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Bio-Efficacy Evaluation of Herbicides for Weed Management in Rabi Onion

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment entitled "Bio-efficacy evaluation of herbicides for weed management in *rabi* onion" was conducted at Weed Control Research Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat) during the *rabi* season of 2021-22 on medium black calcareous soil. The experiment comprising 14 treatments was laid out in a randomized block design with three replications. The results revealed that next to weed-free treatment, tank-mix pendimethalin 450 g/ha + oxyfluorfen 120 g/ha as pre-planting *fb* HW at 40 DATP, tank-mix pendimethalin 450 g/ha + oxyfluorfen 120 g/ha as pre-planting *fb* pre-mix propaquizafop + oxyfluorfen 43.75+105 g/ha at 40 DATP and tank-mix pendimethalin 450 g/ha + oxyfluorfen 120 g/ha as pre-planting *fb* pre-mix quizalofop + oxyfluorfen 100 g/ha at 40 DATP control of complex weed flora, reduced population and dry matter of weeds and having less reduction in yield due to better control of weeds, less crop-weed competition, higher weed control efficiency.

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Keywords: Herbicide mixtures; onion; weed; weed indices.

1. INTRODUCTION

Onion (*Allium cepa* L.) belongs to the *Alliaceae* family and is either biennial or perennial. It is native to Central Asia and the Mediterranean region. Onions must have been grown in India since very ancient times, as mentioned in the *Charak Sanhita*, a famous early medical treatise of India. Charak attributes many virtues to the onion [1-3]. Onion has diuretic properties, is beneficial to the digestive tract, and is recommended for patients with high cholesterol, weakness, and lack of vitality. Onion bulbs are rich in minerals, calcium, phosphorus, carbohydrates, proteins, and vitamin-C [4]. Onion is popularly known as the "*Queen of the kitchen*" because of its characteristic flavour and taste. It promotes appetite, is useful against malaria, and night blindness and lowers blood pressure [5]. Major onion growing states in India are Maharashtra, Bihar, Rajasthan, Andhra Pradesh, West Bengal, Haryana and Uttar Pradesh.

"Weed problems in onions are serious. Onion crops are more prone to weed menace and are usually infested with a wide spectrum of broad-leaf and grassy weeds. Onion has a shallow root system and the non-branching habit makes the onion crop a weak competitor against weeds and it makes the crop unable to cover the soil surface for prevention of weed growth. Ultimately the crop facilitates weed growth by encouraging favourable conditions with sufficient sunlight, air coupled with regular irrigation and high fertilization". [6] "The critical period for weed infestation is between 15 and 45 days after transplanting, resulting in a 69.3% reduction in bulb yield over weed free crops [7]. Effective weed management practices during the critical crop growth stage are essential for obtaining an optimum economic yield. The most effective herbicide currently suitable for weed destruction in onions is oxyfluorfen, as reported by Stall and Gilreath [8]. "The common weed management practice for onion is the pre-emergence application of selective herbicides like pendimethalin, oxyfluorfen and oxadiazon followed by one-hand weeding or use of post-emergences herbicides" [9,10]. "Pre-emergence herbicides offer the most practical, effective, and economical method of weed control to increase the bulb yield of onions" [11]. "Herbicide combinations are more effective tools for taking weed menace, thereby nutrient depletion them than a single herbicide approach" [12]. Chemical weed control, or the use of herbicides, is the only modern tool to manage crop-weed competition. It is easy and convenient to use, and apart from that, it reduces the cost of labour required for hand weeding.

2. MATERIALS AND METHODS

The experiment was conducted during the *rabi* season of 2021-22 at Weed Control Research Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat). The mean maximum and minimum temperature during the crop growth and development period ranged from 24.7 to 42.8 ^{0}C and 9.4 to 26.3 ^{0}C, respectively. The soil of the experimental plot was clayey in texture, high in organic carbon (0.96%) and alkaline in reaction with pH 8.04 and EC 0.57 dS/m. The soil was medium in available nitrogen (406.00 kg/ha), high in available phosphorus (88.23 kg/ha) and available potassium (322.00 kg/ha).

