

Original Research Article

ASSESSMENT OF POST EMERGENCE HERBICIDE EFFICACY FOR DRONE SPRAYING IN TRANSPLANTED RICE (*Oryza sativa* L.)

Abstract

A field experiment was conducted at Rice Research Centre, Agriculture Research Institute, Rajendranagar, Hyderabad during *Kharif*, (2022) to assess the post emergence herbicide efficacy for drone spraying in transplanted rice (*Oryza sativa* L.). The experiment was laid out in randomized block design with 7 treatments and replicated thrice. Results revealed that among different doses of herbicidal treatments, post emergence application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 180 g a.i ha⁻¹ using drone recorded highest number of tillers at harvest, plant height at harvest, number of panicles at harvest, grain yield and weed dry matter at 60 DAT. It was statistically on par with application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 120 g a.i ha⁻¹ using knapsack sprayer, application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 150 g a.i ha⁻¹ using drone, and application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 120 g a.i ha⁻¹ using drone followed by application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 90 g a.i ha⁻¹ using drone.

Introduction

Rice (*Oryza sativa* L.) is global grain as it is the most cultivated and consumed grain on the planet, staple diet of billions of people and provides 70% direct employment to the rural India. Paddy production symbolizes the single largest land use for food production on earth and worldwide, rice is grown on 164 M ha with an annual production of about 750 Mt of paddy (FAO, 2019). India is the second largest producer of rice after China. The area, production and productivity of rice in India are 43.66 M ha, 118.8 Mt and 2722 kg ha⁻¹ respectively. In India, major rice producing states are West Bengal, Uttar Pradesh, Punjab, Andhra Pradesh, Odisha, Telangana, Tamil Nadu, Chhattisgarh and Bihar *etc.*, (Ministry of Agriculture and Farmers Welfare, Government of India, 2019-20). The area under rice cultivation in Telangana has increased to 104 lakh acres (2020-2021) as against 25 lakh acres in 2015-16 and also production

increased in leaps and bounds from 45 lakh tonnes in 2015-16 to 218.5 lakh tonnes by 2020-2021 (Telangana Socio Economic Outlook, 2022). The estimated total volume of milled rice produced worldwide reached over 502 million metric tons in the 2022-2023 crop year (<https://www.statista.com/statistics/report-content/statistic/255945>).

Rice crop suffers from various biotic and abiotic constraints. Weeds are one of the major yield limiting factors among biotic constraints in rice. Weeds compete with the crop plants for nutrients, moisture and sunlight. Kumar *et al.*, (2010) reported that the reduction in grain yield of rice due to uncontrolled weeds in weedy plot was 70.4 % during 2006 and 67.4 % during 2007 as compared to weed control treatments. Grassy weeds were heavy competitors with rice crop followed by sedges and broad-leaved weeds.

Manual weeding is cumbersome and uneconomical due to labour scarcity and increased labour cost. It consumes more time and drudgery due to walking in the puddled field with tank load and spraying, which is hindering the weed control efficiency. In the current scenario of high labour costs, and non-availability of labour for manual weeding, use of herbicides is inevitable. To face these challenges, advanced technology should be used in agriculture to save time and energy. Drone being a modern technology can be solution for farmers. Agricultural drones provide relief for the modern-day farmers to reduce drudgery and to act timely for crop needs.

A Drone (Unmanned Aerial Vehicle) is essentially flying ROBOT remotely controlled through software-controlled flight plans in their embedded system working in conjunction with onboard SENSORS and GPS (Global Positioning System). Due to high adaptability of UAV platforms makes them viable alternative for aerial pesticide application (Wang *et al.* 2018).

Unmanned Aerial Vehicles (UAV) were initially designed for military purposes, but the rapid development of efficient technologies such as sensors, global positioning systems (GPS), and civilian-accessible computers has expanded the potential of drones for various applications (Ehsani and Maja 2013; Hogan *et al.* 2017). Drones are a potential alternative for aerial chemical spraying due to their high adaptability (Wang *et al.* 2018). Drones can help farmers to save time by assist in a variety of ways, including soil fertilization, spraying, irrigation, crop health monitoring, planting and herd tracking. It is possible to work in dampy or sloping environments, reduce work load and application in specific locations is also possible.

