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Effect of weed management on growth and yield of *Rabi* onion

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Abstract
A trial entitled "Effect of weed management on growth and yield of *rabi* onion" was carried out in the Weed Control Research Farm, Junagadh Agricultural University, Junagadh, on medium black calcareous soil during the *rabi* season of 2021–2022. The 14-treatments experiment was set up in a randomized block design with three replications. The findings showed that next to weed free treatment, tank-mix pendimethalin 450 g ha^{-1} + oxyfluorfen 120 g ha^{-1} as pre-planting *fb* HW at 40 DATP (T_3), tank-mix pendimethalin 450 g ha^{-1} + oxyfluorfen 120 g ha^{-1} as pre-planting *fb* pre-mix propaquizafop + oxyfluorfen 43.75+105 g ha^{-1} at 40 DATP (T_{10}) and tank-mix pendimethalin 450 g ha^{-1} + oxyfluorfen 120 g/ha as pre-planting *fb* pre-mix quizalofop + oxyfluorfen 100 g ha^{-1} at 40 DATP (T_9) enhanced growth characteristics, such as the number of leaves per plant and neck thickness; yield characteristics, such as bulb weight, equatorial diameter, and polar diameter; and finally produced better bulb and stover yields. Also gave significantly higher gross and net returns as well as BCR.

Keywords: Economics, growth, herbicide mixtures, onion, yield

Introduction
A member of the *Alliaceae* family, onions (*Allium cepa* L.) are biennial or perennial plants. It is indigenous to the Mediterranean region and Central Asia. Its semi-cylindrical leaves sprout from a subterranean bulb with short, hardly branching roots that are fascicled. The stem is upright, and at the tip of the stem, a cluster of tiny white or greenish-white flowers resembles an umbel. The fruit is actually a capsule filled with flat, black seeds. Onions have significant culinary, nutritional, and therapeutic value in people's daily lives everywhere. Onion is the best medicine for treating sunstroke. Onion bulbs are rich in minerals, calcium, phosphorus, carbohydrate, proteins and vitamin-C (Rahman *et al*., 2013) [14]. A key element for minimizing coronary heart disease may be onions. (Sangha and Bering, 2003) [17]. Onion is widely recognized as "*Queen of kitchen*" due to its distinctive flavor and taste. The pungency in onions is due to the colourless and odourless volatile compound *allyl-propyl di-sulfide*, which is sulphur-rich compound. China is the world's top producer of onions, with India coming in second place with 8.9% of global exports. With a yield of 31.27 million tons and a productivity of 16.34 t/ha, onions are produced on 1.91 million hectares in India. Gujarat's production on an area of 0.10 million hectares was 25.55 t/ha, yielding 2.55 million tons (Anon, 2022) [1].

There are major weed issues with onions. A significant decrease in bulb output was noted as a result of weed invasion. It is recognized as a crop-killing quiet killer (Priya *et al.*, 2017) [13]. One of the most crucial problems with onions is weed control. With onions because of their close spacing, which reduces crop production and lowers earnings. To achieve optimal plant growth, a greater yield, and higher-quality onions, proper weed control is crucial (Jagadeesha *et al.*, 2020) [8]. Onions have been found to have regrettable crop-weed competition (Channapagoudar and Biradar, 2007; Barla and Upasani, 2019) [4, 3]. It has long been known that crop weed competition is a significant barrier to onion production, resulting in 40–80% reductions in bulb and seed output (Channapagoudar and Biradar, 2007; Sharma *et al*., 2009 and Ramalingam *et al*., 2013) [4, 18, 16]. According to Chopra and Chopra (2007) [5], the critical time for onion crop-weed competition is between 15 and 60 DAT. The sole method available now to regulate crop-weed competition is chemical weed control, or the application of herbicides.

In addition to being simple and handy to use, it lowers the cost of labour needed for manual weeding.

Materials and Methods

In Junagadh, the experiment was conducted during the 2021–2022 *rabi* season at the Weed Control Research Farm. Throughout the crop growth and development period, the mean maximum and lowest temperatures varied from 24.7 to 42.8 ^{0}C and 9.4 to 26.3 ^{0}C, respectively. Fourteen treatments were arranged in an RBD design with three replications for the experiment. The experimental plot's soil had a clayey texture, a high level of organic carbon (0.96%), and an alkaline pH of 8.04 with an EC of 0.57 dS m^{-1}. The soil exhibited a medium level of accessible nitrogen (406.00 kg ha^{-1}), along with high levels of available phosphorus (88.23 kg ha^{-1}) and potassium (322.00 kg ha^{-1}).

