the most important and widely cultivated crop in the world. Rice is grown in over hundred countries and is the staple food for more than 60% of world population. Approximately, 750 million of the world's poorest people depend on rice to survive. Over 759.6 million tonnes (MT) of rice were produced worldwide, with Asia accounting for 90% of this total (FAOSTAT 2018). The difficulty of achieving even higher levels of rice production persists, as it is predicted that the world's grain consumption will double by 2050.

Fertilizer use is one of the major factors for the continuous increase in rice production (Basavarajappa *et al.*, 2021). Nitrogen (N) is an important element in the soil and the biosphere. It is a very crucial and important nutrient required for rice growth, yield and in its absence, the yield is reduced drastically (Hirzel *et al.*, 2011). More than 20% of fertilizer nitrogen (N) produced worldwide is used in the rice fields of Asia. A significant component of today's agricultural output is made up of granular fertilizers, which are thought to be an efficient way to supply sufficient amounts of different nutrients throughout the reproductive cycle of high-yield crops like rice.

In the past, spreading on the ground was the primary method of mechanical or hand fertilization. They can travel more easily in deep paddy fields and/or pass through crops where the stem leaves are high enough to conceal the row spacing, but their work efficiency and profit margins have not increased much (Chen *et al.*, 2018). Also, it is important to take into

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consideration the undesirable harm to the land and soil that results from the field application of powerful ground machines over an extended period of time. Because ground machines are not as flexible or adaptable as they are, agricultural UAV spreaders, a new type of agricultural machinery, can be used in special fields without ever touching the cultivated land surface or the crop canopy. They also require less labor and provide an efficient and adaptable solution.

Fertilizer Requirement for Paddy:

Nitrogen is a most limiting nutrient for optimum rice grain yields under irrigated lowland ecosystems. Increasing rice yield per unit area through the use of appropriate nitrogen management practice has become an essential component of modern rice production technology. Types of fertilizers used are listed in the Table 1.

Table 1. Types of Fertilizers

Inorganic Fertilizers:	Organic Fertilizers:
• Nitrogen Fertilizers • Phosphorus Fertilizer Sources: Urea (46 % N), DAP (18 % N & 46 % P) and MOP (60 % K). 150:60:60 NPK	• Agricultural Waste • Livestock Manure • Industrial Waste • Municipal Sludge

3. Advantages and Disadvantages of Granular Fertilizers:

Advantages	Disadvantages
• They are easy to transport, store and apply	• They are expensive
• They dissolve readily in soil and are soluble in water. Thus, the plants may readily absorb them.	• Skin and respiratory system toxicity is caused by the fertilizers' components.
• They boost agricultural productivity and supply adequate food to feed the sizable population.	• Overuse of fertilizers depletes soil fertility and harms plants. When fertilizers leach and enter waterways, eutrophication results.

UAV Based Fertilizer Spreader:

Agricultural Unmanned Aerial Vehicles (UAVs) are a novel type of agricultural machinery that can operate without making contact with the crop canopy or the cultivated land surface. This makes them a versatile and efficient alternative for specialized sectors where

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ground machines are not as adaptable or trafficable. Notably, because of their flexibility and controllability in flight, unmanned aerial vehicles (UAVs) are better suited for irregular small-scale fields and mountainous terrain, particularly in Asia, than vast, connected agricultural fields, which are better suited for manned fixed-wing aircraft. Furthermore, agricultural UAVs' performance advancements, particularly in payload and flight capacity, have recently expanded fast, widening their applicability in the spreading of granules. The two primary categories of UAV-based spreaders now in use are pneumatic and centrifugal disc kinds.

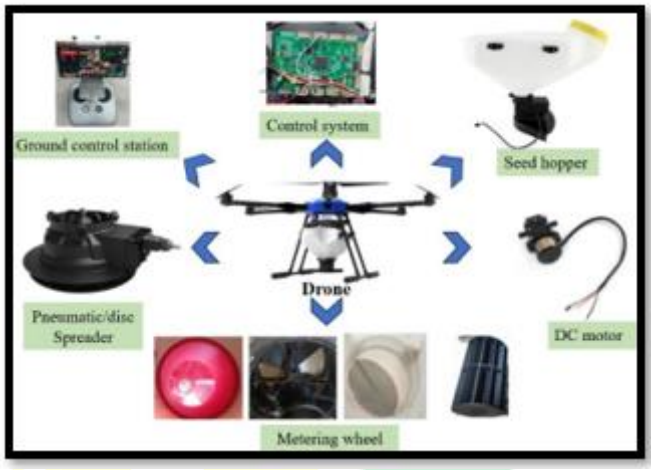

Fig 1. Components of UAV based fertilizer spreader

Types of UAV granular fertilizer spreader:

Two prevalent methods for guiding variable fertilization are based on the research of fixed-point variable fertilization techniques

a. **Fixed rate UAV granular spreader:** The method of detecting soil nutrient content, which uses high-precision instruments to acquire soil nutrient information at the target area. The fixed-rate pattern is based on the manually set target application rate and in a fixed-rate pattern the target discharge rates were continuously adjusted on the handheld ground control station from low to high and from high to low within a permissible range
b. **Variable rate UAV granular spreader:** The prescription fertilization maps are created using spectral sensor-based mapping, taking into account the crop collection's present growth. A personalized prescription map was utilized in the variable-rate pattern for a particular field based on the precise locations

Preparation of prescription map for a variable rate pattern:

- **Step 1:** Collect multispectral images of the paddy fields using UAV

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- **Step 2:** Image pre-processing, correction images for any distortions or inconsistencies in the images. Perform radiometric calibration to standardize the images and stitching of images using photogrammetry software.

  Ex: Pix4D Fields, Pix4D Mapper and ArcGIS Drone2Map

- **Step 3:** Calculate vegetation indices such as NDVI (Normalized Difference Vegetation Index) using the pre-processed images.

$$NDVI = (NIR - Red) / (NIR + Red) \quad \ldots 1$$

where,

NIR is near-infrared and Red is red band reflectance.

- **Step 4:** NDVI Thresholding, in this process we determine threshold values for NDVI that correspond to different levels of crop health or stress. For example, areas with NDVI values below a certain threshold might indicate the need for more fertilizer.
- **Step 5:** Using the NDVI thresholds, create a prescription map that specifies the amount of fertilizer to be applied in each area of the field. This map can be generated based on the NDVI values, with lower NDVI areas receiving higher fertilizer rates (Fig 2.).

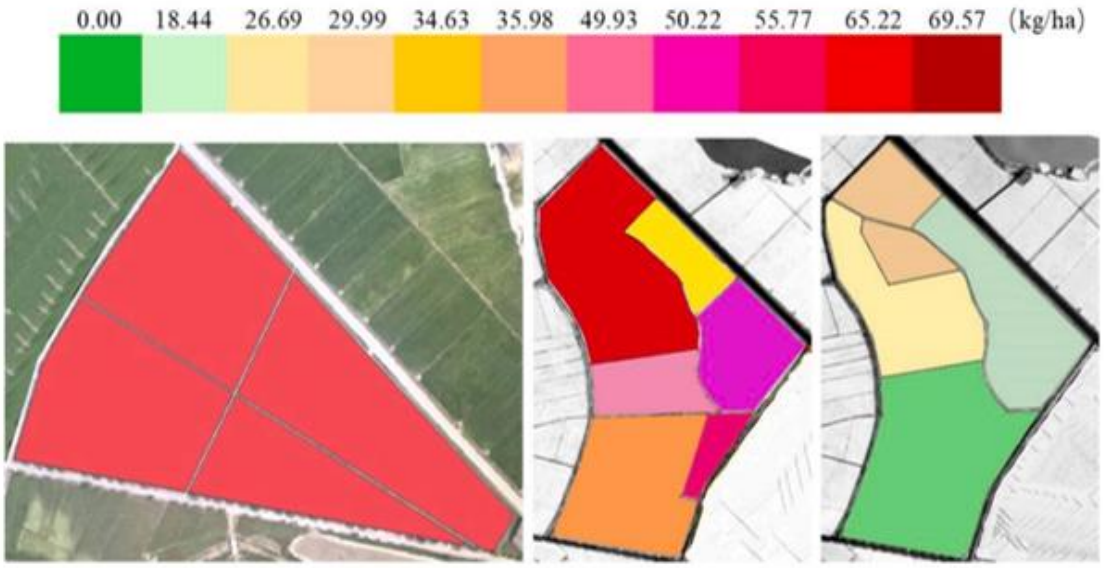

Fig 2. Prescription map

Working Principle of Variable Rate Spreader Control System:

Control process of the variable-rate fertilizer control system: The entire control process of the Variable Rate Spreader Control System is illustrated in Fig 3. The operational steps were as follows:

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- Open the waypoint planning map for the target field area.
- Set relevant work parameter, consisting of choosing fertilizer and calibrated control parameter, setting spread parameter and choosing work pattern and setting flight parameter.
- Upload the waypoint planning map and work parameter.
- The UAV based fertilizer spreader flied along the route and spread fertilizer according to the waypoint planning map. Before applied in the field, the system was calibrated for the target fertilizer.

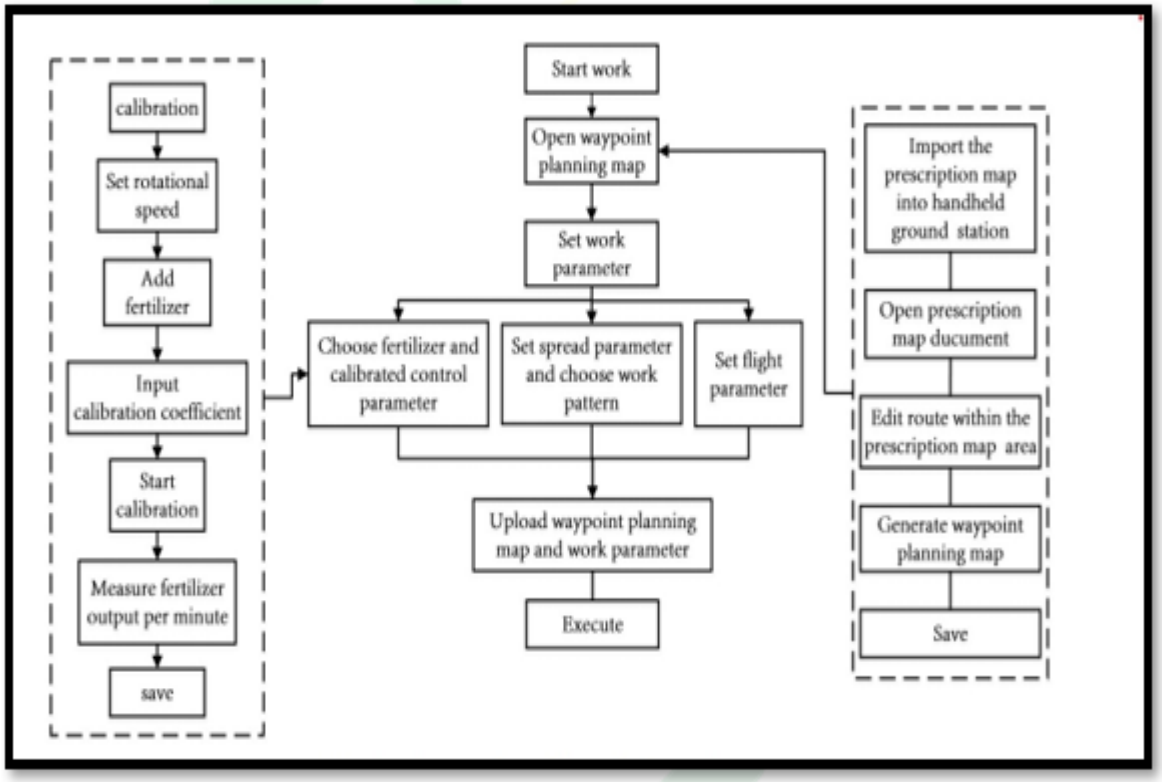

Fig 3. Working Principle of Variable Rate Spreader Control System

Variable-rate fertilization decision process of fertilizer spreader control system:

The variable-rate fertilization decision process, mainly including the logic of the target position and target fertilizer application rate, is shown in Fig. 4. Within the fertilization decision process, once the waypoint position was read, the target fertilizer application rate would be sent to spread controller to calculate the target discharge rate. By adding the travel speed and the routing space into the decision process, the target fertilizer application rate could be converted into an executable command for the metering apparatus.

