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Foliar application of nutrients using agricultural drone on yield and quality of green gram

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Abstract
A field experiment was carried out at Anbil Dharmalingam Agricultural College and Research Institute, Tamil Nadu Agricultural University, Tiruchirappalli to study the effect of foliar application of nutrients using agricultural drone on growth, yield and quality of green gram. The experiment was laid out on randomized block design with seven treatments and three replications. The treatments consisted two levels of TNAU pulse wonder (1% and 2%), two levels of drone spray fluid requirement (30 and 50 liters ha^{-1}) along with manual spray (1% and 2% of TNAU pulse wonder with 500 liters ha^{-1} spray fluid) and control. Results revealed that application of 2% TNAU pulse wonder with spray fluid of 50 litres ha^{-1} significantly recorded taller plants (49.1 cm), higher dry matter production (2311 kg ha^{-1}), more number of flowers $plant^{-1}$ (54.6), number of pods $plant^{-1}$ (39.2), higher grain yield (747 kg ha^{-1}), haulm yield (1684 kg ha^{-1}), grain protein (23.5%) and grain carbohydrate (57.9%) compared to manual spray and control. Hence, it is concluded that drone spray of 2% TNAU pulse wonder with spray fluid of 50 litres ha^{-1} at peak flowering stage could be recommended to improve the yield and quality of green gram.

Keywords: drone, foliar spray, green gram, pulse wonder, spray fluid

1. Introduction
Green gram is a short duration and most important pulse crop in India. It enriches soil by fixing atmospheric nitrogen through root nodules. Being erosion resisting, drought resistant and photo-thermo insensitivity nature, it can be grown as catch crop and suits well in different cropping system (Movalia *et al.*, 2020) [8]. It is rich in lysine content, tryptophan and riboflavin, thus providing balanced diet for human (Yadav *et al.*, 2009). In India, green gram is being cultivated in 47.5 lakh ha area with production of 24.5 lakh tonnes and productivity of 516 kg ha^{-1} (Anonymous, 2019) [1]. Yield potential of green gram was low due to inappropriate management practices (Sridhar *et al.*, 2020) [15]. Being early maturing crop, soil applied fertilizers cannot be completely utilized by green gram.
Foliar application of nutrients helps in better utilization and translocation of nutrients. It absorbs 8 to 20 times more nutrient than nutrients applied to the soil. It nourishes plants, improves photosynthetic efficiency, reduces nutrient losses and increases yield (Smolen, 2012) [14]. Tamil Nadu Agricultural University, Coimbatore developed pulse wonder, a crop booster to reduce flower drop and increase yield (CPG, 2020) [3]. It contains micro and macro nutrients that improves overall source sink relationships and increase plant metabolic process (Sachin *et al.*, 2019) [12]. The conventional method of foliar spraying requires more labour with high input cost. Non-availability of labour and hike of labour cost are the major constraints faced by farmers. In this context, agricultural drones can be used for foliar spraying of nutrients. Drones are known as unmanned aerial vehicle system that is remotely controlled used for spraying of agro-chemicals with an automated pre-programmed GPS system (Pathak *et al.*, 2020) [10]. The drone gives the best solution as it reduces number of labour and cuts down the production cost in conjunction with increased productivity and faster application rate thus saving time. Foliar application of nutrients using drone needs to be studied thoroughly for its feasibility. Hence, this experiment was conducted with the objective of standardizing nutrient concentration and amount of spray fluid required for spraying nutrients to improve the yield of green gram.

2. Materials and Methods
2.1. Experimental site
A field experiment was carried out during *Summer,* 2021 at Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli. The experimental site was located at latitude of 10º45' N, longitude of 78º36' E and 85 m above mean sea level. The soil was sandy clay loam with a pH of 8.9 which was sodic in nature.

2.2. Experimental design and treatment details

The field experiment was laid out in a randomized block design with seven treatments and three replications. The treatment details were: T_1 - Drone spray of 1% TNAU pulse wonder with spray fluid of 30 litres ha^{-1}, T_2 - Drone spray of 1% TNAU pulse wonder with spray fluid of 50 litres ha^{-1}, T_3 - Drone spray of 2% TNAU pulse wonder with spray fluid of 30 litres ha^{-1}, T_4 - Drone spray of 2% TNAU pulse wonder with spray fluid of 50 litres ha^{-1}, T_5 - Manual spray of 1% TNAU pulse wonder with spray fluid of 500 litres ha^{-1}, T_6 - Manual spray of 2% TNAU pulse wonder with spray fluid of 500 litres ha^{-1}, T_7 - Control. VBN Gg (4) was the variety used for the trial. Seeds were sown at a spacing of 30 x 10 cm. Pulse wonder was sprayed once at peak flowering stage using manual knapsack sprayer and agricultural drone.