The onion (*cv*. GJRO-11) was sown on 29th October, 2021 at 15 cm x 10 cm using for sowing in nursery for raising the seedlings with seed rate of 10 kg ha^{-1}and harvested on 21 April 2022. The onion was fertilized with 75-60-50 NPK kg ha^{-1}along with FYM 10 t ha^{-1}. Herbicides were sprayed according to treatments using a hand (knapsack) sprayer with a flat fan nozzle and a spray capacity of 500 L/ha. The data were statistically examined using the proper analysis of variance, following the guidelines provided by Gomez and Gomez (1984) [6]. The important difference (CD) values/DNMRT were computed for every F value that was determined to be significant at the 5% level of probability in order to compare the treatment means.

Results and Discussion

A. Effect on growth parameters

Analyzing plant height data (Table 1) revealed that there was no discernible statistical difference between the different weed management methods. As a result, it is said that there was no negative impact of weed management techniques on onion plant height. An appraisal of data on growth parameters showed that noticeably higher values of the growth characteristics, *viz*., number of leaves per plant and neck thickness, were observed under the weed free check (T_{13}), followed by tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as pre-planting *fb* HW at 40 DATP (T_3), tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as pre-planting *fb* pre-mix propaquizafop + oxyfluorfen 43.75+105 g ha^{-1} at 40 DATP (T_{10}), and tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as pre-planting *fb* pre-mix quizalofop + oxyfluorfen 100 g ha^{-1} at 40 DATP (T_9). This might be due to weed-free environment also preserved growth inputs such as light, moisture, nutrients, and space, and it also improved the edaphic and nutritional conditions in the root zone, which in turn enhanced the onion's growth parameter. These results are nearly identical to those of Priya *et al.* (2017) [13], Jagadeesha *et al.* (2020) [8] and Khan *et al.* (2021) [10].

Table 1: Effect of diverse weed management treatments on plant height, no. of leaves/ plant, neck thickness and equatorial diameter of bulb of onion

Treatments	Plant height (cm)	No. of leaves/ plant	Neck thickness (mm)	Equatorial diameter of bulb (mm)
T_1: Pendimethalin 0.90 kg ha^{-1} as PPI *fb* HW at 40 DATP	47.86	9.79 ab	9.87 abc	52.10 ab
T_2: Oxyfluorfen 0.24 kg ha^{-1} as PPI *fb* HW at 40 DATP	43.99	8.50 abc	8.19 bc	50.87 abc
T_3: Tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as PPI *fb* HW at 40 DATP	49.16	9.97 ab	10.77 ab	53.03 ab
T_4: Oxadiargyl 75 g ha^{-1} as early PoE at 7 DAS *fb* HW at 40 DATP	47.72	8.33 bc	9.48 abc	49.60 bc
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	46.58	8.61 abc	8.93 bc	50.43 bc
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	47.77	8.57 abc	8.86 bc	51.53 ab
T_7: Pendimethalin 0.625 kg ha^{-1} as PPI *fb* pre-mix quizalofop + oxyfluorfen 100 g ha^{-1} at 40 DATP	48.05	9.83 ab	9.88 abc	52.07 ab
T_8: Oxyfluorfen 0.24 kg ha^{-1} as PPI *fb* pre-mix propaquizafop + oxyfluorfen 43.75+105 g ha^{-1} at 40 DATP	48.53	9.84 ab	10.02 abc	52.70 ab
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	48.02	9.89 ab	10.35 ab	52.63 ab
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	48.69	9.96 ab	10.63 ab	52.80 ab
T_{11}: Pre-mix quizalofop + oxyfluorfen 100 g ha^{-1} as PoE at 30 DATP	47.14	8.27 bc	8.14 bc	49.00 bcd
T_{12}:Pre-mix propaquizafop + oxyfluorfen 43.75+105 g ha^{-1} as PoE at 30 DATP	45.90	6.87 cd	7.65 c	47.23 cd
T_{13}: Weed free check	49.18	10.33 a	12.00 a	54.80 a
T_{14}: Unweeded check	40.85	6.20 d	7.37 c	45.23 d
S.Em.±	3.06	0.58	0.79	1.21
C.D. at 5%	NS	1.69	2.29	3.52
C.V.%	11.24	11.30	14.43	4.11

