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RESEARCH ARTICLE
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Enhancing Onion Yield Through Integrated Weed Management Tactics in the Middle Awash Valley, Ethiopia

El rendimiento de la cebolla mejora mediante tácticas de manejo integrado de malezas en el valle medio de Awash, Etiopía

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Abstract

Weeds play a significant role in reducing onion production and productivity in Ethiopia. There is limited information on onion weed management in the hot lowland part of the Country. This study evaluates the effectiveness of integrated weed control tactics in onion crops. The treatments were arranged in a randomized complete block design (RCBD) with three replications. The data collected included different weed species, density, and dry weight of weeds, Additionally, onion yield and yield traits had been taken at maturity. The experimental field was infested by grassy and broad-leaved species of weeds including sedge, the predominant weed species. The result of onion yield and yield traits were significantly ($p < 0.05$) different among treatments. The three-hand hoeing and Pendimethalin 500 SC + Oxyfluorfen 24 EC supported by one-hand weeding on the 70th day after transplant demonstrated superior weed control efficiency as a result they increased onion bulb yield. Cost-benefit analysis indicated that these two weed management approaches provided the highest cost-benefit ratios (15.84 and 13.25) respectively, and recommended for weed management in onion production. Using pre-emergence pendimethalin followed by timing application of Oxyfluorfen 24 EC and hand hoeing after transplanting can suppress weeds effectively and improve weed control efficiency.

Keywords: *Pre-emergence herbicides; post-emergence herbicides; Profitability; Weed control; Weed density*

Resumen

Las malas hierbas juegan un rol importante en la reducción de la producción y la productividad de la cebolla en Etiopía. Existe poca información sobre la gestión en las tierras bajas y cálidas de Ethiopia. Este estudio evalúa la eficacia de las tácticas integradas de control de las malas hierbas en los cultivos de cebolla. En el campo, los tratamientos se dispusieron en un diseño de bloques completos aleatorizados (DBCA) con tres repeticiones. Los datos recogidos fueron las especies de malas hierbas, la densidad y el peso seco de las malas hierbas, además, el rendimiento de la cebolla y los rasgos de rendimiento en la madurez. El campo experimental estaba infestado por especies de malas hierbas herbáceas y de hoja ancha incluida la juncia, la especie de mala hierba predominante. El resultado del rendimiento de la cebolla y rasgos de rendimiento fueron significativamente ($p < 0.05$) diferentes entre tratamientos. La azada a tres manos y la Pendimetalina 500 SC + Oxifluorfeno 24 EC apoyado por escarda a una mano en el día 70 después de de trasplante demostraron una eficacia superior en el control de las malas hierbas, lo que se tradujo en un aumento del rendimiento de los bulbos de cebolla. rendimiento de los bulbos de cebolla. El análisis coste-beneficio indicó que estos dos métodos de control de las malas hierbas ofrecían la mejor relación coste-beneficio (15.84 y 13.25 respectivamente) y se recomiendan para la gestión de malas hierbas en la producción de cebolla. El uso de pendimetalina en preemergencia seguida de la aplicación en el momento oportuno de Oxyfluorfen 24 EC y la escarda manual después del trasplante puede suprimir eficazmente las malas hierbas y mejorar la eficacia de su control.

Palabras clave: *Herbicidas de preemergencia; herbicidas de post-emergencia; Rentabilidad; Control de malas hierbas; Densidad de malas hierbas*

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INTRODUCTION

Onion (*Allium cepa* L.) is a highly popular vegetable crop, which is grown in tropical and subtropical regions under favorable circumstances (Brewster, 2008; Hanci, 2018). In Ethiopia, onion is cultivated in diverse agroecological conditions it contributes to 14.67 % of the cultivated area and 7.07 % of vegetable crop production by small-scale farmers during the 2016/17 primary cropping season (Central Statistical Agency [CSA], 2017). In Ethiopia, onions are largely grown for commercial purposes and are commonly used in salads and other meals. Due to its importance in small-scale production systems, onion production is expanding in different regions of Ethiopia. It serves as a commercialization component for both rural and urban populations.

