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RESEARCH NOTE

Herbicide application using unmanned aerial vehicle in groundnut

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ABSTRACT

A field experiment was conducted during *Rabi*, 2024-25 at S.V. Agricultural College Farm, Tirupati campus of Acharya N.G. Ranga Agricultural University, Andhra Pradesh to evaluate and compare the efficacy of pre- and post-emergence herbicides applied through unmanned aerial vehicle (UAV) and knapsack sprayer for weed management in *Rabi* groundnut. Among different weed management treatments tested, pre-emergence application (PE) of pendimethalin 1kg/ha with UAV at 50 L/ha of spray fluid significantly reduced total weed density and biomass with higher weed control efficiency and resulted in increased groundnut yield attributes and yield. It was statistically comparable with same herbicide application with knapsack sprayer at 500 L/ha. The highest benefit-cost ratio was observed with pendimethalin 1.0 kg/ha PE with UAV using 50 L/ha of spray fluid indicating that usage of unmanned aerial vehicle for herbicide spraying has potential as an alternative to conventional knapsack sprayer for herbicide application in groundnut.

Keywords: Groundnut, Spraying technique, Unmanned aerial vehicle, Weed management

Groundnut (*Arachis hypogaea* L.) is a vital crop in India due to its nutritional, economic and ecological significance. Despite its importance, groundnut productivity is often constrained by several factors, among which weed infestation remains as one of the major yield limiting factor. The yield loss due to weeds in groundnut was reported to be 30 to 80% (Priya *et al.* 2013, Rao and Chauhan 2015, Kumari 2017). Groundnut is highly susceptible to weed infestation because of its slow growth during initial stages up to 40 days after sowing (DAS), short plant stature and underground pod-bearing habit. Weeds interfere with pegging, pod development and harvesting of groundnut, besides competing for essential growth resources. Therefore, effective weed control is the foremost critical production factor in groundnut cultivation (Choudhary *et al.* 2022). Ttraditionally, knapsack sprayers are widely used in small holdings for herbicide application, which requires high spray volumes of 500 L/ha, making them less suitable for dryland situations due to shortage of water in the water bodies for spraying. In addition, it is time-consuming and physically demanding, which limits their efficiency on larger farms and also poses significant health hazards to the humans who are involved in spraying operations.

In this context, unmanned aerial vehicle (UAV) or drones have emerged as a promising alternative for pesticide and herbicide application in agriculture (Gatkal *et al.* 2025). Drones are capable in navigating challenging terrains and inaccessible zones ensuring comprehensive coverage (Wang *et al*. 2020), reducing application time by 99% (Ahmad *et al*. 2020) and reducing labour requirement by 85% compared to manual method (Partel *et al*. 2021). UAV spray was evaluated in summer cotton (Vimalraj et al. 2025) and direct-seeded rice (Karthickraja et al. 2024) to effectively manage the diverse weed flora and enhance crop yield. However, the use of UAV for herbicide application, especially in crops like groundnut, is still in its nascent stage and their impact on weed control remains largely unexplored. Herbicidal applications in groundnut are still carried out using knapsack sprayers, which demand high spray volume of 500 L/ha, whereas UAVs operate with significantly lower spray volume of 25 L/ha (Jeevan *et al*. 2023). There is an urgent need for scientific evaluation to establish standard operating procedures for drone application of herbicides in India. In this context, a field study was conducted to evaluate the efficacy of pre- and post-emergence herbicides application using drones in *Rabi* groundnut.

