

Research Article

# Integrated Management of Weeds of Wheat (*Triticum aestivum* L.) Through Hand Weeding and Herbicides Frequency in Kuyu District, North Shewa Zone, Oromia

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## Abstract

Field Experiment on Integrated Weed management in wheat was conducted at the Fitcha Agricultural Research Center during the main growing season of 2022 and 2023. The study was designed in a randomized complete block design with three replications and consisted of eleven (11) treatments. As a result of the experiment, the lowest total weed density was recorded in Weed free check ( $2.58 \text{ m}^{-2}$ ) and One times application of Obest 8EC at three weeks after Emergence + one times hand weeding at five weeks after emergence ( $5.067 \text{ m}^{-2}$ ), followed by One times application of Obest 8EC at three weeks after Emergence treatment ( $8.08 \text{ m}^{-2}$ ), and the grain yield from weed free plot was found to be the maximum ( $4966.677 \text{ kg ha}^{-1}$ ), followed by One times application of Obest 8EC at three weeks after Emergence + one times hand weeding at five weeks after emergence ( $4509.801 \text{ kg ha}^{-1}$ ) and One times application of Obest 8EC at three weeks after Emergence treatment ( $4061.322 \text{ kg ha}^{-1}$ ). The highest control efficiency was recorded (94.64% in the weed free plots, One times application of Obest 8EC at three weeks after Emergence + one times hand weeding at five weeks after emergence (93.28%). In contrast the highest weed density ( $123.253 \text{ m}^{-2}$ ) and lowest grain yield ( $1274.796 \text{ kg ha}^{-1}$ ) were achieved in weed-infested control plot. According to the economic analysis, the maximum net benefits ( $403130.56 \text{ birr}^{-1}$ ) were obtained from Weed free check treatments and One times application of Obest 8EC at three weeks after Emergence + one times hand weeding at five weeks after emergence ( $367956.74 \text{ birr ha}^{-1}$ ) and One times application of Obest 8EC at three weeks after Emergence treatment ( $340061.22 \text{ birr ha}^{-1}$ ). Overall, it was concluded that One times application of Obest 8EC at three weeks after Emergence treatment were highly effective in controlling the major weeds grasses observed in wheat fields. One times application of Obest 8EC at three weeks after Emergence + one times hand weeding at five weeks after emergence is recommended for the study area.

## Keywords

Hand Weeding, Hoeing, Obest 8EC, Weak After Emergence

## 1. Introduction

Bread wheat (*Triticum aestivum* L.) is one of the world's most important food crops and provides a stable food source

for more than 35% of the world's population, with annual global production of 772.6 million tons [24]. Globally, China,

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India, and Russia are the largest producers of wheat, and in sub-Saharan Africa, South Africa and Ethiopia are the largest producers of wheat [15]. Ethiopia's annual production is approximately 5.8 million tons, with an average productivity of 3 tons per hectare [26], which is relatively lower than the achievable crop yields, which reach up to 5t ha<sup>-1</sup> [32]. Wheat accounts for approximately 17% of Ethiopia's total grain production, making it the third most important grain crop after teff and maize [26], the most suitable altitude range for wheat production is between 1900 and 2700 meters above sea level [26]. In the Ethiopian highlands, wheat production and productivity are influenced not only by socio-economic challenges in agricultural systems, especially among smallholder farmers, but also by the complex and interactive effects of biotic factors. Among biological factors, weeds are the main factor limiting crop productivity.

