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Weed control efficiency with herbicide application by the combination of Drone and Knapsack sprayer in wheat (*Triticum aestivum* L.)

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Abstract
The field experiment was conducted during *rabi* season of 2020-2021 at experimental farm, Department of Agronomy, Marthwada Krishi Vidyapeeth, Parbhani, Maharashtra with a view to study the effect of different sprayers on weed control in wheat. Experiment was conducted under randomized block design (RBD) with 8 treatments i.e. T_1-Herbicide application by knapsack sprayer PE Metribuzin 70% @ 0.175 kg.a.i ha^{-1} +1HW, T_2- Herbicide application by knapsack sprayer POE Metribuzin 70% @ 0.175 kg.a.i ha^{-1} +1HW, T_3 -Herbicide application by knapsack sprayer PE + drone POE Metribuzin 70% @ 0.175 kg.a.i ha^{-1}, T_4- Cultural methods (cycle hoe at 30, 60 90 DAS), T_5- Herbicide application by drone POE Metribuzin 70% @ 0.175 kg.a.i ha^{-1} +1HW, T_6-Herbicide application by drone with different concentration POE Metribuzin 70% @ 0.175 kg.a.i ha^{-1} (75% less i.e. 0.37 kg ha^{-1}), T_7- Weed free (Hand weeding at 30, 60, 90 DAS), T_8- Weedy check. The gross plot size of experiment field is 7.2m x 6m and net plot size 6.3m x5.6m. Observations and data was recorded for weed count, weed control efficiency and weed index. Highest weed control efficiency and lowest weed index was observed with treatment T_3 -Herbicide application by knapsack sprayer PE + drone POE Metribuzin 70% @ 0.175 kg.a.i ha^{-1}.

Keywords: Drone, knapsack sprayer, Metribuzin, weed, wheat

Introduction
In natural habitat there are four types of plants: crop plants, wild plants, rogue plants, and weed plants. Weeds are those plants which are out of place, unwanted, non useful, often prolific and persistent, competitive, harmful, even poisonous which interfere with agricultural operations, increase labour, add to costs, reduce yields and detract from comforts of life. Weeds interface with the utilization of natural resources, harmful, dangerous, prolific, persistent, resistant, competitive, even poisonous, economically detrimental and can grow under adverse climatic conditions. Weeds are a serious threat to primary production and biodiversity. Weeds compete with crop for water, nutrients and light and have been a matter of great concern to the growers.

Knapsack sprayers are indispensable agricultural tools. Understanding how to use them is essential for the successful application of agricultural chemicals, especially selective post emergence herbicides.

Unmanned Aerial Vehicles (UAVs) also commonly known as Drones are regarded as pilotless aircraft systems used in diverse applications like Industrial monitoring, photography, battlefield surveillance, air ambulance, package delivery and many more. Drones operated by single-operated pilot, are regarded as short distance flying objects, and on the other hand, there are long distance flying drones known for flying at High Altitude. Modern drones are fitted with GPS and camera which can be used by pilot to track and fly the drones to larger distances via making use of GPS enabled smartphones and even portable LCD enabled remote controls. Drones can be categorized in two categories: Fixed Wing Airplanes and Rotary Motor Helicopters Each of these drones has its own advantages and limitations. The fixed wing drones can fly at higher speeds ranging from 25-45 mph and can cover the range of 500 to 750 acres per hour depending on the battery. Rotary motor drones on the other hand can hover and focus on specific problem in real world and can fly over constant speed. They suffer from limited battery life and can take off and land off safely in small confined areas and are absolutely best for starters to learn Drone Flying.

