

Efficacy of Oxyfluorfen Herbicide on the Weed Control, Yield and Profitability of Onion (*Allium cepa* L.)

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Abstract: A field study was conducted at Spices Research Sub-Centre (SRSC), Bangladesh Agricultural Research Institute (BARI), Faridpur, Bangladesh during winter season of 2021-2022 to find out the efficacy of weed control practices on the growth, yield, quality and profitability of onion with the variety BARI Piaz-4. In the study eight treatments such as: T₁- control as check (no weeding), T₂- 3 HW at 25, 45 and 65 DAT, T₃- 4 HW at 24, 45, 65 and 85 DAT, T₄- PE spray of oxyfluorfen, T₅- PE spray of oxyfluorfen + one HW at 45 DAT, T₆- POE spray of oxyfluorfen at 45 DAT, T₇- PE spray of oxyfluorfen + POE spray of oxyfluorfen at 45 DAT and T₈- PE spray of oxyfluorfen + two HW at 45 & 65 DAT were compared. Oxyfluorfen 23.5 EC @ 250g a.i./litre was used in the experiment. The study was investigated in a randomized complete block design with three replications. The study revealed that the weed control treatments under the study significantly influenced the characters of weed growth and parameters of growth, development, yield, quality & profitability of onion except neck size and dry matter of bulb. The trial field of onion was infested with 14 species of weeds. Among them, *Chenopodium album* (lambquarters/bathua) was found as predominant weed with average relative weed composition (59.06%) followed by RWC (18.43%) of *Physalis angulata* (cutleaf ground cherry). The T₃ gave the highest WCE (97.99%) insignificantly followed by T₂ (96.58%), T₈ (89.41%) and T₅ (87.13%). The lowest WCE (38.08%) was observed with T₄. The T₃ had the maximum fresh yield of onion bulb (19.27 t/ha) insignificantly followed by T₂ (18.76 t/ha) and T₈ (18.09 t/ha). However, the T₁ produced the lowest fresh yield of onion bulb (8.83 t/ha). The highest benefit-cost ratio (BCR) was calculated from the T₅ (2.38) closely followed by T₈ (2.36) and T₂ (2.33). Nevertheless, the lowest BCR (1.36) was obtained from the T₁ followed by the T₄ (1.79). Growing Transplanting Aman rice before onion crop suppressed emergence of *Cyperus rotundus* (mutha) under the present study.

Keywords: Onion (*Allium cepa* L.), weeding, oxyfluorfen, Hand weeding, Pre-emergence and post emergence

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Introduction

Weeds constitute one of the serious problems in agriculture that not only reduce the yield and quality of onion but also utilize essential nutrients, space, soil moisture and light (Ramalingam *et al.*, 2013). Onion (*Allium cepa* L.) exhibits greater susceptibility to weed competition as compared to the other crops due to its inherent characteristics such as their slow growth, small nature, shallow roots and lack of dense foliage (Dhananivetha *et al.*, 2017). Ramalingam *et al.* (2013), Vijayvergiya *et al.* (2018), Khan *et al.* (2013) and Rameshwar *et al.* (2001) found 40-80%, 30-60%, 42.3%, 94.7% yield reduction in onion, respectively due to crop-weed competition. Onion producers face serious problem for getting higher quality and quantity productivity of onion due to infestation of weeds. Removing weeds throughout the growing season may not be economical. Therefore, onion crop must be kept weed free during its critical period, 55 DAT (Khan *et al.*, 2013); 20-60 DAT (Chopra and Chopra, 2006); 50 DAT (Qasem, 2005) and 60 DAT (Rameshwar *et al.*, 2001) to avoid yield reduction and to gain economic return. The effective weed control involves identification of weed flora, method of weed control (manual, cultural, chemical, mechanical and biological) and judicious combination of effective weed control methods (Dhananivetha *et al.*, 2017). Weed management methods, best suited for an individual grower, depend on several factors such as present weed species, crop variety, crop growth stage, weed species, labour cost and availability (Bell and Boutwell, 2001). Hand weeding (4 or 3 HW) gave better results on weed density and yield contributing characters than chemical control (Waseem-ul-Hassan and Malik, 2001) but they did not computed economics aspect under their study. Critically viewing, the conventional method of weed control with only hand/hoe is extremely laborious, time consuming, expensive, less effective (Dhananivetha *et al.*, 2017 and Sanker *et al.*, 2015). It is thus highly imperative to schedule suitable method of weed control by application of different herbicides for enhancing profits to the onion growers (Sanker *et al.*, 2015). Continuous and imbalanced use of herbicides adversely affects the sustainability of agricultural production besides causing environmental pollution (Gyani *et al.*, 2020). In addition, only application of herbicide (weedicide) does not give the effective control. Chemical weed control is an option in integrated weed management that refers to the integrated use of cultural, manual, mechanical and/or chemical control method. The common worldwide weed management practice in onion is pre-emergence (PE)/post-emergence (POE) application of selective herbicides like pendimethalin, oxyfluorfen, oxadiazon, quizalofop ethyl, alachlor, butachlor and metolachlor followed by one hand weeding (Gyani *et al.*, 2020; Jangre *et al.*, 2019; Angmo *et al.*, 2018; Dhananivetha *et al.*, 2017; Chattopadhyay *et al.*, 2016; Ramalingam *et al.*, 2013, Prakash *et al.*, 2000 and Tewari *et al.*, 1999) which are used alone or in different combinations. The most effective herbicide suitable for weed destruction presently in onion is oxyfluorfen as reported by Stall and Gilreath (2002). Oxyfluorfen is selective and contact herbicide which applied for controlling pre- and post-emergence monocot and dicot weeds (wide spectrum of annual broadleaf weeds and grasses in onion). In PE application, seedling of weeds rarely emerges from the soil. After seedling emergence, it acts as a contact herbicide for which light is required. Oxyfluorfen is, more persistent than pendimethalin, considered as low risk to contaminate groundwater on the basis of half life (34.3 to 52.3 days at 90 days after application) and soil residues (16.7 to 34.8% at 90 days after application), as described by Alister *et al.* (2009). Kumar (2014) stated that effective weed control was recorded under PE application of oxyfluorfen 23.5 EC @ 2 ml/litre + one HW at 40 DAT. Hence, it is necessary to test the efficacy of Oxyfluorfen herbicide alone and in combination with manual weeding at proper stage of onion growth.