Weeds cause significant yield losses mainly because they compete with crops for light, nutrients, water, and space, especially during the rainy season. Heavy rains promote the rapid and abundant growth of weeds, resulting in heavy weed infestation in all crops in the highlands of Northern Oromia. Farmers in this country are aware of the problem of weeds in their fields, but due to labor shortages, they are often unable to cope with large weed infestations during the peak of agricultural activity, and as a result, most fields are left without weed control. Either it's late or the weeding isn't done. Such ineffective weed control is considered to be the main factor behind the low average yield of wheat, resulting in a 35% reduction in average annual yield [5]. The difficulty in identifying grass weeds from wheat seedlings in the early vegetative phases makes timely hand weeding impossible [13]. Furthermore, persistent labor shortages during peak agricultural seasons result in weeding being done too late or not at all, leaving farmers with significant yield penalties. Ethiopian farmers employ a variety of techniques to counteract this, such as hand weeding and the growing use of post-emergence herbicides to compensate for labor shortages. Both strategies, meanwhile, have significant drawbacks. Herbicide resistant weed biotypes and a shift in the weed community toward more tolerant species can result from an over-reliance on a single technique, such as the repeated application of a single herbicide. The most efficient, environmentally friendly, and sustainable method for addressing these drawbacks is Integrated Weed Management (IWM) [14]. IWM uses a variety of strategies, including mechanical, cultural, and chemical approaches, to maintain weed populations below a certain economic threshold. While research in other Ethiopian highlands has proved the potential of IWM, these findings are not universally applicable. According to [21] research has demonstrated that in the central highlands, a combination of herbicides and one additional hand weeding can be successful.

It is very difficult to distinguish grass weeds from wheat [13], so they cannot be easily weeded by hand at the vegetative stage. Some studies have shown that most broadleaf weeds can be effectively controlled by manual weeding, as 2,4-D

herbicides are easy to identify and available at low cost. However, no effective and applicable technology for controlling grass weed species in wheat has been introduced in the study area. This calls for the introduction of improved weed control techniques that are economically and agronomical feasible, such as a combination of herbicides and manual weed control can be considered in bread wheat growing areas of Northern Oromia. Therefore, the objective of this study was to identify and develop effective options for weed control in bread wheat (*Triticum aestivum* L.) in Northern Oromia.

## 2. Materials and Methods

### 2.1. Description of Study Area

The experiment was carried out for two years on kuyu subsites of the Fitch Agricultural Research Center. kuyu subsites (9°48'47.7"N, 38°25'4"E, 2548 meters above sea level) during the main growing season of 2022 and 2023. Fitch is approximately 114 km North of Addis Ababa and kuyu is 156 km in a similar direction from Addis Ababa.

### 2.2. Treatments and Experimental Design

The experiment includes eleven (11) treatments arranged in a randomized complete block design (RCBD) with three replications with a plot size of 3m x 1.6m. The distance between adjacent replications (blocks) and plots was 1m and 0.5m, respectively. Treatment details includes: Onetime hand weeding at three weeks after emergence, Two-times hand weeding at three weeks after emergence and five weeks after emergence, Onetime application of 2,4-D at three weeks after emergence, One time application Pallas 45 OD/Atlantis at three weeks after emergence, One time application of 2,4-D at three weeks after emergence + one time hand weeding at five weeks after emergence, One time application of Pallas 45 OD/Atlantis at three weeks after emergence + one time hand weeding at five weeks after emergence, One time application of Obest 8EC at three weeks after emergence, One time application of Obest 8EC at three weeks after emergence + one time hand weeding at five weeks after emergence, One time application of 2,4-D at three weeks after emergence + one time application of Obest 8EC four weeks after emergence, Weed free check and compared with a weedy check. The Danda variety was used in the experiment at a seeding rate of 150 kg ha<sup>-1</sup>. Herbicide was applied at 21 and 30 days after sowing as post-emergence with the help of Knapsack/Backpack sprayer. 2,4-D (Power), Pallas 45 OD and Obest 8EC were applied at a rate of 1.2 L, 0.5L and 0.4L/ ha, respectively.

### 2.3. Data Collection

Weed species identification was made by using different manuals and reference books. After the weed flora were identified, they were categorized as grasses and broad leaf weeds

using reference of manuals, consulting experienced professionals and comparing with existed herbarium as described by Stroud and Parker (1989). Data regarding the kind of weed species and their densities were counted at 21 day after sowing i.e., before the application of herbicides by using four quadrates with sizes of 0.25 m x 0.25 m randomly placed in each plot and their density was calculated m<sup>-2</sup>. In addition, individual weed species density count was also done after herbicides were applied by randomly placing four quadrates of sizes 0.25 m x 0.25 m converted to m<sup>-2</sup>. The density of each weed species in the field was counted after treatment by randomly placing of four quadrates of sizes 0.25 m x 0.25 m in each plots and calculated m<sup>-2</sup> basis.