Materials and Methods

An experiment was conducted at experimental farm, Department of Agronomy, Marthwada Krishi Vidyapeeth, Parbhani, Maharashtra. Experiment was conducted under randomized block design (RBD) with 8 treatments i.e. T_1- Herbicide application by knapsack sprayer PE Metribuzin 70% @ 0.175 kg.a.i ha^{-1} +1HW, T_2- Herbicide application by knapsack sprayer POE Metribuzin 70% @ 0.175 kg.a.i ha^{-1} + 1HW, T_3 -Herbicide application by knapsack sprayer PE + drone POE Metribuzin 70% @ 0.175 kg.a.i ha^{-1}, T_4- Cultural methods (cycle hoe at 30, 60 90 DAS), T_5- Herbicide application by drone POE Metribuzin 70% @ 0.175 kg.a.i ha^{-1} + 1HW, T_6-Herbicide application by drone with different concentration POE Metribuzin 70% @ 0.175 kg.a.i ha^{-1} (75% less i.e. 0.37 kg ha^{-1}), T_7- Weed free (Hand weeding at 30, 60, 90 DAS), T_8- Weedy check. The gross plot size of experiment field is 7.2m x 6m and net plot size 6.3m x5.6m. The experimental field was leveled and well drained, clay in texture, medium in available Nitrogen, low in Phosphorus and high in available Potassium.

Variety of wheat used for experimental study was NIAW-301(Trimbak). Sowing was done by tractor on 17 November 2020 with seed rate 125kg/ha.

The pre-emergence done on first day after sowing and post emergence herbicide application was done 35 days after sowing with knapsack sprayer. The water requirement for pre-emergence herbicide application was 682L/ha and post emergence herbicide application require 516L/ha and herbicide requirement was 1.41kg/ha with 70% @ 0.175 kg a.i. ha^{-1}(metribuzin).

The post emergence herbicide application was done with drone sprayer at 35 DAS, water requirement for drone sprayer was 25 L/ha and herbicide used by drone sprayer was Metribuzin 70% WP @ 0.175 kg a.i. ha^{-1}. It was applied 1.41kg/ha for T_3 and T_5. The rate of application for Metribuzin 70% WP @ 0.175 kg a.i. ha^{-1} was reduced by 75 per cent i.e. 0.37 kg ha^{-1} in treatment T_6.

Results and Discussion

Weed count (m^2)

Monocot weed count

The data pertaining to weed count for both monocot and dicot has been presented in Table 1. there were more weed count in treatment (T_8) Weedy check and (T_4) cultural method (cycle hoe at 30, 60, 90 DAS) which was due to improper removal of weeds from cultivable area between two wheat lines and existance of weeds in wheat in wheat line, near the plant root system and lowest weed count was observed in (T_7) Weed free among herbicide treated treatments lowest intensity of monocot weed observed in (T_3) Herbicide application by knapsack sprayer (PE)+Drone (POE) metribuzin 70%@ 0.175 kg a.i. ha^{-1} +1HW.This was due to regular hand weeding in T_7 and herbicide application of PE and POE in T_3. The most dominant monocot weed was *cynodon doctylon* this was in conformity with Bhardwaj *et al*. (2004) [1].

Dicot weed count

lowest dicot weed intensity was observed with treatment (T_7) Weed free and among herbicide treated treatments lowest dicot weed intensity was observed in (T_3) Herbicide application by knapsack sprayer (PE)+Drone (POE) metribuzin 70%@ 0.175 kg a.i. ha^{-1}. This was due to regular hand weeding in T_7 and herbicide application of PE and POE in T_3. where as highest dicot weeds m^{-2} were observed with treatment T_4 cultural method (cycle hoe 30, 60, 90 DAS). Among the both weeds dicot weeds were higher than monocot both at 60 and 90 DAS. These results were in conformity with Rahmatullah *et al*. (2009), Sarfaraz Khan *et al*. (2012), Chhokar *et al*. (2007) [2], Dangwal *et al*. (2010) [4], Bajya *et al*. (2015) [3].

Dry weight of monocot weeds (g)

The dry weight of monocot weeds was significantly influenced due to different treatments. Mean dry weight of monocot weeds ware 27.16, 69.04, 70.69, 73.27g at 30, 60, 90 DAS and at harvest respectively.

At 30 DAS lowest monocot dry weed weight was observed with (T_7) weed free treatment and among herbicide treated treatments the lowest monocot dry weight was observed in (T_3) Herbicide application by knapsack sprayer (PE)+Drone (POE) metribuzin 70%@ 0.175 kg a.i. ha^{-1}. Whereas, highest monocot weeds dry weight was observed with treatment (T_8) weed check and in (T_4) Cultural method (Cycle hoe at 30, 60, 90 DAS).

At 60, 90 DAS and at harvest same trend of dry weight of monocot weeds (kg ha^{-1}) was observed.