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

B. Effect on yield attributes

An analysis of the data (Tables 1 and 2) revealed that the different weed control strategies had a notable impact on yield, influencing characteristics such as bulb weight, polar diameter, and equatorial diameter. Among the different weed management treatments, nearest to weed-free check (T_{13}), tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as pre-planting *fb* HW at 40 DATP (T_3), tank-mix pendimethalin 0.45 kg ha^{-1} + Oxyfluorfen 0.12 kg ha^{-1} as pre-planting *fb* pre-mix propaquizafop + oxyfluorfen 43.75+105 g ha^{-1} at 40 DATP (T_{10}), tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as pre-planting *fb* pre-mix quizalofop + oxyfluorfen 100 g ha^{-1} at 40 DATP (T_9), oxyfluorfen 0.24 kg ha^{-1} as pre-planting *fb* pre-mix propaquizafop + oxyfluorfen 43.75+105 g ha^{-1} at 40 DATP (T_8), pendimethalin 0.625 kg ha^{-1} as pre-planting *fb* pre-mix quizalofop + oxyfluorfen 100 g ha^{-1} at 40 DATP (T_7) and pendimethalin 0.90 kg ha^{-1} as pre-planting *fb* HW at 40 DATP (T_1) enhanced yield attributing characters like equatorial diameter of bulb, polar diameter of bulb and bulb weight. It's possible that less crop weed competition preserved a large

amount of nutrients for the crop and led to profuse growth, which allowed the crop to absorb more soil moisture and nutrients from deeper soil layers, which is why traits like bulb weight, polar diameter, and equatorial diameter are associated with higher yields. These outcomes resemble those published by Patel *et al.* (2011) [11], Apurva *et al.* (2018) [2], and Sourabh *et al.* (2020) [19].

Table 2: Effect of various weed management treatments on polar diameter of bulb, bulb weight, bulb and stover yields of onion

Treatments	Polar diameter of bulb (mm)	Bulb weight (g)	Bulb yield (kg/ha)	Stover yield (kg/ha)
T_1: Pendimethalin 0.90 kg ha^{-1} as PPI *fb* HW at 40 DATP	37.53 abc	56.33 abcd	22945 abc	920 abc
T_2: Oxyfluorfen 0.24 kg ha^{-1} as PPI *fb* HW at 40 DATP	35.00 cde	51.33 defg	21328 bc	728 de
T_3: Tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as PPI *fb* HW at 40 DATP	39.10 ab	58.00 ab	24737 ab	868 abcd
T_4: Oxadiargyl 75 g ha^{-1} as early PoE at 7 DAS *fb* HW at 40 DATP	35.50 bcde	52.33 cdef	19851 c	722 de
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	35.43 bcde	51.67 def	21478 bc	745 cde
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	36.27 abcd	52.67bcdef	21482 bc	770 bcde
T_7: Pendimethalin 0.625 kg ha^{-1} as PPI *fb* pre-mix quizalofop + oxyfluorfen 100 g ha^{-1} at 40 DATP	37.13 abc	55.33 abcde	21660 abc	882 abcd
T_8: Oxyfluorfen 0.24 kg ha^{-1} as PPI *fb* pre-mix propaquizafop + oxyfluorfen 43.75+105 g ha^{-1} at 40 DATP	37.87 abc	56.67 abcd	23257 abc	945 ab
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	38.83 ab	57.67 abc	22983 abc	873 abcd
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	37.90 abc	58.33 a	24319 ab	825 abcd
T_{11}: Pre-mix quizalofop + oxyfluorfen 100 g ha^{-1} as PoE at 30 DATP	34.60 de	50.67 efg	19787 c	800 abcde
T_{12}: Pre-mix propaquizafop + oxyfluorfen 43.75+105 g ha^{-1} as PoE at 30 DATP	33.00 e	49.00 fg	20207 c	707 de
T_{13}: Weed free check	39.90 a	60.00 a	25419 a	978 a
T_{14}: Unweeded check	31.80 e	45.67 g	11752 d	625 e
S.Em.±	1.10	1.71	1151	54
C.D. at 5%	3.21	4.97	3348	157
C.V.%	5.25	5.48	9.27	11.49

C. Effect on crop yield

A data narrated in Table 2 showed revealed that many weed control techniques had a substantial impact on the yields of stover and onion bulbs. Notably, there were increased yields of onion bulb and stover were seen with the weed-free check (T_{13}), followed by tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as pre-planting *fb* pre-mix quizalofop + oxyfluorfen 100 g ha^{-1} at 40 DATP (T_9), tank-mix pendimethalin 0.45 kg ha^{-1} + Oxyfluorfen 0.12 kg ha^{-1} as pre-planting *fb* pre-mix propaquizafop + oxyfluorfen 43.75+105 g ha^{-1} at 40 DATP (T_{10}), oxyfluorfen 0.24 kg ha^{-1} as pre-planting *fb* pre-mix propaquizafop + oxyfluorfen 43.75+105 g ha^{-1} at 40 DATP (T_8), pendimethalin 0.90 kg ha^{-1} as pre-planting *fb* HW at 40 DATP (T_1) and tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as pre-planting *fb* HW at 40 DATP (T_3). Greater weed control under these treatments may have encouraged increased nutrient and water intake, which could be the reason for higher bulb and stover yields. The current results are in similar proximity to those that have been documented with other weed control methods by Ramalingam *et al.* (2013) [16], Gyani *et al.* (2020) [7] and Rahul *et al.* (2020) [15].