The present research work was, therefore, designed with the variety BARI Piaz-4 for following objectives:

1. To study the efficacy of Oxyfluorfen herbicide on controlling weeds and growth, yield & quality of onion.
2. To find out profitability for controlling weeds in onion field.

Materials and Methods

The field trial was conducted at SRSC, BARI, Faridpur during winter season of 2021-2022 to assess the efficacy of Oxyfluorfen (nitrodiphenyl ether) herbicide (23.5 EC @ 250g a.i./litre) alone and in combination with manual weeding at proper stage of onion growth. The treatments were: T₁-control as check (no weeding), T₂- 3 HW at 25, 45 and 65 days after seedling transplanting (DAT), T₃- 4 HW at 24, 45, 65 and 85 DAT, T₄- PE spray of oxyfluorfen, T₅- PE spray of oxyfluorfen + one hand weeding (HW) at 45 DAT, T₆- post- POE spray of oxyfluorfen at 45 DAT, T₇- PE spray of oxyfluorfen + POE spray of oxyfluorfen at 45 DAT and T₈- PE spray of oxyfluorfen + two HW at 45 & 65 DAT. The investigation was laid out in randomized complete block design replicated three times. Early T. Aman rice (cv. BRRI Dhan-57) was cultivated in 2021 as previous crop of onion. The 40-day old uniform and healthy seedlings were transplanted on 18 December 2021 in 3m x 2m unit plots with a spacing of 15 cm x 10 cm. The trial field was fertilized with 3000 kg well-decomposed cowdung, 120 kg N, 50 kg P, 85 kg K and 20 kg S per hectare. Nitrogen, phosphate, potash and sulphur were supplied in the form of Urea, TSP, MP and Gypsum, respectively. The entire quantity of cowdung, P, K, S and one third of N were applied as basal dose during land preparation. The remaining N was used as top dress in two equal splits at 20 and 30 days after seedlings transplanting. Weeds were left until harvest for control plot (no weeding). Oxyfluorfen solution was sprayed @ 1.0 l/ha with a Hi-Sprite Pressure Sprayer. The PE herbicide was imposed in wet soil at 5 days before transplanting of seedlings and POE herbicide was applied as per treatment. Weeds were removed by using hand hoe for manual hand weeding (HW).