Materials and methods

A field experiment was conducted at Rice Research Centre, Agriculture Research Institute, Rajendranagar, Hyderabad during *Kharif* (2022). On clay loam soil neutral in nature (pH 7.6), having EC 0.71 dSm^{-1} , organic carbon (0.45%) and available nitrogen (212 kg ha^{-1}), phosphorus (28.2 kg ha^{-1}) and potassium (452.6 kg ha^{-1}). The experiment was laid out in randomized block design with 7 treatments and replicated thrice. Rice variety RNR-15048 was sown with a seed rate of 50 kg ha^{-1} , maintaining $15 \times 15 \text{ cm}$ with two seedlings per hill. For transplanted rice was $120:60:40 \text{ kg N, P}_2\text{O}_5, \text{ K}_2\text{O}$ respectively which was supplied to crop through urea, single super phosphate and muriate of potash. Entire dose of phosphorous was applied as basal dose. Whereas, nitrogen was applied in three equal splits at transplanting, maximum tillering stage and at panicle initiation stage. The recommended potash was applied in two equal splits at transplanting and panicle initiation stage of rice. Pre-emergence (PE) application of herbicides was done at 3 days after transplanting (DAT) and post-emergence (PoE) at 30 DAT using 500 liters of water/ha as spray fluid with flat fan nozzle fitted knapsack sprayer and 40 liter water/ha using drone. The observations on plant height (cm), number of tillers (m^{-2}), number of panicles (m^{-2}) at harvest, grain yield (kg ha^{-1}) and weed dry matter at 60 DAT.

Results and discussion

Effect on crop

Plant height at harvest (cm)

At harvest significantly higher plant height (cm) was recorded with T_6 (weed free hand weeding at 20, 40 and 60 DAT) and it was statistically at par with T_5 (application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ $180 \text{ g a.i ha}^{-1}$ using drone), T_1 (application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ $120 \text{ g a.i ha}^{-1}$ using knapsack sprayer), T_4 (application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ $150 \text{ g a.i ha}^{-1}$ using drone) and T_3 (application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ $120 \text{ g a.i ha}^{-1}$ using drone) followed by T_2 (application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 90 g a.i ha^{-1} using drone). T_7 (Un weeded control) plot recorded significantly lower plant height over all the treatments. All the weed management practices recorded significantly higher plant height over

unweeded control. Increased plant height in weed management practices compared to weedy check treatment might be due to reduced weed competition for light, water and nutrients etc. The results are in conformity with the findings of Hossain and Mondal (2014). (Table2).

Table 1: Details of the treatments

| Treatment No. | Treatment details |
|----------------|---|
| T ₁ | Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 120 g a.i ha ⁻¹ using knapsack sprayer. |
| T ₂ | Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 90 g a.i ha ⁻¹ using drone. |
| T ₃ | Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 120 g a.i ha ⁻¹ using drone |
| T ₄ | Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 150 g a.i ha ⁻¹ using drone. |
| T ₅ | Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 180 g a.i ha ⁻¹ using drone. |
| T ₆ | Weed free (Hand weeding at 20, 40 and 60 DAT) |
| T ₇ | Unweeded control |

Number of tillers (m⁻²) at harvest

At harvest the maximum number of tillers were recorded with T₆ (Hand weeding at 20, 40 and 60 DAT) and it was statistically at par with T₅ (application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 180 g a.i ha⁻¹ using drone), T₁ (application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 120 g a.i ha⁻¹ using knapsack sprayer) followed by T₄ (application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 150 g a.i ha⁻¹ using drone), and it was stastically at par with T₃ (application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 120 g a.i ha⁻¹ using drone) followed by T₂ (application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 90 g a.i ha⁻¹ using drone). Treatment T₇ (Unweeded control) was recorded significantly lower number of tillers (m⁻²) due to higher crop weed competition significantly lower over all the treatments. These results are in line with Yakadri *et al.* (2016), Rana *et al.* (2018) and venkatesh *et al.* (2019).(Table3).