Table 3: Effect of distinct weed management treatments on economics of onion

Treatments	Gross return (₹/ha)	Cost of cultivation (₹/ha)	Net return (₹/ha)	B:C Ratio
T_1: Pendimethalin 0.90 kg ha^{-1} as PPI *fb* HW at 40 DATP	344635	113619	231016	3.03
T_2: Oxyfluorfen 0.24 kg ha^{-1} as PPI *fb* HW at 40 DATP	320289	119124	201165	2.69
T_3: Tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as PPI *fb* HW at 40 DATP	371484	112804	258680	3.29
T_4: Oxadiargyl 75 g ha^{-1} as early PoE at 7 DAS *fb* HW at 40 DATP	298131	116024	182107	2.57
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	322538	108839	213698	2.96
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	322620	108452	214168	2.97
T_7: Pendimethalin 0.625 kg ha^{-1} as PPI *fb* pre-mix quizalofop + oxyfluorfen 100 g ha^{-1} at 40 DATP	325341	110051	215290	2.96
T_8: Oxyfluorfen 0.24 kg ha^{-1} as PPI *fb* pre-mix propaquizafop + oxyfluorfen 43.75+105 g ha^{-1} at 40 DATP	349323	110881	238442	3.15
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	345187	110425	234762	3.13
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	365193	110506	254686	3.30
T_{11}: Pre-mix quizalofop + oxyfluorfen 100 g ha^{-1} as PoE at 30 DATP	297210	107509	189701	2.76
T_{12}: Pre-mix propaquizafop + oxyfluorfen 43.75+105 g ha^{-1} as PoE at 30 DATP	303464	107590	195873	2.82
T_{13}: Weed free check	381779	127727	254052	2.99
T_{14}: Unweeded check	176593	103941	72652	1.70

D. Economics

The data in Table 3 was analyzed, and the results showed that the cultivation cost (127727 ₹/ha) and highest gross profits (381779 ₹/ha) were obtained with weed free (T_{13}). The higher gross returns under this treatment could be due to better bulb and stover yields. The higher cost of cultivation under this treatment was owing to higher cost of manual weeding and pre-planting herbicides and its application cost. Maximum net realization of (258680 ₹/ha) and higher B:C ratio (3.29) was obtained with the application of tank-mix pendimethalin 0.45 kg ha^{-1} + oxyfluorfen 0.12 kg ha^{-1} as pre-planting *fb* pre-mix propaquizafop + oxyfluorfen 43.75+105 g ha^{-1} at 40 DATP (T_3). This may be the result of integrating hand weeding, pre-planting, and post-emergence herbicides to effectively and efficiently control weeds; In addition to increased onion stover and bulb yields, the comparatively cheaper cost of herbicides when compared to hand weeding contributed to the larger advantages under these treatments. The outcomes correspond with those of Chopra and Chopra (2007) [5], Tripathy *et al*. (2019) [20], Pramod and Rakesh (2021) [12].

Conclusion

Based on the results, it is possible to produce onions profitably and effectively control complex weed flora with a greater yield by either application of tank-mix pendimethalin 450 g ha^{-1} + oxyfluorfen 120 g ha^{-1} as pre-planting *fb* HW at 40 DATP or tank-mix pendimethalin 450 g ha^{-1} + oxyfluorfen 120 g ha^{-1} as pre-planting *fb* pre-mix propaquizafop + oxyfluorfen 43.75+105 g ha^{-1} at 40 DATP or tank-mix pendimethalin 450 g ha^{-1} + oxyfluorfen 120 g ha^{-1} as pre-planting *fb* pre-mix quizalofop + oxyfluorfen 100 g ha^{-1} at 40 DATP or oxyfluorfen 240 g ha^{-1} as pre-planting *fb* pre-mix propaquizafop + oxyfluorfen 43.75+105 g ha^{-1} at 40 DATP or pendimethalin 900 g ha^{-1} as pre-planting *fb* HW at 40 DATP.

Author's contributions

Each author worked collaboratively to complete this research project. The completed work was read and approved by all writers.

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