The relative weed density was calculated by the formula (Marwat et al., 2013),  $RWD (\%) = \frac{\text{Number of weeds of a species}}{\text{Total number of weeds}} \times 100$

The aboveground dry biomass of grass weeds and dry biomass of broad leaf weeds harvested from each quadrates placed into paper bags separately and oven drying at a 65 °C for 48 hours and subsequently the dry weights were measured. Weed control efficiency

(WCE) was determined by the following formula:

$$WCE (\%) = \frac{WDF - WDP}{WDC} \times 100$$

$$YL (\%) = \frac{\text{Maximum grain yield from treatment} - \text{Grain yield of particular treatment}}{\text{Maximum grain yield from treatment}} \times 100$$

## 2.4. Data Analysis

Weed data was square root transformed ((X + 0.5)) to obtain a normal data distribution. Data were subjected to analysis of variance using version R-software 4.2 and mean separation of significant treatment means was performed using least significant difference (LSD) at the 5% probability level.

## 2.5. Partial Budget Analysis

The partial budget analysis was made to determine the economic feasibility of the treatments. It was calculated by taking into account the variable input cost involved and the gross returns obtained from different treatments. The variable cost included the different herbicides and labor cost involved for weeding as their cost varied according to the time, availability of labor and the market price. Actual yield was adjusted downwards to 10% of the experimental yield to represents the farmer's yield as described by [10]. For determining gross returns, the prevailing local market price Ethiopian birr 8000 /100 kg of wheat at the harvest of wheat was considered. The

WCE=Weed Control Efficiency, WDC=Weed Dry weight in Weed free Plot and DWP = Weed Dry weight in Particular treatment

Numbers of total productive tillers counted from five rows with the length of 1 m randomly taken in each net plot area and was converted into m<sup>2</sup> at harvest. Number of seeds per spike was determined from randomly taken 4 spikes per plot. Thousand grains weight was counted from the bulk of threshed produce from the net plot area and their weight recorded. Biological yield (kg ha<sup>-1</sup>) was determined by taking the total weight of the harvest from each net plot area after sun dried the whole aboveground biomass. Grain yield was measured after threshing the sun dried plants harvested from each net plot and the yield was adjusted at 12.5% grain moisture content [2]. Harvest index was calculated by dividing grain yield per plot by the total aboveground dry biomass yield per plot [2, 32].

HI (%) = Grain yield\*100

Total above ground dry biomass

$$HI (\%) = \frac{\text{Grain yield}}{\text{Total above ground dry biomass}} \times 100$$

Yield loss was calculated by subtraction of grain yield of particular treatment from maximum grain yield from treatments divided by maximum grain yield from treatments [2].

net returns were calculated by subtracting the cost of treatment from the gross returns as RNR = GR-VC, where, RNR = Relative net returns, GR = Gross returns, and VC = Variable cost. Benefit to cost ratio was calculated by dividing gross return to total variable cost. The marginal rate of return was calculated by the formula MRR = DNI/DIC Where, MRR = the marginal rate of return, DNI = difference in net income compared with control and DIC = difference in input cost compared with control as described by [11, 17].

## 3. Results and Discussion

### 3.1. Weed Parameters

#### 3.1.1. Weed floral Composition of the Experimental Site

The site was infested with different weed species belonging to different family's life forms and categories. The predominant weed flora comprised in the experiment was in (Table 1).