Weeds pose a significant problem in onion farms, competing with onions for nutrients, light, water, and space (Sahoo et al., 2017). Also, reduces onion production and productivity due to their sluggish emergence, low initial growth rate, long vegetative phase, and reduced crop competitiveness (Boyham et al., 2016). Onion is a poor weed competitor because of its slow, vertical growth, which fails to overshadow weeds (Kizilkaya et al., 2001). The weed can lead to a 49 % to 86 % reduction in onion bulb yield (Loken & Hatterman-Valenti, 2010).

There is a lack of an effective and economically feasible weed management approach in onion production which has been identified as a significant limitation, limiting farmers' willingness to cultivate the crop (Waijanjo et al., 2009). The traditional techniques of weed management such as manual weeding, and hand-hoeing are time and cost-consuming pre and post-emergence herbicides that considerably reduce the weed population in the crop (Nargis-Bano et al., 2006; Panse et al., 2014). Conversely, Patel et al. (2012) discovered that using a pre-emergence herbicide followed by manual weeding effectively increased onion yields. An integrated weed management approach may be more effective than a sole weed management approach in the onion field.

The use of herbicides increased yearly due to labor shortages in rapidly developing countries like India and China. Similarly, the use of herbicides is a troubling increase in Ethiopia as well. Africa is currently experiencing significant agricultural and economic changes (Reardon et al., 2015; Frankema, 2014; Tamru et al., 2016). Ethiopia stands out as a compelling case study due to its emphasis on small-scale farming and the swift transformations taking place in rural areas (World Bank, 2015; Bachewe et al., 2015).

Herbicide weed management is highly effective in controlling weeds in onion cultivation, because of its cost-effectiveness, rapid action, and potential to enhance yields (Nadeem et al., 2013). The combination of manual weeding with pre or post-emergence herbicides holds significant potential (Popy et al., 2017; Dhakal et al., 2019). By combining chemical and cultural approaches to weed control, it is possible to create a holistic weed management plan that delivers enduring results while minimizing environmental impact. Consequently, this study aims to evaluate the effects of integrated weed management tactics in onion production in the Middle Awash Valley of Ethiopia.

MATERIALS AND METHODS

Description of the study area

The field experiment was conducted at Werer Agricultural Research Centre (WARC) during the 2021 and 2022 cool cropping seasons. The WARC is located 278 km east of Addis Abeba at an elevation of 750 meters above sea level, with coordinates 90 20' 31" N and 400 10' 11" E. The study area is characterized by having the soil type vertisol and alluvial types, uneven annual rainfall of 540 mm, with average maximum and lowest temperatures of 34.4 °C and 19.6 °C, respectively (Wondimagegne & Abere, 2012).

Experimental design and treatments

The onion variety Adam red, which is widely adapted and recommended to the area was used for the field trial. The experiment was laid down in a randomized complete block design (RCBD) with three replications. Each experimental plot had a size of 12 m^2 (3 m length and 4 m width). Space between ridge 0.4 m and space between plant 0.05 m. The onion seedlings were transplanted along two sides of the ridge. A total of fifteen treatments were listed as weed management tactics (Table 1).

Experimental Procedure

The experimental field was prepared in the October 2021 and 2022 cool cropping season. Ahead of the field plantation, the onion seedlings were raised on well-prepared beds near by experimental field. Important equipment and materials were prepared before transplanting. All agronomic practices were employed according to local recommendations. The seedlings about 45 days old were transplanted in experimental plots after the pre-emergence herbicides (Pendimethalin and S-metolachlor) with a water volume of 200 $L.ha^{-1}$ were administered by using a backpack hand-operated sprayer. The onion seedlings were transplanted and then the fertilizer was applied at the rate of 100 kg of DAP per hectare and 100 kg of urea per hectare. All dose of DAP and 50 % of urea was applied at the time of transplanting and the other 50 % of urea was applied at a half month of transplant. Optimum irrigation water was applied as per the recommended frequency and time. The post-emergence herbicides were applied when weeds bore three true leaves. Finally, during the course study in the field, all important weed, yield, and yield component data were recorded.

Table 1. List of treatments used for the experimental field and their description.