The fungicide mancozeb/iprodione @ 3 g/l litre of water was sprayed at fortnightly interval commencing from one month after transplanting of seedlings. All other recommended management practices were followed for each treatment as and when needed. Bulbs were harvested at maturity when the pseudostem becomes flaccid and unable to support the leaf blades (Brewster, 1990^a). Onions were harvested on 27 March, 2022. The leaves of harvested onion were removed at 3 days after curing by cutting 2.0-2.5 cm above the bulb (Brewster, 1990^b). After curing, the total bulb fresh weight was measured for each plot. The data recorded were: plant height (cm), number of leaves/plant (no.), neck size (mm), equatorial diameter of bulb (cm), individual bulb weight (g), bulb dry matter (DM, %), total soluble solid (TSS, °brix), bulbs weight per plot (kg/ha) then calculated as yield per hectare (t), types of flora & relative weed composition (RWC, %), weed density (WD, weeds/m²), weed index (WI, %), dry weight of weed (g/m²), weed control efficiency (WCE, %), profitability analysis. In onion field, the onion plants are infested by different types of weed flora which were identified from each unit plot. Weed density for the treatments T₂ and T₃ were counted as per treatment. But weed density for remaining treatments was recorded at 75 DAT of onion seedlings. Density of weeds was observed by placing a "Quadrat" of 0.5 m x 0.5 m randomly from three places in each plot. The weed population falling within the frames of the "Quadrat" was recorded species-wise and expressed as number per m². Relative weed composition (%) of an individual weed species was calculated by the following formula (Barla and Upasani, 2019). The RWC of a species (%) = (No. of individual species/Total no. of all weeds) x 100. The weeds from each category were dried in hot-air oven at 80 °C for 72 hr (Ramalingam *et al.*, 2013). Weeds dry weight (WDW) was expressed in g/m². The WI is the measure of the efficiency of a particular treatment when compared with a weed free treatment. It was calculated as following method of Ramalingam *et al.* (2013) and expressed in %. WI (%) = {(X-Y)/X} x 100, where WI- weed index (%), X- bulb yield (kg/ha) from minimum weed competition plot and Y- bulb yield (kg/ha) from the treatment plot for which WI to be worked out. Weed control efficiency (WCE) which indicates the comparative magnitude of reduction in weed dry matter was highly influenced by different weed control treatments. It was calculated as per the procedure of Ramalingam *et al.* (2013) and expressed in % as follows. WCE (%) = {(WD_c - WD_t)/ WD_c} x 100, where WCE- weed control efficiency (%), WD_c- weed biomass (g/m²) in control plot and WD_t- weed biomass (g/m²) in treated plot. The plant height was measured from the ground to the tip of the leaves. The total bulb weight per unit plot was measured in kg per plot and finally converted into hectare (t). The percent DM content of bulbs was calculated by dry weight

basis as per procedure of Walle *et al.* (2018). The TSS content of bulbs was recorded by hand refractometer (ATAGO, Master-53M, Japan) with a range of 0-53 °brix. For the profitability analysis, an input cost and interest on fixed (land) and running capital cost were taken into accounts. The interest was measured @ 16% for 6 months. Cost and return analysis were calculated into gross margin and benefit-cost ratio (BCR). Based on the market price of all the applied inputs and wholesale prices of the produce; cost, return and benefit-cost ratio (BCR) were estimated. Net return, gross margin and BCR were calculated as follows. Net return (Tk./ha) = Gross return (Tk./ha) – Cost of production (Tk./ha). Gross margin (Tk./ha) = Gross return (Tk./ha) – Variable cost (Tk./ha). BCR = Gross return (Tk./ha)/Cost of production (Tk./ha). The recorded data were subjected to analyze statistically as suggested by Gomez and Gomez (1984) and the means of significant treatment were compared the least significant difference.

Results and Discussion

Effect of different weed control practices on the growth of weeds

The weed control practices influenced the RWC, WD, WDW, WI and WCE in onion (Table 1 and Table 2).

Relative weed composition: The trial field of onion was infested with diverse species of weeds (Plate 1). Among them, *Chenopodium album* (lambquarters/bathua) was found as pre-dominant weed with average relative weed composition (59.06%) followed by RWC (18.43%) of *Physalis angulata* (cutleaf ground cherry). However, the third (9.59%) and the fourth (4.07%) highest RWC were recorded for *Cyperus rotundus* (mutha) and *Echinochloa crusgalli* (shyma/barnyard grass), respectively. Besides these four species of weeds, some more species of weeds like *Portulaca oleracea* (duck weed/nunia), *Rumex crispus* (broad-leaved dock/ban palong), *Heliotropium indicum* (indian heliotrope/hatisur), *Euphorbia hirta* (asthma plant/dudhia), *Eclipta prostrata* (false daisy/kakokeshi), *Abutilon indicum* (indian mallow), *Alternanthera sessilis* (dwarf copper leaf/sissoo spinach), *Leontodon taraxacum*/Taraxacum officinale (hawkbit/bhuichapa), *Cynodon dactylon* (durba/bermuda grass) and *Amaranthus viridis* (slender amaranth/notayshak) represented 7.98% of RWC. The current finding disagrees with the findings of previous works (Khan *et al.*, 2021; Islam *et al.*, 2020 and Khokhar *et al.*, 2006). They recorded the highest percent weed infestation with *Cyperus rotundus* in onion field. But the result corroborates the finding of Khan *et al.* (2013) who found *Chenopodium album* as the most predominant weed flora in onion field. Pre-dominant flora in onion field might be depend on season, previous crops, edaphic & climatic factors, cultural practices, irrigation methods, crop growing method etc. Growing Transplanting Aman rice before onion crop might be suppressed emergence of *Cyperus rotundus* in the present study.