The experiment having 14 treatments *viz.,* pendimethalin 900 g/ha as pre-planting *fb* HW at 40 DATP (T_1), oxyfluorfen 240 g/ha as pre-planting *fb* HW at 40 DATP (T_2), tank-mix pendimethalin 450 g/ha + oxyfluorfen 120 g/ha as pre- planting *fb* HW at 40 DATP (T_3), oxadiargyl 75 g/ha as early post-emergence at 15 DATP *fb* HW at 40 DATP (T_4), tank-mix pendimethalin 450 g/ha + oxyfluorfen 120 g/ha as pre- planting *fb* quizalofop 40 g/ha at 40 DATP (T_5), tank-mix pendimethalin 450 g/ha + oxyfluorfen 120 g/ha as pre- planting *fb* propaquizafop 62.5 g/ha at 40 DATP (T_6), pendimethalin 625 g/ha as pre- planting *fb* pre-mix quizalofop + oxyfluorfen 100 g/ha at 40 DATP (T_7), oxyfluorfen 240 g/ha as pre- planting *fb* pre-mix propaquizafop + oxyfluorfen 43.75+105 g/ha at 40 DATP (T_8), tank-mix pendimethalin 450 g/ha + oxyfluorfen 120 g/ha as pre- planting *fb* pre-mix quizalofop + oxyfluorfen 100 g/ha at 40 DATP (T_9), tank-mix pendimethalin 450 g/ha + oxyfluorfen 120 g/ha as pre- planting *fb* pre-mix propaquizafop + oxyfluorfen 43.75+105 g/ha at 40 DATP (T_{10}), pre-mix quizalofop + oxyfluorfen 100 g/ha as post-planting at 30 DATP (T_{11}), pre-mix propaquizafop + oxyfluorfen 43.75+105 g/ha as post-planting at 30 DATP (T_{12}), weed free check (HW at 15, 30, 45 and 60 DATP) (T_{13}), unweeded check (T_{14}) were laid out in RBD design with 3 replications. The gross and net plot size were 4.0

m x 2.4 m and 3.0 m x 1.8 m, respectively. The onion (*cv*. GJRO-11) was sown on 29th October, 2021 at 15 cm x 10 cm and used for sowing in the nursery for raising the seedlings with a seed rate of 10 kg/ha and harvested on 21 April 2022. The onion was fertilized with 75-60-50 N-P_2O_5-K_2O kg/ha along with FYM 10 t/ha. The herbicides were sprayed as per treatments with the help of a hand (knapsack) operating sprayer using a flat fan nozzle with a spray volume of 500 L/ha.

3. RESULTS AND DISCUSSION

3.1 Effect on Total Weed Count

An analysis of the data found that the different weed management treatments had a notable impact on total weed count. Among the different weed management treatments, nearest to weed-free check, tank-mix pendimethalin 0.45 kg/ha + oxyfluorfen 0.12 kg/ha as pre-planting *fb* HW at 40 DATP and tank-mix pendimethalin 0.45 kg/ha + oxyfluorfen 0.12 kg/ha as pre-planting *fb* pre-mix propaquizafop + oxyfluorfen 43.75+105 g/ha at 40 DATP recorded with the lowest total weed count at 20, 40, 60 DATP and harvest. On the contrary, un-weeded checks recorded significantly the highest total weed count at 20, 40 and, 60 DATP and harvest. These findings are conform with those of Udit et al. [13] and Rakesh and Pramod [14].

3.2 Effect on Dry Weight of Total Weeds

An analysis of the data showed that the diverse weed control strategies had a notable impact on the dry weight of total weeds. Among the different weed management treatments, the weed-free check (T_{13}) recorded significantly lowest dry weight of total weeds at 20, 40 and, 60 DATP and harvest, The next superior treatments in this regard was tank-mix pendimethalin 0.45 kg/ha + oxyfluorfen 0.12 kg/ha as pre-planting fb HW at 40 DATP (T_3) and tank-mix pendimethalin 0.45 kg/ha + oxyfluorfen 0.12 kg/ha as pre-planting fb pre-mix propaquizafop + oxyfluorfen 43.75+105 g/ha at 40 DATP (T_{10}). Whereas, the highest dry weight of total weeds at 20, 40 and, 60 DATP and harvest was recorded under the unweeded check (T_{14}). These outcomes resemble those published by Angmo and Chopra [15], Jagadeesha et al. [16], and Sahu et al. [17].