Trt no.	Treatments with rates/ha	Application time
1	Pendamethaline @3lt/ha + Oxyfluorfen @1lt/ha	Pre + post spray
2	S-metolachlor@1.5lt/ha + Oxyfluorfen @1lt/ha	Pre + post spray
3	Oxyfluorfen 1lt/ha+ Clodinafop-Propargyl 80EC @1lt/ha	Pre + post spray
4	S-metolachlor@1.5lt/ha+Clodinafop-Propargyl @1lt/ha	Pre + post spray
5	Pendamethaline @3lt/ha + Oxyfluorfen @1lt/ha + IHW	Pre + post spray+ HW @70 -DAT
6	S-metolachlor@1.5lt/ha+Oxyfluorfen @1lt/ha+1HW	Pre + post spray+ HW @70-DAT
7	Oxyfluorfen @1lt/ha + Clodinafop-Propargyl 80EC @+1HW	Pre + post spray+ HW @70DAT
8	S-metolachlor@1.5lt/ha+Clodinafop-Propargyl 80EC @1lt/ha+1HW	Pre + post spray+HW @70-DAT
9	Pendamethaline @3lt/ha + 1HW	Pre-spray + HW@40-DAT
10	S-metolachlor @ 1.5lt/ha	Pre-spray + HW@40-DAT
11	Oxyfluorfen @2lt/ha	Post spray + HW@40-DAT
12	Clodinafop-Propargyl 80EC @2lt/ha	Post spray + HW@40-DAT.
13	Three-hand weeding (farmer practice)	20, 40,70 days after transplanting
14	Two hand weeding	20, 40 days after transplanting
15	Weedy check	Untreated

Data collected

The data collection covered all relevant data including weed species, weed density, and weed dry weight. The weed densities were counted randomly with a quadrat of 0.5 m * 0.5 m area from three checkpoints per plot. The weed density data was counted at three timing intervals 20th, 40th, and 70th day after transplanting. Weed dry weight was determined after the density of the weed population had been taken from each quadrat. The weeds were pulled up and placed in separate paper bags, and sun-dried for 10 days. The dry weight was then measured with a sensitive balance. Additionally, onion plant height, neck thickness, bulb diameter, bulb length, bulb weight, and bulb yield were collected basis on single plant and plot level. Data on yield qualities were obtained from five randomly selected sample plants per plot at maturity. At harvest time, yield data was collected from the plot.

Weed control efficiency was calculated using the following formula (Mani et al., 1973):

$$WCE\ (\%) = \frac{WC-WT}{WC} * 100$$

where WC is the weed in the control plot and WT is the weed in the treated plot.

Cost-benefit analysis

Partial budget analysis of herbicide price and labor costs for weeding and chemical spray were used to calculate the net returns from onion weed management tactics, which were to increase production and productivity. The average local price of onion bulbs was used during the study year. Average chemical prices (Ethiopian birr.ha^{-1}) were obtained from the commercial market. The cost-benefit analysis included the cost of labor, the price of the onion bulb, and the benefit or profit. This output can be used in the decision-making process in onion weed management practice to be cost-effective or not cost-effective. The partial budget analysis was conducted using the partial budget procedure (International Maize and Wheat Improvement Center [CIMMYT], 1988).

Data Analysis

The data were subjected to analysis of variance (ANOVA), and when F values were found to be significant at the $p < 0.05$ level, the means were compared using Fisher's least significant difference (LSD) test.

RESULTS

In the experimental field, the dominant species of grassy weeds were *Echinochloa colana, Eriocloa fatmensis, and Digitaria abyssinica* whereas *Cyperus rotundus* from sedge groug.The broad-leaved weeds included *Boerhavia erecta, Desmodium spp., Datura stramonium, Acalyph crenata, Corchorus trilocularis, Portulaca oleracea, Parthenium hysterophorus,* and *Chenopodium ambrosiodes* (Table 2).

Analysis of variance indicated that weed management significantly ($p < 0.05$) influenced the weed densities and dry weights at 25th , 45th , and 70th days after treatment. Three-hand hoeing on 20th , 40th , and 70th day after transplanting exhibited the most effective weed control efficiency followed by the plot treated with Pendimethalin 500 SC and Oxyfluorfen 24 EC, supported by one hand weeding at 70 days after transplanting. Remarkably, weed dry weights were significantly reduced (77.8, 95.8, 90.3, and 95.8) g.m^{-2}, with the highest weed control efficiencies (WCE) of 81.7 %, 77.5 %, and 78.5 % achieved through the three hand hoeing treatments. These results have followed the plots treated by Oxyfluorfen application supported by hand hoeing at 40th day after transplanting; the Pendimethalin, S-metolachlor, and Oxyfluorfen supported by one hand weeding at 40 DAT, followed by one hoeing at 70 DAT were effective in the reduction of weed dry weight (Table 3).