Table 1. RWC (%) as affected by different weed control practices in onion field at SRSC, BARI, Faridpur during 2021-2022

Treatments	<i>Chenopodium album</i>	<i>Physalis angulata</i>	<i>Cyperus rotundus</i>	<i>Echinochloa crusgalli</i>	Other weeds
T ₁	55.99	38.03	0.71	1.11	4.15
T ₂	67.75	22.88	4.19	2.96	2.20
T ₃	52.39	16.10	10.91	3.68	10.24
T ₄	53.01	16.91	19.33	4.21	6.52
T ₅	48.6	23.80	8.07	3.26	16.25
T ₆	75.25	2.30	5.80	9.27	7.37
T ₇	73.49	2.26	17.62	4.08	2.52
T ₈	46.06	25.13	10.13	4.03	14.63333
CV (%)	22.35	26.25	33.19	21.35	24.69
LSD (0.05)	23.11	22.02	4.01	2.34	3.36

Level of sig.	*	*	*	*	*
Average	59.06	18.43	9.59	4.07875	7.98

Footnote: * Significant at 5% level of probability; T₁- Control as check (no weeding), T₂- 3 HW at 25, 45 and 65 DAT, T₃- 4 HW at 24, 45, 65 and 85 DAT, T₄- PE spray of oxyfluorfen, T₅- PE spray of oxyfluorfen + one HW at 45 DAT, T₆- POE spray of oxyfluorfen at 45 DAT, T₇- PE spray of oxyfluorfen + POE spray of oxyfluorfen at 45 DAT and T₈- PE spray of oxyfluorfen + two HW at 45 & 65 DAT

Weed density: The attributed weed control measures in onion clearly reduced the WD as the maximum (65.94 weeds/m²) WD was recorded with no weeding (control plot). The lowest WD (13.33 weeds/m²) was obtained in 4 HW significantly followed by 3 HW (21.55 weeds/m²) and PE spray of oxyfluorfen including two HW (23.44 weeds/m²). The variation found in WD among the weed management practices due to changes of practices. The lowest WD under the treatment T₃ might be due to quadruple checking of weed growth with HW at 25, 45 (critical period of onion weed control), 65 and 85 DAT.

Weed dry weight: The treatments imposed for weed control under the study admittedly reduced the WDW. The treatment T₁ (weedy check) gave the maximum WDW (367.11 g/m²) significantly followed by the T₄ (223.69 g/m²). The 3rd highest WDW was obtained from the T₆ (195.67 g/m²) significantly followed by the T₇ (143.97 g/m²) and the T₁₁ (67.29 g/m²). However, the minimum (7.03 g/m²) WDW was computed from the T₃ followed by the T₂ (12.65 g/m²) and the T₈ (37.10 g/m²). Vishnu *et al.* (2015) found significant reduction in DM of weeds by all treatments as compared to un-weeded control. The maximum dry weight from T₁ (weedy check) might be attributed due to increased WD & continuous weed growth and due to the higher amount of nutrient uptake (Kumari *et al.*, 2019; Gaharwar *et al.*, 2017; Chattopadhyay *et al.*, 2016; Vishnu *et al.*, 2015; Patel *et al.*, 2012 and Nadal and Singh, 2002).

Table 2. Effects of different weed control practices on the growth of weeds in onion field at SRSC, BARI, Faridpur during 2021-2022

Treatments	Weed density (weeds/m ²)	Weed dry weight (g/m ²)	Weed index (%)	Weed control efficiency (%)
T ₁	65.94	367.11	56.37	0.00
T ₂	21.55	12.65	2.50	96.58
T ₃	13.33	7.03	0.00	97.99
T ₄	29.22	223.69	30.97	38.08
T ₅	26.22	49.15	14.92	87.13
T ₆	27.88	195.67	27.77	46.69
T ₇	26.61	143.97	19.48	60.61
T ₈	23.44	37.10	10.58	89.41
CV (%)	31.53	29.16	26.43	15.80
LSD (0.05)	16.17	66.17	9.90	17.87
Level of sig.	**	**	**	**

Footnote: ** Significant at 1% level of probability; T₁- Control as check (no weeding), T₂- 3 HW at 25, 45 and 65 DAT, T₃- 4 HW at 24, 45, 65 and 85 DAT, T₄- PE spray of oxyfluorfen, T₅- PE spray of oxyfluorfen + one HW at 45 DAT, T₆- POE spray of oxyfluorfen at 45 DAT, T₇- PE spray of oxyfluorfen + POE spray of oxyfluorfen at 45 DAT and T₈- PE spray of oxyfluorfen + two HW at 45 & 65 DAT

Weed index: The treatments used for controlling weeds fairly lessened the WI. The maximum WI (56.37%) was calculated in the T₁ (weedy check) significantly followed by the T₄ (30.97%). The 3rd (27.77%) and 4th (19.48%) highest WI were recorded from the T₆ and T₇, respectively. On the other hand, the treatment T₂ had the minimum WI (2.50%).

The present result agrees with the findings of Sahoo *et al.* (2017) and Ramalingam *et al.* (2013). Ramalingam *et al.* (2013) found higher weed index from un-weeded control treatment due to heavy competition of weeds for nutrients, space and light. Sahoo *et al.* (2017) found zero (0) percent weed control index in weed free check.