3.3 Effect on Weed Indices

A Data revealed that many weed control techniques had a substantial impact on the weed indices. Besides the treatment weed free check, lower WI/WCI was recorded in tank-mix pendimethalin 0.45 kg/ha + oxyfluorfen 0.12 kg/ha as pre-planting fb HW at 40 DATP and higher WCE was noted under tank-mix pendimethalin 0.45 kg/ha + oxyfluorfen 0.12 kg/ha as pre-planting fb pre-mix propaquizafop + oxyfluorfen 43.75+105 g/ha at 40 DATP. Among the different herbicidal treatments, higher HEI was registered under tank-mix pendimethalin 0.45 kg/ha + oxyfluorfen 0.12 kg/ha as pre-planting fb HW at 40 DATP. The higher WPI was observed under oxadiargyl 75 g/ha as early post-emergence at 15 DATP fb HW at 40 DATP and higher CRI was recorded under weed free check. The higher WMI, AMI and IWMI were higher under pre-mix quizalofop + oxyfluorfen 100 g/ha as post planting at 30 DATP followed by tank-mix pendimethalin 0.45 kg/ha + oxyfluorfen 0.12 kg/ha as pre-planting fb HW at 40 DATP. The current results are in similar proximity to those that have been documented with other weed control methods by Thakare et al. [18], Pushpa and Choudhary [19] Tripathy et al. [20], Swati et al. [21].

Table 1. Effect of various weed management treatments on total weed count

Treatments	Total weed count (No./m^2)			
	20 DATP	**40 DATP**	**60 DATP**	**Harvest**
T_1 : Pendimethalin 0.90 kg ha^{-1} as PPI *fb* HW at 40 DATP	2.72 (7.00)	3.34 (10.67)	3.07 (9.00)	3.58 (12.33)
T_2 : Oxyfluorfen 0.24 kg ha^{-1} as PPI *fb* HW at 40 DATP	1.84 (3.00)	3.06 (9.00)	2.79 (7.33)	3.89 (14.67)
T_3 : Tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as PPI *fb* HW at 40 DATP	2.09 (4.00)	2.55 (6.00)	2.61 (6.33)	2.91 (8.00)
T_4 : Oxadiargyl 75 g ha^{-1} as early PoE at 7 DAS *fb* HW at 40 DATP	3.02 (8.67)	3.64 (13.00)	3.28 (10.33)	3.94 (15.00)

Treatments	Total weed count (No./m^2)			
	20 DATP	40 DATP	60 DATP	Harvest
T_5 : Tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as PPI *fb* quizalofop 40 g ha^{-1} at 40 DATP	2.45 (5.67)	3.12 (9.33)	3.18 (9.67)	4.02 (15.67)
T_6 : Tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as PPI *fb* propaquizafop 62.5 g ha^{-1} at 40 DATP	2.81 (7.67)	3.61 (12.67)	3.52 (12.00)	4.25 (17.67)
T_7 : Pendimethalin 0.625 kg ha^{-1} as PPI *fb* pre-mix quizalofop + oxyfluorfen 100 g ha^{-1} at 40 DATP	2.84 (7.67)	3.08 (9.00)	3.13 (9.33)	3.67 (13.00)
T_8 : Oxyfluorfen 0.24 kg ha^{-1} as PPI *fb* pre-mix propaquizafop + oxyfluorfen 43.75+105 g ha^{-1} at 40 DATP	2.48 (5.67)	2.73 (7.00)	2.66 (6.67)	3.13 (9.33)
T_9 : Tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as PPI *fb* pre-mix quizalofop + oxyfluorfen 100 g ha^{-1} at 40 DATP	2.26 (4.67)	2.80 (7.33)	2.41 (5.33)	3.07 (9.00)
T_{10} :Tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as PPI *fb* pre-mix propaquizafop + oxyfluorfen 43.75+105 g ha^{-1} at 40 DATP	1.93 (3.33)	2.24 (4.67)	2.26 (4.67)	2.72 (7.00)
T_{11} :Pre-mix quizalofop + oxyfluorfen 100 g ha^{-1} as PoE at 30 DATP	4.17(17.00)	3.70 (13.33)	4.41 (19.00)	4.88 (23.33)
T_{12} :Pre-mix propaquizafop + oxyfluorfen 43.75+105 g ha^{-1} as PoE at 30 DATP	4.19(17.33)	3.72 (13.33)	4.41 (19.00)	5.03 (25.00)
T_{13} :Weed free check	0.71 (0.00)	1.34 (1.33)	1.46 (1.67)	1.95 (3.33)
T_{14} : Unweeded check	5.34(28.00)	6.18 (38.00)	6.72 (44.67)	7.35 (53.67)
S.Em.±	0.25	0.21	0.14	0.16
C.D. at 5%	0.72	0.62	0.42	0.48
C.V.%	15.48	11.49	7.65	7.33