Dry weight of dicot weeds (g)

The dry weight of dicot weeds were significantly influenced due to different treatments. Mean dry weight of dicot weeds was 52.20, 93.46, 95.66, 98.34g at 30, 60, 90 DAS and at harvest respectively.

At 30 DAS lowest dicot weed weight was observed with (T_7) Weed free treatment and among the herbicide treatments lowest dicot weed weight was observed in (T_3) Herbicide application by knapsack sprayer (PE) drone + (POE) metribuzin 70% @ 0.175 kg a.i ha^{-1}, and highest dicot weed dry weight was observed with (T_8) Weed check and in (T_4) Cultural method (Cycle hoe 30, 60, 90).

Same trend of dry weight of dicot weeds (g) observed at 60, 90 DAS and at harvest.

Weed control efficiency (%)

The data pertaining to weed control efficiency has been presented in Table 3. For both monocot and dicot weeds highest weed control efficiency (%) was recorded with treatment (T_7) Weed free and among herbicide treated treatments highest weed control efficiency (%) was observed in (T_3) Herbicide application by knapsack sprayer (PE) drone + metribuzin 70% @ 0.175 kg a.i ha^{-1} at 30, 60, 90 DAS and at harvest respectively followed by (T_1) Herbicide application by knapsack sprayer (PE) metribuzin 70% @ 0.175 kg a.i ha^{-1}+1HW. The results of the present quest are in line with the findings of Martin *et al.* (2020) [5], Zhang *et al.* (march 2020) [6].

Weed index (%)

The data on weed index (%) presented in Table 3. revealed that lower weed index was recorded due to (T_3) Herbicide application by knapsack sprayer (PE) drone + (POE) metribuzin 70% @ 0.175 kg a.i ha^{-1} followed by (T_1) Herbicide application by knapsack sprayer PE metribuzin 70% @ 0.175 kg a.i ha^{-1} and highest observed with the treatment (T_8) Weedy check and by (T_4) cultural method (cycle hoe at 30, 60, 90 DAS).

Table 1: Mean weed count m^{-2} as influenced by different treatments at 30, 60, 90 DAS and at harvest

S. No	Treatments	30DAS		60DAS		90 DAS		At harvest	
		monocot	dicot	monocot	dicot	monocot	dicot	monocot	dicot
1	T_1- Herbicide application by knapsack sprayer (PE) metribuzin 70% @ 0.175kg a.i. ha^{-1}+1HW	13.12	16.03	15.76	34.87	30.12	31.64	28.55	29.12
2	T_2- Herbicide application by knapsack sprayer (POE) metribuzin 70% @ 0.175kg a.i. ha^{-1}+1HW	16.76	19.46	17.21	40.76	36.12	37.54	34.14	35.64
3	T_3- Herbicide application by knapsack sprayer (PE)+Drone (POE) metribuzin 70%@ 0.175 kg a.i. ha^{-1}	10.76	11.23	15.43	11.86	10.42	9.88	10.11	8.54
4	T_4-Cultural methods (cycle hoe 30,60,90 DAS)	19.23	24.52	23.16	43.43	39.12	40.78	37.65	38.23
5	T_5- Herbicide application by Drone (POE) metribuzin 70% @ 0.175 kg a.i. ha^{-1} +1HW	17.53	19.89	19.46	42.76	38.43	40.04	36.32	37.87
6	T_6- Herbicide application by drone with different concentration (POE) metribuzin 70% @ 0.175 kg. a.i ha^{-1} (75% less i.e. 0.37 kg ha^{-1})	14.46	17.21	16.03	38.19	34.54	35.21	32.31	33.53
7	T_7- weed free (Hand weeding at 30,60,90 DAS)	8.24	6.45	6.65	8.44	7.98	7.75	6.21	6.12
8	T_8- Weedy check	34.11	42.65	43.65	78.65	83.40	81.43	86.76	84.13
	SE +	1.05	0.92	0.95	1.77	1.64	1.67	1.63	1.57
	C.D. (5%)	3.17	2.79	2.84	5.34	4.95	5.06	2.30	4.7
	General mean	16.77	19.68	20.14	37.37	35.11	35.53	34.00	34.14

Table 2: Mean dry weed weight as influenced by different treatments at 30, 60, 90 DAS and at harvest.