Weed control efficiency: Weed management practices under the study undoubtedly increased the WCE. The WCE ranged from 23.56 to 100.00% under the present study. A fourfold HW (T₃) at 25, 45, 65 and 85 DAT of seedling gave the highest WCE (97.99%) insignificantly followed by thrice HW (T₂) at 25, 45 and 65 DAT (96.58%), twice HW at 45 and 65 DAT along with PE spray of Oxyfluorfen (T₈, 89.41%) and PE application of Oxyfluorfen with one HW (T₅, 87.13%). The lowest WCE (38.08%) was observed with PE spray of Oxyfluorfen (T₄) which was statistically at par (46.69%) with the WCE of POE spray of Oxyfluorfen along with one HW at 45 DAT (T₆).

Effect of different weed control practices on the growth and development of onion

Different weed control practices caused significant variation on the parameters of growth and development of onion except neck size (Table 3).

Plant height: The plant height ranged from 59.60 to 65.16 cm with the tallest in the T₁ (no weeding) and the shortest in the T₅. The 2nd (63.23 cm), 3rd (62.06 cm), 4th (61.13 cm) and 5th (60.03 cm) tallest plant heights were measured from the T₈, T₄, T₆ and T₇, respectively. In addition, these values of the corresponding treatment were not statistically differed with each other. The tallest plant from weedy plot might be due to shading effect. Shade stimulates cellular expansion and rapid cell division resulting in increase leaf length and plant height (Schoch, 1972). Similar observation was made by Waiganji *et al.* (2009), who stated that onion plants from the un-weeded plots grew much taller probably in search of sunlight as a result of shading by weeds, although not significantly taller than plants from all other treatments. Khan *et al.* (2013) also found the highest plant height from weedy plot. In contrast, Kumari *et al.* (2019) found higher plant height from the treated plot which might be due to less weed crop competition. Shortest plant height from weedy check might be due to heavy weed population increased the weed crop competition and stress on onion crop (Gaharwar *et al.*, 2017).

Table 3. Effects of different weed control practices on the growth and development of onion at SRSC, BARI, Faridpur during 2021-2022

Treatments	Plant height (cm)	No. leaves/plant	Neck size (mm)	Bulb diameter (cm)	Individual bulb weight (g)
T ₁	65.16	5.76	8.51	3.10	18.19
T ₂	59.83	7.76	9.88	4.13	40.47
T ₃	59.90	8.00	9.91	4.42	41.04
T ₄	62.06	7.33	8.66	3.30	25.24
T ₅	59.60	7.60	9.63	3.96	37.51
T ₆	61.13	7.36	8.93	3.50	33.47
T ₇	60.03	7.70	8.98	3.88	36.4
T ₈	63.23	7.83	9.59	4.00	37.86
CV (%)	4.87	5.73	11.12	3.28	4.69
LSD (0.05)	5.23	0.61	1.80	0.21	2.77
Level of sig.	*	*	NS	**	**

Footnote: ** Significant at 1% level of probability, * Significant at 5% level of probability and NS-Not significant; T₁- Control as check (no weeding), T₂- 3 HW at 25, 45 and 65 DAT, T₃- 4 HW at 24, 45, 65 and 85 DAT, T₄- PE spray of

oxyfluorfen, T₅- PE spray of oxyfluorfen + one HW at 45 DAT, T₆- POE spray of oxyfluorfen at 45 DAT, T₇- PE spray of oxyfluorfen + POE spray of oxyfluorfen at 45 DAT and T₈- PE spray of oxyfluorfen + two HW at 45 & 65 DAT

Number of leaves per plant: The highest number of leaves/plants was counted in the T₃ (8.00) insignificantly followed by T₈ (7.83), T₂ (7.76), T₈ (7.70), T₅ (7.60) and significantly followed T₆ (7.36). The T₁ produced the minimum number of leaves/plant (5.76). Lowest number of leaves/plant from weedy check might be due to heavy weed population increased the weed crop competition and stress on onion crop (Gaharwar *et al.*, 2017). Similar types of results were also reported by Vishnu *et al.* (2015), Kalhapure and Shete (2013), Sahoo and Tripathy (2019), Gupta *et al.* (2020) and Kumar (2014).

Diameter of bulb: The equatorial diameter of bulb ranged from 3.10 to 4.42 cm under the trial of weed management practices. The maximum diameter of bulb was measured from the T₃ (4.42 cm) significantly followed by T₂ (4.13 cm). However, the minimum bulb diameter was recorded from the T₁ (3.10 cm) insignificantly followed by T₄ (3.30 cm) but significantly followed by T₆ (3.50 cm). The reduced crop-weed competition provides proper development of crop growth characters (plant height, number of leaves per plant and dry matter accumulation), which enhanced the diameter of bulb (Patel *et al.*, 2012).

Individual bulb weight: Four times HW at 25, 45, 65 and 85 DAT (T₃) gave rise to the heaviest bulb (41.04 g) insignificantly followed by thrice HW at 25, 45 and 65 DAT (T₂, 40.47 g) but significantly followed by T₈ (37.86 g). Nevertheless, the T₁ (no weeding) produced the lightest bulb (18.19 g) which was statistically differed with all other treatments. The increased bulb weight from all weed management treatments over the weedy check might be due to comparatively better weed control, which reduced the competition to a greater extent and this helped in faster growth and development of onion bulb crop resulting in obtaining higher individual bulb weight.