PPI: pre-planting, PoE: post-emergence, HW: Hand weeding, DATP: Days after transplanting

Table 2. Effect of diverse weed management treatments on dry weight of total weeds

Treatments	Dry weight of total weeds (g/m^2)			
	20 DATP	40 DATP	60 DATP	Harvest
T_1 : Pendimethalin 0.90 kg ha^{-1} as PPI *fb* HW at 40 DATP	0.89	2.45	18.80	26.92
T_2 : Oxyfluorfen 0.24 kg ha^{-1} as PPI *fb* HW at 40 DATP	0.70	2.66	18.55	31.23
T_3 : Tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as PPI *fb* HW at 40 DATP	0.30	0.89	7.67	15.67
T_4 : Oxadiargyl 75 g ha^{-1} as early PoE at 7 DAS *fb* HW at 40 DATP	0.97	2.84	22.38	39.77
T_5 : Tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as PPI *fb* quizalofop 40 g ha^{-1} at 40 DATP	0.79	2.15	18.63	37.17
T_6 : Tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as PPI *fb* propaquizafop 62.5 g ha^{-1} at 40 DATP	0.91	2.30	23.87	40.93
T_7 : Pendimethalin 0.625 kg ha^{-1} as PPI *fb*	0.80	2.17	11.71	31.48

Treatments	Dry weight of total weeds (g/m^2)			
	20 DATP	40 DATP	60 DATP	Harvest
pre-mix quizalofop + oxyfluorfen 100 g ha^{-1} at 40 DATP				
T_8 :Oxyfluorfen 0.24 kg ha^{-1} as PPI *fb* pre-mix propaquizafop + oxyfluorfen 43.75+105 g ha^{-1} at 40 DATP	0.76	1.23	9.93	19.57
T_9 :Tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as PPI *fb* pre-mix quizalofop + oxyfluorfen 100 g ha^{-1} at 40 DATP	0.59	1.16	9.03	16.42
T_{10} :Tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as PPI *fb* pre-mix propaquizafop + oxyfluorfen 43.75+105 g ha^{-1} at 40 DATP	0.42	1.00	7.61	14.00
T_{11} :Pre-mix quizalofop + oxyfluorfen 100 g ha^{-1} as PoE at 30 DATP	1.54	2.69	35.92	46.67
T_{12} :Pre-mix propaquizafop + oxyfluorfen 43.75+105 g ha^{-1} as PoE at 30 DATP	1.59	3.02	38.46	53.00
T_{13} :Weed free check	0.00	0.36	1.10	3.22
T_{14} : Unweeded check	2.21	32.17	95.33	120.33
S.Em.±	0.12	0.44	1.88	3.14
C.D. at 5%	0.36	1.27	5.45	9.13
C.V.%	23.96	18.53	14.26	15.34

Table 3. Effect of different weed management treatments on various weed indices

Treatments	WI/WCI (%)	WCE (%)	HEI
T_1 : Pendimethalin 0.90 kg ha^{-1} as PPI *fb* HW at 40 DATP	9.73	78.47	2.27
T_2 : Oxyfluorfen 0.24 kg ha^{-1} as PPI *fb* HW at 40 DATP	16.09	75.07	1.80
T_3 : Tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as PPI *fb* HW at 40 DATP	2.69	88.39	4.52
T_4 : Oxadiargyl 75 g ha^{-1} as early PoE at 7 DAS *fb* HW at 40 DATP	21.90	67.99	1.27
T_5 : Tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as PPI *fb* quizalofop 40 g ha^{-1} at 40 DATP	15.51	70.25	1.52
T_6 : Tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as PPI *fb* propaquizafop 62.5 g ha^{-1} at 40 DATP	15.49	66.01	1.33
T_7 : Pendimethalin 0.625 kg ha^{-1} as PPI *fb* pre-mix quizalofop + oxyfluorfen 100 g ha^{-1} at 40 DATP	14.79	75.07	1.83
T_8 : Oxyfluorfen 0.24 kg ha^{-1} as PPI *fb* pre-mix propaquizafop + oxyfluorfen 43.75+105 g ha^{-1} at 40 DATP	8.51	84.42	3.17
T_9 : Tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as PPI *fb* pre-mix quizalofop + oxyfluorfen 100 g ha^{-1} at 40 DATP	9.58	86.97	3.75
T_{10} :Tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as PPI *fb* pre-mix propaquizafop + oxyfluorfen 43.75+105 g ha^{-1} at 40 DATP	4.33	87.82	4.24
T_{11} :Pre-mix quizalofop + oxyfluorfen 100 g ha^{-1} as PoE at 30 DATP	22.16	60.91	1.04
T_{12} :Pre-mix propaquizafop + oxyfluorfen 43.75+105 g ha^{-1} as PoE at 30 DATP	20.50	56.09	0.95
T_{13} :Weed free check	0.00	97.93	-
T_{14} : Unweeded check	53.77	0.00	-