2.3. Spray equipment

AD610D model was the agricultural drone used for foliar spraying of nutrients in this study. Agricultural drone was operated with 10 litres loading capacity. The operational parameters namely GPS, flight height and flight velocity were pre-determined for the experimental site and controlled by well-trained operator.

Knapsack sprayer fitted with flat fan nozzle was used for manual spraying of foliar nutrients. The loading capacity of the knapsack sprayer was 15 litres. The detailed specifications of the technical parameters of agricultural drone are presented in Table 1.

Table 1: Technical parameters of Agricultural spraying drone

Classification	Parameters
Drone model	AD610D
Dimensions (mm)	1365x1365x480
Motor (Kv)	6215-100
Maximum tilt angle	15®
Nozzle type	Flat fan standard nozzle
Tank capacity (Litres)	10
Spraying width (m)	3.5
Flight height (m)	1.5

2.4. Observations

Ten plants were tagged randomly from each plot and used to record growth, yield and quality parameters. Plant height (cm), dry matter production (kg ha^{-1}) and number of flowers $plant^{-1}$ were recorded at 15 days after spray. Number of pods $plant^{-1}$, grain yield (kg ha^{-1}) and haulm yield (kg ha^{-1}) were recorded at harvest stage. Quality parameters *viz.,* grain protein and carbohydrate were analysed. Grain protein was analysed as the procedure given by Lowry *et al.* (1951) [6] and grain carbohydrate was analysed as the method given by Hedge and Hofreiter (1962) [4] and was expressed in percentage.

2.5. Statistical analysis

Experimental data collected was statistically analysed as outlined by Panse and Sukhatme (1967) [9]. Critical difference at 5 per cent probability level was calculated for the treatments with significant difference.

3. Results and Discussion

3.1. Growth parameters

Drone spray of 2% TNAU pulse wonder with spray fluid of 50 litres ha^{-1} significantly recorded taller plants (49.1 cm) and higher dry matter production (2311 kg ha^{-1}) over manual spray and control (Table 2). However, this was on par with drone spray of 2% TNAU pulse wonder with spray fluid of 30 litres ha^{-1} and drone spray of 1% TNAU pulse wonder with 50 litres ha^{-1}. Control recorded shorter plants (39.8 cm) and lesser dry matter production (1827 kg ha^{-1}). Pulse wonder contains macro and micro nutrients and plant growth regulators that supplemented crop and boosted plant growth which attributed to increased plant height and dry matter production. These results were in accordance with findings of Balaji *et al.* (2019) [2].

Table 2: Effect of foliar application of pulse wonder using agricultural drone on growth and yield parameters of green gram

Treatments	Plant height (cm)	Dry matter production (kg ha^{-1})	Number of flowers $plant^{-1}$	Number of pods $plant^{-1}$
T_1- Drone spray of 1% pulse wonder with 30 litres ha^{-1}	44.7	2067	49.7	29.1
T_2-Drone spray of 1% pulse wonder with 50 litres ha^{-1}	46.8	2220	51.8	37.2
T_3-Drone spray of 2% pulse wonder with 30 litres ha^{-1}	48.2	2269	52.5	38.1
T_4-Drone spray of 2% pulse wonder with 50 litres ha^{-1}	49.1	2311	54.6	39.2
T_5-Manual spray of 1% pulse wonder with 500 litres h^{-1}	43.9	2031	48.2	28.5
T_6-Manual spray of 2% pulse wonder with 500 litres ha^{-1}	45.2	2106	50.4	30.2
T_7-Control	39.8	1827	44.9	21.3
SEd	1.7	88	2.05	1.39
CD (P=0.05)	3.71	192	4.48	3.04

3.2. Yield parameters

Application of drone spray of 2% Pulse wonder with spray fluid of 50 litres ha^{-1} significantly recorded more number of flowers $plant^{-1}$ (54.6) and pods $plant^{-1}$ (39.2) than manual spray and control (Table 2). Manual spray of 1% TNAU pulse wonder with spray fluid of 500 litres ha^{-1} recorded lesser number of flowers $plant^{-1}$ (48.2) and pods $plant^{-1}$ (28.5) than drone spray. Control recorded lesser number of flowers $plant^{-1}$ (44.9) and pods $plant^{-1}$ (21.3). The increased number of flowers and pods were due to pulse wonder application using drone supplemented nutrient at critical stage of growth, decreased flower dropping and increased floral bud by increasing the metabolic activity of the plant and finally more number of pods. Similar findings were reported by

Kunjammal and Sukumar (2019) [5].