Effect of different weed control practices on the yield and quality of onion

There was a significant variation among the weed control practices on the parameters of yield and quality of onion except DM content (Table 4).

Table 4. Effects of different weed control practices on the quality and yield of onion at SRSC, BARI, Faridpur during 2021-2022

Treatments	Dry matter of bulb (%)	TSS of bulb (°brix)	Fresh yield (t/ha)	Yield increase over weedy check (%)
T ₁	14.06	13.24	8.83	0.00
T ₂	15.41	14.16	18.76	112.45
T ₃	15.57	14.32	19.27	118.23
T ₄	14.25	13.45	12.18	38.96
T ₅	14.81	13.92	17.22	96.21
T ₆	14.10	13.79	14.59	65.60
T ₇	14.20	13.90	16.36	84.81
T ₈	14.84	13.97	18.09	105.64
CV (%)	6.62	3.71	7.86	17.53
LSD (0.05)	1.69	0.90	2.19	24.88
Level of sig.	NS	*	**	**

Footnote: ** Significant at 1% level of probability, * Significant at 5% level of probability and NS-Not significant; T₁- Control as check (no weeding), T₂- 3 HW at 25, 45 and 65 DAT, T₃- 4 HW at 24, 45, 65 and 85 DAT, T₄- PE spray of oxyfluorfen, T₅- PE spray of oxyfluorfen + one HW at 45 DAT, T₆- POE spray of oxyfluorfen at 45 DAT, T₇- PE spray of oxyfluorfen + POE spray of oxyfluorfen at 45 DAT and T₈- PE spray of oxyfluorfen + two HW at 45 & 65 DAT

Dry matter content of bulb: The T₃ tended to be the highest DM content of bulb (15.57%) in spite of insignificant variation among the treatments. Nonetheless, the lowest DM content of bulb was registered from the T₁ (14.06%). Patel *et al.* (2012) found significant variation among the weed management practices. The increase in DM content by all the weed management treatments over weedy check was because of the fact that the weed population and weed growth remained low during the crop growth period, which markedly improved the DM content of bulb (Patel *et al.*, 2012).

Total soluble solid content of bulb: The TSS content ranged from 13.24 to 14.32 °brix. The highest TSS content was recorded from the T₃ (14.32°brix) insignificantly followed by T₂ (14.16°brix), T₈ (13.97°brix), T₅ (13.92°brix), T₇ (13.90°brix), T₆ (13.79°brix) and T₄ (13.45°brix). However, significantly the least reading of TSS content was observed from the control plot (T₁, 13.24°brix). The increase in TSS content by all the weed management practices over weedy check was because of the fact that the weed population and weed growth remained low during the crop growth period, which markedly improved the TSS content of bulb (Patel *et al.*, 2012).

Fresh bulb yield: The T₃ (four times HW) had the maximum fresh yield of onion bulb (19.27 t/ha) insignificantly followed by thrice HW (T₂, 18.76 t/ha) and PE spray of Oxyfluorfen including twice HW (T₈, 18.09 t/ha) but significantly followed by PE spray of Oxyfluorfen with one HW (T₅, 17.22 t/ha). In addition, The T₅ and T₈ were mutually at par. On the other hand, the un-weeded plot for whole season (T₁) produced the lowest fresh yield of onion bulb (8.83 t/ha) significantly followed by T₄ (12.18 t/ha). The lowest yield was recorded in weedy check plots owing to low chlorophyll content and photosynthetic rate due to un-checked weed growth there by reducing the availability of moisture, light and nutrients to the crop thus resulting in loss of yield. The maximum yield was recorded in four times HW followed by other manual/herbicidal treatments due to the favourable environmental conditions created by the clean crop culture resulted in more absorption of solar radiation and plant nutrients which ultimately resulting in more photosynthetic rates and DM accumulation (Angmo *et al.*, 2018). The similar results are also published by Tripathy *et al.* (2013), Panse *et al.* (2014), Khan *et al.* (2013), Kumari *et al.* (2019), Kalhapure *et al.* (2013) and Waiganji *et al.* (2009). The application of oxyfluorfen provides a favourable ecological environment to onion crop resulting in better bulb development and yield through early inhibition of weed growth (Gupta *et al.*, 2020).

Yield increase over weedy check: The maximum yield increase (118.23%) over weedy control plot (T₁) was calculated from the T₃ (four times HW) insignificantly followed by thrice HW (T₂, 112.45%) and PE spray of Oxyfluorfen including twice HW (T₈, 105.64%) but significantly followed by PE spray of Oxyfluorfen with one HW (T₅, 96.21%). However, the T₄ (PE spray of oxyfluorfen) exhibited the lowest yield increase (38.96%) over un-weeded control plot.