Table 2. Effect on weed species mean density (plant.m^{-2}) recorded in onion in 2021 to 2022 cropping season

N°	Scientific Name	Family	class	20 DACE	40 DACE	70 DACE	At harvest
1	*Cyperus rotundus*	Cyperaceae	Sedge	5.97	10.61	10.74	14.87
2	*Echinocloa colana*	Poaceae	Grass	3.04	2.78	2.13	1.87
3	*Eriocloa fatmensis*	Poaceae	Grass	1.53	1.39	0.50	0.83
4	*Cynodon dactylon*	Poaceae	Grass	0.01	0.02	0.00	0.33
5	*Sorghum arundianaceum*	Poaceae	Grass	0.13	0.09	0.08	0.06
6	*Boerhavia erecta*	Nyctaginaceae	Broadleaf	5.71	7.32	3.34	2.44
7	*Desmodium* spp.	Leguminaceae	Broadleaf	1.5	0.93	0.62	0.47
8	*Launaea cornuta*	Asteraceae	Broadleaf	0.08	0.21	0.17	0.19
9	*Datura stramonium*	Solanaceae	Broadleaf	1.06	0.77	0.54	0.37
10	*Xanthium strumarium*	Asteraceae	Broadleaf	0.02	0.13	0.03	0.03
11	*Hibiscus trionum*	Malvacea	Broadleaf	0.00	0.00	0.01	0.02
12	*Acalyph crenata*	Euphorbiaceae	Broadleaf	0.1	0.03	0.04	0.00
13	*Corchorus trilocularis*	Tiliaceae	Broadleaf	0.47	0.51	0.18	0.28
14	*Portulaca oleracea*	Portulacaceae	Broadleaf	0.17	0.03	0.01	0.02
15	*Parthenium hysterophorus*	Asteraceae	Broadleaf	0.19	0.06	0.03	0.01
16	*Ipomea eriocarpa*	Convolvulaceae	Broadleaf	0.00	0.20	0.00	0.01
17	*Amaranthus hybridus* L.	Amaranthaceae	Broadleaf	0.00	0.01	0.00	0.00
18	*Ipomea ariocarpa*	Convolvulaceae	Broadleaf	0.01	0.01	0.00	0.03
19	*Solanum nigrum* L.	Solanaceae	Broadleaf	0.00	0.03	0.01	0.06
20	*Prosopis juliflora*	Fabaceae	Broadleaf	0.03	0.02	0.01	0.03
21	*Cyperus rotundus*	Cyperaceae		20.02	24.99	18.47	21.92
Total				87.70	126.47	113.57	5.97

Table 3. Weed density, dry weight, and control efficiency as affected by weed management practices in Onion at Werer, in 2021 to 2022 cropping season