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A field experiment was conducted during *Rabi* 2024-25 at dryland farm of ANGRAU-S.V. Agricultural College, Tirupati, Andhra Pradesh. The soil was sandy loam in texture, neutral in reaction, low in organic carbon and available nitrogen, high in available phosphorus and medium in available potassium. Healthy and sound groundnut kernel of test variety '*Visishta*' were sown on 26 December 2024 at a spacing of 22.5 cm × 10 cm using a seed rate of 140 kg/ha. The experiment was laid out in randomized block design with eight weed management treatments replicated thrice. The pre-emergence application (PE) of pendimethalin 1.0 kg/ ha with unmanned aerial vehicle (UAV) using 25 and 50 L/ha of spray fluid and post-emergence application (PoE) of imazethapyr + propaquizafop (ready-mix) 125 g/ha with UAV using 25 and 50 L/ha spray fluid, application of above herbicides with conventional knapsack sprayer using 500 L/ha spray fluid, hand weeding twice at 20 and 40 days after sowing (DAS) and unweeded check. The soils of the experimental site was sandy loam in texture, neutral in soil reaction (6.9), low in organic carbon(0.28%) and available nitrogen (215 kg/ha), high in available phosphorus (21 kg/ha) and medium in available potassium(250 kg/ha).The drone used for the experiment was ANGRAU-Pushpak-03, which is a hexacopter agricultural drone with a 12 L tank capacity developed by Acharya N.G. Ranga Agricultural University for aerial spraying of pesticides approved by DGCA. It is pressure-based UAV with 4 flat-fan nozzles fitted with nozzle model - 110015 VP and a swath width of 3 meters and nozzle discharge rate is 0.42 to 0.45 L/m operated by certified drone pilot. The UAV consisting of 2 units of batteries each 16,000 mAH capacity. Prior to herbicide application, UAV was calibrated to ensure accurate and uniform delivery of the spray fluid as per the treatments by measuring the droplet size. A detailed geo-referenced map of the treatment plots was developed to ensure accurate application of spray fluid. The mean diameter of spray droplets in UAV and Knapsack sprayer was 390.3 and 412.4 micrometers, respectively. The UAV was operated at a constant height of 1 meter above the soil/crop canopy with a flight speed of 5 m/s for 25 L/ha and 2.5 m/s for 50 L/ha of spray fluid to ensure uniform coverage. For pre-emergence herbicide application, weather conditions recorded were 77 % relative humidity, 2.5 km/hr wind speed and 25.5 °C temperature with soil moisture content at field capacity. For post-emergence herbicide application, the relative humidity, wind speed and temperature were 73 %, 0.6 km/hr and 22.5 °C respectively. Knapsack sprayer was fitted with standard flat fan nozzle and was calibrated before PE and PoE herbicide application by adjusting nozzle discharge and walking speed. Pre-emergence herbicidal application of pendimethalin was done at 1 DAS while post-emergence herbicidal application of imazethapyr + propaquizafop (ready-mix) was done at 20 DAS. Gross plot area for UAV and knapsack sprayer was 5.4 m × 14 m and 5.4 m × 4 m, respectively by maintaining buffer zone of 2 m around the UAV plot. Recommended fertilizer dose of 20 kg N, 40 kg P and 50 kg K/ha were applied through urea, single super phosphate and muriate of potash, respectively to all plots as basal while 10 kg of N was applied in form of urea at 25 DAS as topdressing. The rest of the package of practices was adopted as per Acharya N.G. Ranga Agricultural University recommendations. Unweeded check plots were allowed to remain infested with weeds throughout the crop duration. Category wise weed density and biomass was recorded at harvest by using 0.25 m^2 quadrant. The data on weed density and biomass was subjected to square root transformation ($\sqrt{x+0.5}$) before statistical analysis. Weed control efficiency of different weed management practices were calculated based on the following formula.

$$WCE = \frac{DM_C - DM_T}{DM_C} \times 100$$

where,

WCE = Weed control efficiency (%)

DM_C = Dry matter of weeds in the un-weeded check (control)

DM_T = Dry matter of weeds in the treatment imposed plot.

The crop was harvested on 17 April 2025. Net returns were arrived by deducting the cost of cultivation from gross returns for each treatment. The hiring charges for UAV is Rs750/ha.