**Table 1.** Weeds in the experimental site with some descriptions.

| Scientific name of weeds | Family         | Life forms     | Categories  |
|--------------------------|----------------|----------------|-------------|
| Andropogon abyssinicus   | Poaceae        | Annual         | Grass       |
| Avena fatua              | Graminaea      | Annual         | Grass       |
| Commelina benghalensis L | Commelinaceae  | Annual/P       | Broadleaved |
| Cynodon dactylon         | Poaceae        | Perennial      | Grass       |
| Eragrostis cillianensis  | Poaceae        | Annual         | Grass       |
| Erucastrum arabicum      | Brassicaceae   | Annual         | Broadleaved |
| Galansoga palviflora     | Asteraceae     | Annual         | Broadleaved |
| Gallium sporium          | Rubiaceae      | Annual         | Broadleaved |
| Guzotia scabra           | Asteraceae     | Annual         | Broadleaved |
| Phalaris paradox         | Graminaea      | Annual         | Grass       |
| Plantaqo lanceolata      | Plantaginaceae | perennial      | Broadleaved |
| Polygonium nepalense     | Polygonaceae   | Annual         | Broadleaved |
| Rumex abyssinicus        | Polygonaceae   | Perennial herb | Broadleaved |
| Snowdenia polistach L    | Graminaea      | Annual         | Grass       |
| Trifolium rueppellianum  | Fabaceae       | Annual         | Broadleaved |

### 3.1.2. Weed Density

The experimental results showed that all weed control methods significantly reduced weed density compared to the following weedy checks in (Table 2). However the amount of the reduction depends on the types of practice. This is consistent with the findings of [19, 21] who reported that weed densities were lower for all weed control methods compared to weedy check plots.

The result showed that the lowest weed density *Weed free check* ( $2.58m^{-2}$ ) and *One times application of Obest 8EC at three weeks after Emergence + one times hand weeding at five weeks after emergence* ( $5.067m^{-2}$ ), followed by *One times application of Obest 8EC at three weeks after Emergence treatment* ( $8.08m^{-2}$ ), at harvest. This finding was similarly with [25, 26] who concluded that maximum weed density in weedy check can be attributed to unchecked growth, while application of herbicide caused mortality of weed resulting in lower weed density at harvest. Unavailability of nutrients in control and suppression by well-developed wheat plants resulted in similar weed density, while the highest density of weeds it turns out that was recorded in the weed control plot ( $123.25 m^2$ ) was at harvest. However, no significant difference was observed between one hand weeding at three weeks after emergence and one times application of Power 2, 4-D at three weeks after emergence. These results are consistent with a study that reported that herbicides plus cultural practice (manual weeding) improved weed control ability [2, 21].

### 3.1.3. Weed Dry Biomass

Various weed control methods have been shown to have a significant impact on weed dry weight. The lowest weed dry weight ( $72gm^2$ ) was recorded in the weed-free plot, followed by one times application of 2, 4- D power at three weeks after emergence + one times application of Obest 8EC at four weeks after emergence ( $103.3 gm^2$ ), followed closely by one times application of Obest 8EC at three weeks after emergence + one times hand weeding at five weeks after emergence ( $105.5gm^2$ ). However, the highest biomass was observed for weed control ( $458.6 gm^2$ ). These results are in line with those of [2] who reported that post-emergence herbicides and hand weeding at the tillering stage reduced weed dry weight compared to herbicides or weed control alone.

### 3.1.4. Weed Control Efficiency

There are large differences in weed control efficiency between different weed control methods. The weed control efficiency was highest in weed-free plots (94.64%), followed by *One times application of Obest 8EC at three weeks after Emergence + one times hand weeding at five weeks after emergence* (93.28%), but the lowest weed control efficiency was in weed control plot (0.00%). This might be related to the activity of broad spectrum of the herbicide against both broad and grassy weeds as compared to other herbicides application. These findings are similar with who reported that herbicides

with broad spectrum provided better weed control efficiency than control treatment [4, 32] reported that the high control efficiency indicated that the weed were controlled when they are young or before they accumulated more dry matter by competing with the crop plants. This result further indicates that weed less herbicide application supplemented with hand

weeding is more effective in reducing weed density and weed dry biomass weight. This result is consistent with a report that supplementing herbicides with manual weeding increases weed control efficiency [2], which may be due to the complementary effects of hand weeding and herbicides.