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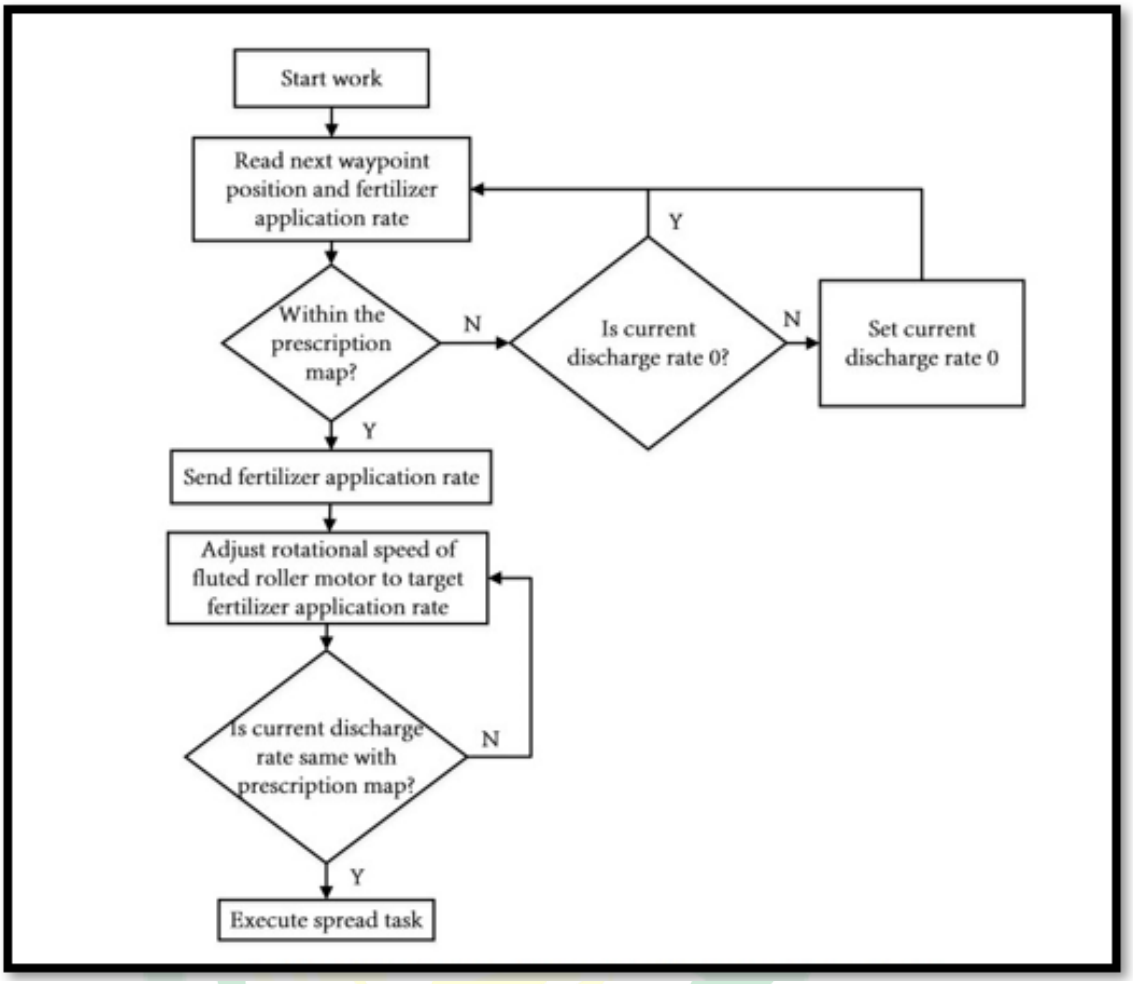

Fig 4. Variable-rate fertilization decision process of fertilizer spreader control system.

Conclusion:

The variable rate control systems of UAV based fertilizer spreaders will be functional, effectively controlling the application rate of the fertilizer according to the requirement. The UAV-based variable rate granular fertilizer may enable site specific fertilization management. It can optimize fertilizer use and minimizes waste, ultimately improving yield and quality of paddy. By using the site-specific application of nutrients can prevent over-application and leading to reduced fertilizer expenses, can benefit farmers in cost savings.

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