N°	Treatment Name	Weed density N°.m^{-2}				A dry weight of weeds (g.m^{-2})	Weed control efficiency (%)
		25-DAT	45-DAT	65-DAT	At harvest		
1	Pendimethalin 500 SC + Oxyfluorfen 24 EC	45.5^{bc}	101.7^{ab}	45.7^{de}	49.0^{cde}	143.1^{defg}	66.3
2	S-metolachlor 960EC + Oxyfluorfen 24 EC	41.0^{bcd}	67.5^{bcde}	31.5^{ef}	45.5^{def}	148.6^{def}	65.0
3	Pendimethalin 500 SC + Clodinafop-Propargyl 80EC	50.5^{b}	83.0^{abcd}	63.5^{cd}	53.0^{cd}	240.3^{b}	43.5
4	S-metolachlor 960EC + Clodinafop-Propargyl 80EC	36.5^{bcde}	69.5^{bcde}	63.0^{cd}	62.5^{c}	236.1^{bc}	44.4
5	Pendimethalin 500 SC + Oxyfluorfen 24 EC + 1HW	37.5^{bcde}	95.5^{abc}	46.5^{de}	36.5^{defg}	90.3^{fg}	78.8
6	S-metolachlor 960EC + Oxyfluorfen 24 EC + 1HW	22.5^{e}	71.0^{bcde}	33.5^{ef}	31.5^{fg}	95.8^{efg}	77.5
7	Pendimethalin 500SC+Clodinafop-Propargyl 80EC+ 1HW	34.5^{cde}	62.0^{cde}	57.5^{cd}	33.0^{efg}	190.3^{bcd}	55.2
8	S-metolachlor 960EC + Clodinafop-Propargyl 80EC+ 1HW	28.0^{de}	48.5^{de}	46.0^{de}	27.0^{gh}	175.0^{bcd}	58.8
9	Pendimethalin 500 SC + HW	45.5^{bc}	63.0^{cde}	54.5^{cd}	89.5^{b}	136.1^{defg}	67.9
10	S-metolachlor 960EC + HW	44.0^{bc}	54.0^{de}	69.5^{bc}	87.5^{b}	130.6^{defg}	69.3
11	Oxyfluorfen 24 EC + HW	91.5^{a}	45.0^{e}	27.0^{ef}	79.5^{b}	95.8^{efg}	77.5
12	Clodinafop-Propargyl 80EC+ HW	98.5^{a}	69.5^{bcde}	84.5^{b}	86.0^{b}	170.8^{cd}	59.8
13	Three-hand weeding	84.0^{a}	38.0^{e}	20.0^{f}	13.5^{h}	77.8g	81.7
14	Two hand weeding	83.0^{a}	46.0^{e}	44.0^{de}	79.5^{b}	157.2^{de}	63.0
15	Weedy Check	88.5^{a}	114.0^{a}	142.0^{a}	116.0^{a}	425a	-
CV (%)		9.3	17.1	11.7	9.4	13.2	
LSD (0.05)		15.7	35.5	19.6	16.9	66.8	

There were significant differences ($p < 0.05$) among treatments in respect of yield and yield attributes (Table 4). The highest growth attributes (viz, plant height, neck thickness, bulb diameters, bulb length, and bulb weight. Dry matter weight and bulb yield were observed in three manual hoeing followed by the application of pendimethalin + Oxyfluorfen HW on 70th day after transplanting.

Cost-benefit analysis**:** Partial budget analysis for onion management through integrated weed management indicated that the net returns varied from 151 500 ETB. ha^{-1} to 618 500 Ethiopian birr. ha^{-1} (Table 5). All weed management tactics were cost-effective, since the cost-benefit ratio was greater than one (1<CBR). Among the treatments manual weeding produced the greatest cost-benefit ratio of 15.84 followed by Pendimethalin 500 SC + Oxyfluorfen 24 EC + 1 HW, indicating that, when investing (1 birr) for the management of onion weeds, it provided a high profit as compared to other treatments.

Table 4. Effects of Weed Management Practices on Onion Yield and Yield Components at Werer in 2021 to 2022 cropping season