Effect of different weed control practices on profitability of onion

The profitability analysis of onion crops were worked out in respect of the net return, the gross margin and finally the benefit-cost ratio (BCR), are shown in Table 5. The analysis data revealed that fourfold HW at 25, 45, 65 and 85 DAT (T₃) incurred the highest total cost of onion bulb production (Tk. 188121.00) followed (Tk. 175281.00) by thrice HW at 25, 45 & 65 DAT (T₂). The T₁ (un-weeded check plot) had the lowest total cost of production (Tk. 136761.00). The maximum gross return was calculated from the T₃ (Tk. 481750.00) followed by T₂ (Tk. 469000.00), PE application of Oxyfluorfen with twice HW at 45 & 65 DAT (T₈, Tk. 452250.00), PE application of Oxyfluorfen along with one HW (T₅, Tk. 430500.00). On the other hand, the minimum gross return was computed from the T₁ (Tk. 220750.00) followed (Tk. 304500.00) by T₄ (PE application of Oxyfluorfen). The maximum net return (Tk. 268219.00) was computed under the treatment T₂ followed by T₃ (Tk. 268129.00), T₈ (Tk. 256819.00), T₅ (Tk. 247909.00). However, the minimum net return was scored in the T₁ (Tk. 58489.00) followed by T₄ (Tk. 131749.00). The treatment T₂ exhibited the highest gross margin (Tk. 293719.00) closely followed by T₃ (Tk. 293629.00), T₈ (Tk. 282319.00). In contrast, the least gross margin was recorded from the T₁ (Tk. 83989.00) followed by T₄ (Tk. 160249.00). The highest benefit-cost ratio (BCR) was calculated from the T₅ (2.38) closely followed by T₈ (2.36) and T₂ (2.33). Nevertheless, the lowest BCR (1.36) was obtained from the T₁ followed by the T₄ (1.79). The maximum gross return under fourfold HW was due to obtaining the highest yield.

But fourfold HW did not give the highest BCR due to higher and expensive labour consumption. Priya *et al.* (2017) found higher economic returns from PE application of oxyfluorfen with one HW at 40 DAT. While Gaharwar *et al.* (2017) obtained maximum benefit-cost ratio spraying oxyfluorfen at 15-20 DAT with one HW at 45 DAT followed by PE application of oxyfluorfen with one HW at 45 DAT. Gupta *et al.* (2020) stated that though weeds were controlled more efficiently and bulb yield production was highest in weed free treatment but engaged more human labour and cost of cultivation was more resulted in lower benefit-cost ratio. The weedy check plot had the minimum gross return, gross margin, net return and BCR due to producing the least yield by the weedy check plot. The lowest total cost of production was also calculated from the weedy check plot which was due to no manual or chemical weed management practice in the weedy check plot. Weedy check plot and one hand weeding at 20 DAT recorded minus benefit-cost ratio due to poor yield as compared to cost of cultivation (Gaharwar *et al.*, 2017). The lowest BCR was found with weedy check plot over rest of treatments due to lower bulb yield (Nadal and Singh, 2002).

Table 5. Effect of weed management practices on the profitability of onion at SRSC, BARI, Faridpur during 2021-2022 (Tk./ha)

Treatment	A. Variable cost (Tk.)							
	Cost of land preparation (1 ha = 247 decimal @ 22.00/decimal)	Cost of seeds (price @ 3000.00/kg) (Seed rate: @ 6 kg/ha)	Cost of manures and fertilizers (@ Tk. 8.00, 16.00, 22.00, 15.00 and 7.00/kg of 3000 kg cow dung, 220 kg urea, 220 kg TSP, 150 kg MOP and 110 kg gypsum, respectively)	Cost of Oxyfluorfen herbicides: @ 1.00 l/ha & price- @ Tk. 175.00/25 ml	Cost of plant protection (fungicide/insecticide) (LS))	Cost of labours (seedling raising, transplanting, spreading manure & fertilizers, spraying herbicides, irrigation, hand weeding, earthing up, harvesting, post harvest processing etc.)	Interest on investment @ 14% per year for 6 months	Sub-total (A)
T ₁	5434.00	18000.00	35380.00	00.00	16000.00	53000.00	8947.00	136761.00
T ₂	5434.00	18000.00	35380.00	00.00	16000.00	89000.00	11467.00	175281.00
T ₃	5434.00	18000.00	35380.00	00.00	16000.00	101000.00	12307.00	188121.00
T ₄	5434.00	18000.00	35380.00	7000.00	16000.00	53000.00	9437.00	144251.00
T ₅	5434.00	18000.00	35380.00	7000.00	16000.00	65000.00	10277.00	157091.00

T ₆	5434.00	18000.0 0	35380.00	7000.00	16000.00	53000.00	9437.00	144251.00
T ₇	5434.00	18000.0 0	35380.00	14000.00	16000.00	53000.00	9927.00	151741.00
T ₈	5434.00	18000.0 0	35380.00	7000.00	16000.00	77000.00	11117.0 0	169931.00

Footnote: T₁- Control as check (no weeding), T₂- 3 HW at 25, 45 and 65 DAT, T₃- 4 HW at 24, 45, 65 and 85 DAT, T₄- PE spray of oxyfluorfen, T₅- PE spray of oxyfluorfen + one HW at 45 DAT, T₆- POE spray of oxyfluorfen at 45 DAT, T₇- PE spray of oxyfluorfen + POE spray of oxyfluorfen at 45 DAT and T₈- PE spray of oxyfluorfen + two HW at 45 & 65 DAT; PE-Pre-emergence and POE-Post-emergence

Contd. Table 5.