Sr. No	Treatments	30DAS		60DAS		90 DAS		At harvest	
		monocot	dicot	monocot	dicot	monocot	dicot	monocot	dicot
1	T_1- Herbicide application by knapsack sprayer (PE) metribuzin 70% @ 0.175kg a.i. ha^{-1}+1HW	24.12	56.12	65.92	89.13	67.98	90.32	69.75	93.87
2	T_2- Herbicide application by knapsack sprayer (POE) metribuzin 70% @ 0.175kg a.i. ha^{-1}+1HW	29.98	60.31	76.69	107.72	78.65	109.85	80.70	112.62
3	T_3- Herbicide application by knapsack sprayer (PE)+Drone (POE) metribuzin 70%@ 0.175 kg a.i. ha^{-1}	15.42	23.43	27.79	44.89	27.45	47.39	36.64	48.96
4	T_4-Cultural methods (cycle hoe 30,60,90 DAS)	34.43	55.63	87.65	115.13	88.34	117.38	89.42	119.82
5	T_5- Herbicide application by Drone (POE) metribuzin 70% @ 0.175 kg a.i. ha^{-1} +1HW	31.32	61.74	84.82	110.53	85.14	113.87	87.31	115.64
6	T_6- Herbicide application by drone with different concentration (POE) metribuzin70% @ 0.175kg a.i. ha^{-1}(75% less i.e., 0.37 kg ha^{-1}	28.21	59.32	72.62	95.16	75.34	97.43	78.32	99.87
7	T_7- weed free (Hand weeding at 30,60,90 DAS)	5.68	5.67	12.15	12.76	12.15	12.35	14.65	11.32
8	T_8- Weedy check	48.13	95.41	124.65	172.43	130.54	176.73	135.42	184.66
	SE +	1.30	2.44	3.20	4.40	3.40	4.47	3.42	4.56
	C.D. (5%)	3.95	7.38	9.67	13.28	10.27	13.51	10.33	13.79
	General mean	27.16	52.20	69.04	93.46	70.69	95.66	73.27	98.34

Table 3: Weed control efficiency (%) and weed index.

S. No	Treatments	30DAS		60DAS		90 DAS		At harvest		WI (%)
		monocot	dicot	monocot	dicot	monocot	dicot	monocot	dicot	
1	T_1- Herbicide application by knapsack sprayer (PE) metribuzin 70% @ 0.175kg a.i. ha^{-1}+1HW	49.88	41.18	47.08	48.88	47.92	48.89	48.49	49.16	17.5
2	T_2- Herbicide application by knapsack sprayer (POE) metribuzin 70% @ 0.175kg a.i. ha^{-1}+1HW	37.71	36.78	38.47	37.52	39.75	37.84	40.37	38.98	21.09
3	T_3- Herbicide application by knapsack sprayer (PE)+Drone (POE) metribuzin 70%@ 0.175 kg a.i. ha^{-1} +1HW	67.96	75.44	78.23	73.96	78.97	73.18	77.37	73.48	2.78
4	T_4-Cultural methods (cycle hoe) 30,60,90 DAS	28.46	42.74	29.68	33.23	32.32	33.58	33.96	35.10	31.23
5	T_5- Herbicide application by Drone (POE) metribuzin 70% @ 0.175 kg a.i. ha^{-1} +1HW	34.92	33.53	32.00	35.89	34.77	35.56	35.52	37.37	26.57
6	T_6- Herbicide application by drone with different (POE) metribuzin 70% @ 0.175kg a.i. ha^{-1} (75% less i.e. 0.37 kg ha^{-1})	41.38	37.82	41.74	44.81	42.28	44.87	42.16	45.91	17.51
7	T_7- weed free (Hand weeding at 30,60,90 DAS)	88.19	94.05	90.25	92.59	90.69	93.01	89.18	93.16	0
8	T_8- Weedy check	0	0	0	0	0	0	0	0	38.19

Conclusion

The findings of the present investigation revealed that, among weed control treatments the highest weed control efficiency was observed with treatment (T_3) the herbicide application by knapsack sprayer (PE) + drone (POE) metribuzin 70% @ 0.175 kg a.i. ha^{-1} which was 74.82% and lowest weed index was 2.78% which reflects its effectiveness in weed control.

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