The predominant weed species observed were *Boerhavia erecta* L. (45.0%), *Cyperus rotundus* L. (15.0%), *Celosia argentea* L. (11.0%), *Euphorbia hirta* L. (10.0%), *Dactyloctenium aegyptium* (L.) Willd. (9.0%), *Ageratum conyzoides* L. (5.0%) and other minor weeds (5.0%) in unweeded check plots at harvest. All the weed management practices significantly influenced the weed growth and yield of *Rabi* groundnut. The lowest density and biomass of weeds as well as higher weed control efficiency (WCE) were recorded with hand weeding twice at 20 and 40 DAS which was significantly lower than rest of the weed management treatments due to effective removal of weeds by the laborers. Pendimethalin 1 kg/ha PE with UAV at 50 L/ha of spray fluid recorded significantly lower weed density and biomass, which

was however comparable with application of same herbicide with knapsack sprayer at 500 L/ha of spray fluid (**Table 1**). The improved weed control with pendimethalin 1.0 kg/ha applied using UAV with 50 L/ ha of spray fluid can be attributed due to better spray coverage and more effective deposition of the herbicide per unit surface area of soil and pendimethalin inhibited the mitotic activity by disrupting microtubule assembly and ultimately led to cessation of cell division in target weeds. These results are in conformity with the findings of Madhusree *et al.* (2024) in greengram. Additionally, there was no significant difference in weed control due to post-emergence herbicides application using knapsack sprayer and UAV (Naveen *et al.* 2023).

Weed management treatments significantly influenced yield attributes, yield and economics of *rabi* groundnut (**Table 2**). The highest groundnut yield attributes and yield was recorded with hand weeding twice at 20 and 40 DAS, which was significantly higher than rest of the weed management treatments. Among two different methods of herbicide application, pendimethalin 1.0 kg/ha using UAV at 50L/ha spray fluid recorded taller plants, increased number of filled pods/plant and 100-pod weight and higher groundnut pod yield. However, it was statistically at par with application of the same herbicide with knapsack sprayer at 500 L/ha of spray fluid. Yield loss due to weeds in unweeded check was 41.71% compared to pendimethalin pre-emergence application with UAV using 50 L/ha of spray fluid.

Table 1. Weed density, weed biomass and weed control efficiency at harvest as influenced by pre- and post-emergence herbicides application using unmanned aerial vehicle (UAV) and knapsack sprayer in *rabi* groundnut

Weed management practices	Weed density (no./m^2)				Weed biomass (g/m^2)				WCE (%)
	Grasses	Sedges	BLWs	Total weeds	Grasses	Sedges	BLWs	Total weeds	
Pre-emergence application (PE) of pendimethalin 1.0 kg/ha with UAV at 25 L/ha spray fluid	2.67 (6.67)	6.77 (45.33)	4.34 (18.33)	8.42 (70.33)	1.59 (2.02)	7.10 (50.05)	2.69 (6.73)	7.70 (58.79)	61.16
Pendimethalin 1.0 kg/ha PE with UAV at 50 L/ha spray fluid	2.27 (4.67)	5.96 (35.00)	3.76 (13.67)	7.34 (53.33)	1.37 (1.37)	6.52 (42.10)	2.23 (4.47)	6.95 (47.94)	68.33
Post-emergence application (PoE) propaquizafop + imazethapyr 125 g/ha with UAV at 25 L/ha of spray fluid	3.08 (9.00)	5.43 (29.00)	11.52 (132.33)	13.06 (170.33)	1.79 (2.70)	5.64 (31.36)	6.70 (44.50)	8.89 (78.56)	48.10
Propaquizafop + imazethapyr 125 g/ha PoE with UAV at 50 L/ha of spray fluid	3.03 (8.67)	5.40 (28.67)	11.46 (131.00)	12.99 (168.33)	1.77 (2.63)	5.54 (30.24)	6.51 (41.91)	8.68 (74.77)	50.60
Pendimethalin 1.0 kg/ha PE with knapsack sprayer at 500 L/ha spray fluid	2.35 (5.00)	6.15 (37.33)	3.85 (14.33)	7.56 (56.67)	1.42 (1.51)	6.55 (42.45)	2.33 (4.93)	7.02 (48.88)	67.71
Propaquizafop + imazethapyr 125 g/ha PoE with knapsack sprayer at 500 L/ha spray fluid	2.97 (8.33)	5.30 (27.67)	11.44 (130.67)	12.92 (166.67)	1.73 (2.49)	5.33 (27.91)	6.43 (40.94)	8.47 (71.33)	52.88
Hand weeding twice at 20 and 40 days after seeding	1.46 (1.67)	2.73 (7.00)	2.86 (7.67)	4.10 (16.33)	1.26 (1.10)	3.61 (12.54)	1.51 (1.79)	3.99 (15.43)	89.81
Unweeded check	4.45 (19.33)	9.22 (84.67)	19.49 (380.00)	22.00 (484.00)	2.01 (3.56)	7.66 (58.24)	9.48 (89.58)	12.32 (151.37)	-
LSD (p=0.05)	0.20	0.43	0.85	0.69	0.10	0.54	0.49	0.65	-