3.3. Yield

Drone spray of 2% TNAU pulse wonder with spray fluid of 50 litres ha^{-1} significantly registered higher grain yield (747 kg ha^{-1}) and haulm yield (1684 kg ha^{-1}) (Table 3). This was comparable with drone spray of 2% TNAU pulse wonder with spray fluid of 30 litres ha^{-1} and drone spray of 1% TNAU pulse wonder with spray fluid of 50 litres ha^{-1}. It was followed by manual spray of 2% TNAU pulse wonder with spray fluid of 500 litres ha^{-1}. Lesser grain yield of 574 kg ha^{-1} and haulm yield of 1398 kg ha^{-1} was registered with control. Foliar spray of pulse wonder delayed the senescence and supplied balanced nutrients to the crop that improved overall transport and partitioning efficiency, thus resulted in continuous translocation of source to sink which reflected in more number of pods $plant^{-1}$, number of seeds pod^{-1} and produced higher yield. These results were in conformity with the work of Kunjammal and Sukumar (2019) [5] and Sachin *et al.* (2019) [12]. The reason behind higher yield under drone spray over manual spray was due increased absorption of pulse wonder. The turbulence created by the propellers caused a downwash air flow which fluttered and flipped the leaves over resulted in increased deposition of pulse wonder from top to bottom of the crop canopy on the active site of the leaf. Uniform distribution of finer spray droplets with increased penetration might also have improved the translocation of nutrients efficiently than manual spray. All the factors together resulted in increased growth and physiological parameters resulted in better crop growth and yield. These results were in line with the work of Qin *et al.* (2016) [11], Yang *et al.* (2018) [17] and Martin *et al.* (2020) [7]. Application of 2% concentration performed better than 1% due to increased droplet deposition density; spray fluid 50 litres ha^{-1} performed better than 30 litres ha^{-1} due to better spray coverage under drone spray.

Table 3: Effect of foliar application of pulse wonder using agricultural drone on yield and quality parameters of green gram

Treatments	Grain yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Grain protein (%)	Grain carbohydrate (%)
T_1- Drone spray of 1% pulse wonder with 30 litres ha^{-1}	668	1523	21.8	55.1
T_2-Drone spray of 1% pulse wonder with 50 litres ha^{-1}	700	1575	22.5	56.8
T_3-Drone spray of 2% pulse wonder with 30 litres ha^{-1}	723	1625	22.9	57.1
T_4-Drone spray of 2% pulse wonder with 50 litres ha^{-1}	747	1684	23.5	57.9
T_5-Manual spray of 1% pulse wonder with 500 litres h^{-1}	666	1519	21.5	54.9
T_6-Manual spray of 2% pulse wonder with 500 litres ha^{-1}	677	1543	22.1	55.5
T_7-Control	574	1398	21.2	54.6
SEd	30	54	0.54	1.03
CD (P=0.05)	65	118	1.19	2.25

3.4. Quality parameters

Among the treatments, drone spray of 2% TNAU Pulse wonder with spray fluid of 50 litres ha^{-1} recorded higher grain protein (23.5%) and grain carbohydrate (57.9%) over control (Table 3). Drone spray of 2% TNAU Pulse wonder with spray fluid of 30 litres ha^{-1} and drone spray of 1% TNAU Pulse wonder with spray fluid of 50 litres ha^{-1} recorded grain protein of 22.9% and 22.5% and grain carbohydrate of 57.1% and 56.8%, respectively. Pulse wonder application using drone provided nutrients at critical stages of crop resulted in increased grain protein and grain carbohydrate content. Similar results were given by Sangeetha and Manohari (2020) [13].

4. Conclusion

Productivity and quality of green gram could be improved by foliar application of nutrients. Considering the present labour shortage condition, it is concluded that agricultural drones could be feasibly used for spraying of 2% TNAU pulse wonder with spray fluid of 50 litres ha^{-1} to increase the grain and quality of green gram.

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