Table 2: Plant height at harvest (cm)

| Treatments | Plant height at harvest(cm) |
|--|-----------------------------|
| T ₁ : Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 120 g a.i ha ⁻¹ using knapsack sprayer. | 113.2 |
| T ₂ :Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 90 g a.i ha ⁻¹ using drone. | 101.0 |
| T ₃ : Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 120 g a.i ha ⁻¹ using drone | 108.9 |
| T ₄ : Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 150 g a.i ha ⁻¹ using drone. | 108.9 |
| T ₅ : Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 180 g a.i ha ⁻¹ using drone. | 114.7 |
| T ₆ : Weed free (Hand weeding at 20, 40 and 60 DAT) | 115.8 |
| T ₇ : Unweeded control | 90.6 |
| SE(m)± | 2.2 |
| CD (P=0.05) | 6.9 |

Number of panicles (m⁻²) at harvest

The higher number of panicles (m⁻²) was noticed in T₆ (weed free hand weeding at 20, 40 and 60 DAT) followed by T₅ (application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 180 g a.i ha⁻¹using drone) which was statistically on par with T₁ (application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 120 g a.i ha⁻¹ using knapsack sprayer), T₄ (application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 150 g a.i ha⁻¹using drone) and T₃ (application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 120 g a.i ha⁻¹using drone) followed by T₂ (application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 90 g a.i ha⁻¹using drone). The lower number of panicles (m⁻²) was recorded under T₇ (unweeded control). This was due to severe competition exerted by weeds for space, light and nutrients throughout the crop growth period (Caton *et al.*1997). Number of panicles at harvesting time is a vital determinant of grain yield in rice. However, the variation in panicles m⁻² among weed management practices studied was closely related to tiller production as the total number of panicles in a unit area is a product

of the number of plants established and the number of tillers produced by each plant. Therefore, the higher panicle number could be traced to higher tiller production. (Table 4).

Table 3: Number of tillers (m⁻²) at harvest

| Treatments | Number of tillers (m ⁻²) at harvest |
|--|---|
| T ₁ : Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 120 g a.i ha ⁻¹ using knapsack sprayer. | 365 |
| T ₂ : Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 90 g a.i ha ⁻¹ using drone. | 284 |
| T ₃ : Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 120 g a.i ha ⁻¹ using drone | 348 |
| T ₄ : Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 150 g a.i ha ⁻¹ using drone. | 351 |
| T ₅ : Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 180 g a.i ha ⁻¹ using drone. | 381 |
| T ₆ : Weed free (Hand weeding at 20, 40 and 60 DAT) | 392 |
| T ₇ : Unweeded control | 203 |
| SE(m)± | 7.2 |
| CD (P=0.05) | 31.4 |

Grain yield (kg ha⁻¹)

Rice grain yield was significantly higher with T₆ (weed free hand weeding at 20, 40 and 60 DAT) followed by T₅ (application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 180 g a.i ha⁻¹ using drone) it was on par with T₁ (application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 120 g a.i ha⁻¹ using knapsack sprayer), T₄ (application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 150 g a.i ha⁻¹ using drone) and T₃ (application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 120 g a.i ha⁻¹ using drone) followed by T₂ (application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 90 g a.i ha⁻¹ using drone). The Lower grain yield was registered with T₇ (unweeded control). Similar reports were by Chowdhary and Dixit (2018), (Kashid.2019), (Singh *et al.* 2019) and Ramesha *et al.* (2019). (Table5).