Treatment	B. Fixed cost (Tk.)			Total cost (A + B) = C	Gross return (D)	Net return (D - C)	Gross margin (D - A)	Benefit -cost ratio (D/C)
	Land rent (1 ha = 7.5 bigha @ 6000.00 /bigha/ year)	Land management charge for 6 months (LS)	Sub-total (B)					
T ₁	22500.00	3000.00	25500.0 0	162261.0 0	220750.0 0	58489.00	83989.00	1.36
T ₂	22500.00	3000.00	25500.0 0	200781.0 0	469000.0 0	268219.0 0	293719.0 0	2.33
T ₃	22500.00	3000.00	25500.0 0	213621.0 0	481750.0 0	268129.0 0	293629.0 0	2.25
T ₄	22500.00	3000.00	25500.0 0	169751.0 0	304500.0 0	131749.0 0	160249.0 0	1.79
T ₅	22500.00	3000.00	25500.0 0	182591.0 0	430500.0 0	247909.0 0	273409.0 0	2.38
T ₆	22500.00	3000.00	25500.0 0	169751.0 0	364750.0 0	194999.0 0	220499.0 0	2.14
T ₇	22500.00	3000.00	25500.0 0	177241.0 0	409000.0 0	231759.0 0	257259.0 0	2.30
T ₈	22500.00	3000.00	25500.0 0	195431.0 0	452250.0 0	256819.0 0	282319.0 0	2.36

Footnote: T₁- Control as check (no weeding), T₂- 3 HW at 25, 45 and 65 DAT, T₃- 4 HW at 24, 45, 65 and 85 DAT, T₄- PE spray of oxyfluorfen, T₅- PE spray of oxyfluorfen + one HW at 45 DAT, T₆- POE spray of oxyfluorfen at 45 DAT, T₇- PE spray of oxyfluorfen + POE spray of oxyfluorfen at 45 DAT and T₈- PE spray of oxyfluorfen + two HW at 45 & 65 DAT; PE-Pre-emergence and POE-Post-emergence

Conclusion

- The PE application of Oxyfluorfen with once HW at 45 DAT or PE application of Oxyfluorfen with twice HW at 45 & 65 DAT or 3/4 HW exhibited good performance to control weeds in onion field.

- From the yield point of view, four times HW produced the highest yield very closely followed by thrice HW and PE application of Oxyfluorfen with twice HW.
- Fourfold/thrice HW incurred the maximum total cost of onion production due to more and expensive human labors.
- The BCR ratio was calculated from PE application of Oxyfluorfen with once HW closely followed by PE application of Oxyfluorfen with twice HW.
- From the economic point of view, integrated weed management practice following once PE applications of Oxyfluorfen with once/twice HW proved the best option for growing onion over the other practices.
- Growing Transplanting Aman rice before onion crop suppressed emergence of *Cyperus rotundus*.

Plate 1. The trial field of onion was infested by weed species at SRSC, BARI, Faridpur during 2021-2022.

S. N.	Common Name	Scientific Name	Family	Picture
01.	Lambs quarters (Bathua)	<i>Chenopodium album</i>	Amaranthaceae	
2.	Cutleaf ground cherry (Foska Begun)	<i>Physalis angulata</i>	Solanaceae	
3.	Mutha grass	<i>Cyperus rotundus</i>	Poaceae	
4.	Barneyard grass (Shyma)	<i>Echionochloa crusgalli</i>	Poaceae	

5.	Duck weed (Nunia)	<i>Portulaca oleracea</i>	Portulacaceae	
6.	Broad-leaved dock (Ban Palong)	<i>Rumex crispus</i>	Polygonaceae	
7.	Indian heliotrope (Hatisur)	<i>Heliotropium indicum</i>	Boraginaceae	
8.	Asthma plant	<i>Euphorbia hirta</i>	Euphorbiaceae	
9.	False Daisy (Kalokeshi)	<i>Eclipta prostrata</i>	Asteraceae	
10.	Indian Mallow (Potari)	<i>Abutilon indicum</i>	Malvaceae	
11.	Dwarf copper leaf	<i>Alternanthera sessilis</i>	Amaranthaceae	
12.	Hawkbit (Bhuicgapa)	<i>Leontodontaraxacum/ Taraxacum officinale</i>	Asteraceae	

13.	Durva Grass	<i>Cynodon dactylon</i>	Poaceae	
14.	Slender amaranth	<i>Amaranthus viridis</i> L.	Amaranthaceae	

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