WI/ WCI: Weed Index/ Weed Competition Index, WCE: Weed Control Efficiency, HEI: Herbicidal Efficiency Index

Table 4. Effect of distinct weed management treatments on various weed indices

Treatments	CRI	WPI	WMI	AMI	IWMI
T_1 :Pendimethalin 0.90 kg ha^{-1} as PPI *fb* HW at 40 DATP	9.43	0.94	1.21	0.21	0.71
T_2 :Oxyfluorfen 0.24 kg ha^{-1} as PPI *fb* HW at 40 DATP	7.53	0.91	1.09	0.09	0.59
T_3 :Tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as PPI *fb* HW at 40 DATP	18.76	0.78	1.25	0.25	0.75
T_4 :Oxadiargyl 75 g ha^{-1} as early PoE at 7 DAS *fb* HW at 40 DATP	5.47	1.15	1.01	0.01	0.51
T_5 :Tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as PPI *fb* quizalofop 40 g ha^{-1} at 40 DATP	6.36	1.02	1.18	0.18	0.68
T_6 :Tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as PPI *fb* propaquizafop 62.5 g ha^{-1} at 40 DATP	5.57	1.03	1.25	0.25	0.75
T_7 :Pendimethalin 0.625 kg ha^{-1} as PPI *fb* pre-mix quizalofop + oxyfluorfen 100 g ha^{-1} at 40 DATP	7.69	1.03	1.12	0.12	0.62
T_8 :Oxyfluorfen 0.24 kg ha^{-1} as PPI *fb* pre-mix propaquizafop + oxyfluorfen 43.75+105 g ha^{-1} at 40 DATP	13.22	0.90	1.16	0.16	0.66
T_9 :Tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as PPI *fb* pre-mix quizalofop + oxyfluorfen 100 g ha^{-1} at 40 DATP	15.58	0.78	1.10	0.10	0.60
T_{10} :Tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as PPI *fb* pre-mix propaquizafop + oxyfluorfen 43.75+105 g ha^{-1} at 40 DATP	17.56	0.93	1.22	0.22	0.72
T_{11} :Pre-mix quizalofop + oxyfluorfen 100 g ha^{-1} as PoE at 30 DATP	4.48	0.90	1.12	0.12	0.62
T_{12} :Pre-mix propaquizafop + oxyfluorfen 43.75+105 g ha^{-1} as PoE at 30 DATP	4.05	0.94	1.28	0.28	0.78
T_{13} :Weed free check	108.62	0.33	1.19	0.19	0.69
T_{14} : Unweeded check	1.00	1.00	-	-	-

CRI: Crop Resistance Index, WPI: Weed Persistence Index, WMI: Weed Management Index AMI: Agronomic Management Index, IWMI: Integrated Weed Management Index

4. CONCLUSIONS

Based on the finding, it can be concluded that effective control of complex weed flora with profitable production of onion can be achieved by application of tank-mix pendimethalin 450 g/ha + oxyfluorfen 120 g/ha as pre-planting *fb* HW at 40 DATP, tank-mix pendimethalin 450 g/ha + oxyfluorfen 120 g/ha as pre-planting *fb* pre-mix propaquizafop + oxyfluorfen 43.75+105 g/ha at 40 DATP and tank-mix pendimethalin 450 g/ha + oxyfluorfen 120 g/ha as pre-planting *fb* pre-mix quizalofop + oxyfluorfen 100 g/ha at 40 DATP.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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