S.N	Treatment Name	Plant Height (cm)	Neck thickness (cm)	Bulb diameter (cm)	Bulb length (cm)	Bulb Weight (g)	Dry matter weight (g/plant)	Bulb yield (t.ha^{-1})
1	Pendimethalin 500 SC + Oxyfluorfen 24 EC	10.78^{bcd}	7.26^{de}	9.02^{cdef}	8.43cd	9.01^{de}	3.74	5.80^{de}
2	S-metolachlor 960EC + Oxyfluorfen 24 EC	10.22^{bcd}	6.37^{ef}	7.70^{efg}	7.43de	7.78^{ef}	3.56	5.67^{def}
3	Pendimethalin 500 SC + Clodinafop-Propargyl 80EC	9.33^{cd}	4.22^{h}	6.67^{fg}	5.75ef	5.75^{gh}	2.21	3.67^{efg}
4	S-metolachlor 960EC + Clodinafop-Propargyl 80EC	9.0^{cd}	4.81^{gh}	5.95^{g}	5.05f	4.96^{h}	1.90	3.13^{fg}
5	Pendimethalin 500 SC + Oxyfluorfen 24 EC + 1HW	13.56^{ab}	9.770^{ab}	11.69^{ab}	11.22ab	12.27^{ab}	6.16	10.60^{ab}
6	S-metolachlor 960EC + Oxyfluorfen 24 EC + 1HW	13.11^{abc}	8.70^{bc}	10.25^{bcd}	10.74ab	10.94^{bc}	5.73	9.27^{b}
7	Pendimethalin 500 SC + Clodinafop-Propargyl 80EC+ 1HW	9.44^{bcd}	5.22^{fgh}	7.06^{fg}	6.19ef	6.30^{fg}	2.52	5.07^{def}
8	S-metolachlor 960EC + Clodinafop-Propargyl 80EC+ 1HW	9.67^{bcd}	5.74^{fg}	7.65^{efg}	6.79def	6.99^{fg}	3.10	5.13^{def}
9	Pendimethalin 500 SC + HW	11.11^{abcd}	8.04^{cd}	10.02^{cdef}	9.38bc	10.05^{cd}	3.79	6.20^{de}
10	S-metolachlor 960EC + HW	12.11^{abcd}	8.52^{bcd}	10.59^{bc}	9.96bc	10.69^{bcd}	4.14	6.47^{cd}
11	Oxyfluorfen 24 EC + HW	12.56^{abcd}	9.19^{bc}	11.44^{abc}	9.93bc	11.58^{bc}	5.21	9.0^{bc}
12	Clodinafop-Propargyl 80EC+ HW	10.11^{bcd}	6.04^{efg}	7.84d^{efg}	7.09de	7.38^{efg}	3.17	5.27^{def}
13	Three-hand weeding	15.22^{a}	10.74^{a}	13.21^{a}	12.53a	13.65^{a}	6.58	12.67^{a}
14	Two hand weeding	10.11^{bcd}	6.33^{ef}	8.10^{defg}	7.27de	7.83^{ef}	3.59	5.40^{def}
15	Weedy Check	8.67^{d}	4.11^{h}	6.0^{g}	5.00^{f}	4.81^{h}	0.78	0.80^{g}
CV (%)		12.56	6.58	9.21	7.71	7.09	18	15.88
LSD (0.05)		4.18	1.39	2.48	1.91	1.86	Ns	2.59

Table 5. Partial economic analysis of different weed management practices applied to onion production in 2021 to 2022 cropping season

S.N	Treatment Name	Cost of Management (ETB)	Bulb yield (t.ha^{-1})	Gross return (birr)	Net return (ETB)	Marginal benefit (ETB)	Cost-benefit ratio (CBR)
1	Pendimethalin 500 SC + Oxyfluorfen 24 EC	8000	5.80	290000	282000	242000	7.25
2	S-metolachlor 960EC + Oxyfluorfen 24 EC	10000	5.67	283500	273500	233500	6.84
3	Pendimethalin 500 SC + Clodinafop-Propargyl 80EC	3000	3.67	183500	180500	140500	4.59
4	S-metolachlor 960EC + Clodinafop-Propargyl 80EC	5000	3.13	156500	151500	111500	3.91
5	Pendimethalin 500 SC + Oxyfluorfen 24 EC + 1HW	13000	10.60	530000	517000	477000	13.25
6	S-metolachlor 960EC + Oxyfluorfen 24 EC + 1HW	15000	9.27	463500	448500	408500	11.59
7	Pendimethalin 500 SC + Clodinafop-Propargyl 80EC+ 1HW	10000	5.07	253500	243500	203500	6.34
8	S-metolachlor 960EC + Clodinafop-Propargyl 80EC+ 1HW	12000	5.13	256500	244500	204500	6.41
9	Pendimethalin 500 SC + HW	7000	6.20	310000	303000	263000	7.75
10	S-metolachlor 960EC + HW	9000	6.47	323500	314500	274500	8.09
11	Oxyfluorfen 24 EC + HW	11000	9.0	450000	439000	399000	11.25
12	Clodinafop-Propargyl 80EC+ HW	11000	5.27	263500	252500	212500	6.59
13	Three-hand weeding	15000	12.67	633500	618500	578500	15.84
14	Two hand weeding	12000	5.40	270000	258000	218000	6.75
15	Weedy Check	0	0.80	40000	40000	0	0

Work for hand weeding; 5000 birr.ha^{-1}; average price of bulb/kg: 50 birr
Cost of herbicides: Pendimethalin: 2000 birr.L^{-1}; S-metolachlor: 4000 birr.L^{-1}; Toharvest:1000 birr.L^{-1}, Galigan 24 EC 3000 birr.L^{-1}