BLWs: Broad-leaved weeds WCE: Weed control efficiency

Table 2. Yield attributes, yield and economics of *Rabi* groundnut as influenced by pre- and post-emergence herbicides application using unmanned aerial vehicle (UAV) and knapsack sprayer

Weed management practices	Plant height (cm)	No. of filled pods/ plant	100 pod weight (g)	Pod yield (t/ha)	Haulm yield (t/ha)	Net returns (x 10^3/ha)	Benefit-cost ratio
Pre-emergence application (PE) of pendimethalin 1 kg/ha with UAV at 25 L/ha spray fluid	28.45	22.47	124.21	3.04	4.17	80.41	2.32
Pendimethalin 1 kg/ha PE with UAV at 50 L/ha spray fluid	32.01	24.40	135.00	3.50	4.61	100.66	2.63
Post-emergence application (PoE) propaquizafop + imazethapyr 125 g/ha with UAV at 25 L/ha of spray fluid	23.78	16.73	110.98	2.57	3.70	58.19	1.95
Propaquizafop + imazethapyr 125 g/ha PoEwith UAV at 50 L/ha of spray fluid	24.57	17.47	112.67	2.67	3.75	61.90	1.99
Pendimethalin 1 kg/ha PE with knapsack sprayer at 500 L/ha spray fluid	31.97	24.27	133.65	3.34	4.57	94.03	2.55
Propaquizafop + imazethapyr 125 g/ha PoE with knapsack sprayer at 500 L/ha spray fluid	24.90	18.00	113.37	2.70	3.79	63.99	2.04
Hand weeding twice at 20 and 40 days after seeding	35.23	29.66	144.13	3.80	4.99	98.99	2.28
Unweeded check	21.00	12.80	98.65	2.04	3.12	37.64	1.65
LSD (p=0.05)	2.13	1.40	8.05	2.87	3.36	6.20	0.20

The increased groundnut yield due to herbicide spray either by UAV or knapsack sprayer can be attributed due to weed-free environment during critical period of crop weed competition and thereby increased the development of groundnut pods as reported by Madhusree *et al*. (2024) with UAV usage to spray pendimethalin 50 L/ha of spray fluid in greengram and by Chen *et al*. (2019) in wheat. The highest net return was obtained with pendimethalin 1.0 kg/ha with UAV at 50 L/ha of spray fluid, which was however comparable to hand weeding twice at 20 and 40 DAS, which in turn was comparable to spraying of same herbicide with knapsack sprayer 500 L/ha of spray fluid. The highest benefit-cost ratio was obtained with UAV spray of pendimethalin 1.0 kg/ha using 50 L/ha spray fluid which was at par with application of same herbicide with knapsack sprayer using 500L/ha spray fluid. The highest weed density and biomass with lower pod and haulm yield were recorded with unweeded check due to heavy weed infestation.

Thus, pendimethalin 1.0 kg/ha PE applied with UAV using 50 L/ha of spray fluid was found to be an economically viable weed management option for obtaining broad-spectrum weed control and enhancing yield of *rabi* groundnut on sandy loam soil.

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