Table 4: Number of panicles (m⁻²) at harvest

| Treatments | Number of panicles(m ⁻²) at harvest |
|--|---|
| T ₁ : Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 120 g a.i ha ⁻¹ using knapsack sprayer. | 289 |
| T ₂ : Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 90 g a.i ha ⁻¹ using drone. | 222 |
| T ₃ : Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 120 g a.i ha ⁻¹ using drone | 275 |
| T ₄ : Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 150 g a.i ha ⁻¹ using drone. | 282 |
| T ₅ : Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 180 g a.i ha ⁻¹ using drone. | 292 |
| T ₆ : Weed free (Hand weeding at 20, 40 and 60 DAT) | 339 |
| T ₇ : Unweeded control | 134 |
| SE(m)± | 12.3 |
| CD (P=0.05) | 38.13 |

Effect on weeds

Weed dry matter (gm⁻²) 60DAT

At 60 DAT, Significantly lower weed dry weight was observed with T₆ (weed free hand weeding at 20, 40 and 60 DAT) it was statistically on par with T₅ (application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 180 g a.i ha⁻¹ using drone) ,T₁ (application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 120 g a.i ha⁻¹ using knapsack sprayer), T₄ (application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 150 g a.i ha⁻¹ using drone) and T₃ (application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 120 g a.i ha⁻¹ using drone) followed by T₂ (application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @90 g a.i ha⁻¹ using drone).Significantly higher total weed dry weight was recorded withT₇(unweeded control). The highest weed dry weight was observed with weed check throughout the crop stage. These results are in tune with findings of Kashid (2019), Saranraj *et al.* (2018) and Yogananda *et al.* (2019). (Table6).

Table 5: Grain yield (kg ha⁻¹)

| Treatments | Grain yield kg ha ⁻¹ |
|--|------------------------------------|
| T ₁ : Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 120 g a.i ha ⁻¹ using knapsack sprayer. | 6207.5 |
| T ₂ : Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 90 g a.i ha ⁻¹ using drone. | 4653 |
| T ₃ : Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 120 g a.i ha ⁻¹ using drone | 5829 |
| T ₄ : Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 150 g a.i ha ⁻¹ using drone. | 5886 |
| T ₅ : Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 180 g a.i ha ⁻¹ using drone. | 6239.9 |
| T ₆ : Weed free (Hand weeding at 20, 40 and 60 DAT) | 6718 |
| T ₇ : Unweeded control | 2570.9 |
| SE(m)± | 142.4 |
| CD (P=0.05) | 438.8 |

Table 6: Weed dry matter (g m⁻²) 60DAT

| Treatments | Weed dry matter 60 DAT |
|--|---------------------------|
| T ₁ : Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 120 g a.i ha ⁻¹ using knapsack sprayer. | 3.9 (14.8) |
| T ₂ : Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 90 g a.i ha ⁻¹ using drone. | 5.7 (31.8) |
| T ₃ : Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 120 g a.i ha ⁻¹ using drone | 4.5 (20.1) |
| T ₄ : Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 150 g a.i ha ⁻¹ using drone. | 4.2 (17.6) |
| T ₅ : Application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 180 g a.i ha ⁻¹ using drone. | 3.9 (14.6) |
| T ₆ : Weed free (Hand weeding at 20, 40 and 60 DAT) | 3.7 (13.1) |

| | |
|-----------------------------------|--------------|
| T ₇ : Unweeded control | 11.7 (135.6) |
| SE(m)± | 0.29 |
| CD (P=0.05) | 0.88 |

* Values in the parenthesis are original and ($\sqrt{x+1}$) transformed

Conclusion

In transplanted rice among the different doses of herbicidal treatments T₅ application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 180 g a.i ha⁻¹ using drone recorded the highest plant height, more number of panicles at harvest, grain yield and weed dry weight. It was statistically on par with T₁ application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 120 g a.i ha⁻¹ using knapsack sprayer, T₄ application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 150 g a.i ha⁻¹ using drone and T₃ application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 120 g a.i ha⁻¹ using drone followed by T₂ application of penoxsulam 1.02 % + cyhalofop-butyl 5.1% OD @ 90 g a.i ha⁻¹ using drone.

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