DISCUSSION

The findings from this study highlight the significant impact of weed management strategies on the growth and yield of onion crops in the field experimental, where a diverse array of weed species, including *Echinochloa colana, Eriocloa fatmensis, and Digitaria abyssinica*, *Cyperus rotundus, Boerhavia erecta, Desmodium spp., Datura stramonium, Acalyph crenata, Corchorus trilocularis, Portulaca oleracea, Parthenium hysterophorus,* and *Chenopodium ambrosiodes*, were identified as predominant species. The presence of these weeds can significantly hinder crop development by competing for essential resources such as light, water, and nutrients, which can ultimately lead to reduced yields.

Aggressive competitors like *Cyperus rotundus* are known to reduce crop yields by up to 50 % if not managed effectively (Oerke, 2006).

The observed lower weed density and biomass in treated plots underscore the efficiency of integrated weed management (IWM) practices employed in this study. Specifically, the combination of pre-emergent herbicides (pendimethalin) and post-emergent herbicides (Oxyfluorfen 24 EC), along with manual hoeing 70th days after transplanting, proved to be a successful strategy for controlling weed populations. This integrated approach aligns with the findings of Harker & Donovan (2013), who advocate for the use of multiple control methods to enhance weed management efficacy. The reduced weed biomass in these plots can be attributed to the persistence of the herbicides in the soil, which effectively minimized weed flora over an extended period (Buhler et al., 1997). This reduction in weed competition allowed for enhanced nutrient availability and uptake by the onion plants, resulting in improved growth parameters and bulb yield. The weedy check treatment, which exhibited the highest weed biomass and lowest control efficacy, illustrates the detrimental effects of unmanaged weed populations. This observation is consistent with previous research by Channappagoudar & Biradar (2007); and Vishnu et al. (2015), which emphasize the importance of effective weed management practices in crop production systems. These studies collectively demonstrate that failure to manage weeds can lead to significant declines in crop performance. Moreover, the significant increase in bulb production associated with integrated weed management supports the findings of Sable et al. (2013) and Thakare et al. (2018). Their work indicated that treatments employing both chemical and manual methods not only reduced weed density but also enhanced bulb yield compared to other methods. Notably, manual hand-hoeing operations alone also resulted in substantial yield increases in our study. This can be attributed to the direct removal of competitive weeds, which helps maintain soil fertility by minimizing nutrient depletion caused by weeds (Bhowmik & Inderjit, 2003). Such practices positively influence crop growth parameters and yield quality, reinforcing the notion that effective weed management is crucial for optimizing agricultural productivity. Furthermore, the economic implications of implementing these weed control strategies cannot be overlooked. Research by Nandal & Singh (2002) and Patel et al. (2011) indicates that investments in integrated weed management not only enhance crop yields but also improve overall profitability for farmers. By reducing competition from weeds, farmers can achieve higher marketable yields, which translates into increased revenue and sustainability in onion production.

CONCLUSION

This study on integrated weed management tactics for onion production in Ethiopia's Middle Awash area highlights the importance of good weed control in increasing crop yield and profitability. The study discovered significant differences between various weed management, tactic thus three hand-hoeing sessions, the application of Pendimethalin 500 SC and Oxyfluorfen 24 EC supported by one hand weeding at 70th days after transplanting which yielded the highest weed control efficacy and bulb production. The cost-benefit analysis adds to the economic sustainability of these integrated techniques by identifying promising cost-benefit ratios that emphasize their potential to increase farmers' incomes. The data suggest that pre-emergence herbicides such as Pendimethalin, along with post-emergence treatments and manual hoeing, are viable tactics for suppressing weed populations, improving weed control efficacy, and eventually increasing onion output in the region.

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Author Contributions

Conceptualization: SG, ZA, NS. Data curation: SG, ZA. Formal analysis: ZA. Investigation: SG, ZA, NS. Methodology: SG, ZA. Project administration and Software: ZA. Resources: SG, ZA, NS. Supervision and Validation: SG, ZA, NS. Writing – original draft: SG, ZA. Writing – review & editing SG, ZA, NS.

Conflict of interests

The authors have no conflict of interest

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