**Table 2.** combined data analysis of weed management practices on weed measurements in 2022 and 2023 cropping seasons.

| No | Treatments                                               | WD (m <sup>2</sup> )   | WDB (gm <sup>-2</sup> ) | WCE (%) |
|----|----------------------------------------------------------|------------------------|-------------------------|---------|
| 1  | Weedy check.                                             | 123.253 <sup>g</sup>   | 458.6gm <sup>2</sup>    | 0       |
| 2  | Weed free check                                          | 2.58 <sup>a</sup>      | 72gm <sup>2</sup>       | 94.64   |
| 3  | 1HW at 3WAE.                                             | 24.623 <sup>fg</sup>   | 365.5gm <sup>2</sup>    | 54.85   |
| 4  | 2HW at 3WAE and 5WAE                                     | 12.523 <sup>bc</sup>   | 256.89gm <sup>2</sup>   | 64.27   |
| 5  | 1appl. Of Pallas 45 OD at 3WAE                           | 17.000 <sup>cdef</sup> | 110.56gm <sup>2</sup>   | 63.99   |
| 6  | 1 appl. of Obest 8EC at 3WAE                             | 8.080 <sup>bc</sup>    | 100gm <sup>2</sup>      | 84.09   |
| 7  | 1 appl. of 2,4- D at 3WAE                                | 20.087 <sup>efg</sup>  | 213.5mg <sup>2</sup>    | 32.67   |
| 8  | 1 appl. of Obest 8EC at 3WAE + 1HW at 5WAE               | 5.067 <sup>b</sup>     | 105.5gm <sup>2</sup>    | 93.28   |
| 9  | 1 appl. of Pallas 45 OD at 3WAE + 1HW at 5WAE            | 12.940 <sup>cde</sup>  | 111.5gm <sup>2</sup>    | 60.67   |
| 10 | 1 appl. of 2,4- D at 3WAE+ 1 appl. of Obest 8EC at 4WAE. | 9.850 <sup>bc</sup>    | 103.3gm <sup>2</sup>    | 91.65   |
| 11 | 1 appl. of 2,4- D at 3WAE + 1HW at 5WAE                  | 19.500 <sup>defg</sup> | 290gm <sup>2</sup>      | 38.86   |
|    | Mean                                                     | 23.22                  | 184.85                  | 61.73   |
|    | LSD (5%)                                                 | 7.64                   | 18.62                   | -       |
|    | CV (%)                                                   | 25.6                   | 27.5                    | -       |

Keys: WD: Weed density, WDB: Weed dry biomass, WCE: Weed control efficiency, HW: Hand weeding, 1app: one time application.

3.2. Yield and Yield-Related Parameters of Wheat was Affected by Weed Management Methods

Analysis of variance revealed that there was a statistically significance difference observed among treatments regarding yield and yield attributing parameters like plant height, spike length, productive of tillers m<sup>-2</sup>, spikelet per spike and thousand kernel weight, biomass, grain yield, and harvest index.

3.2.1. Plant Height

The effect of weed management practices on plant height was statistically significantly affected by weed management practices at (p<0.05). The highest plant height (80.87cm) was recorded in weed free plots, followed closely by one times application of Obest 8EC at three weeks after emergence + one times hand weeding at five weeks after emergence (79.13 cm) and one times application of 2, 4- D power at three weeks after emergence + one times application of Obest 8EC at four

weeks after emergence (75.87cm), minimum plant height recorded from weed check (60.13cm) and followed by one times application of 2,4- D at three weeks after emergence. Maximum plant height may be due to the effective weed control provided by these treatments and minimum plant height may be due to adverse effects on the crop due to competition. The resources of weeds are high with crops, and have the effect of preventing crop growth. This result is similar to [13].

3.2.2. Spike Length

The effect of weed management practices on spike length was statistically significantly affected by the weed management methods (p<0.05). In weed free plots, the highest spike length was recorded (8.27cm), followed by one times application of Obest 8EC at three weeks after emergence + one times hand weeding at five weeks after emergence (8.00cm), while the shortest spike length was recorded in the one times application of 2,4- D at three weeks after emergence (6.8cm). This result is similar to [18, 21] the highest Spike length can explain a favorable environment for plants to grow and develop

healthily, thereby creating a favorable environment for flowering and panicle establishment.

### 3.2.3. Productive Tiller

The number productive tillers were significantly affected by the different herbicidal application as well as hand weeding. It was found that the highest number of productive cultivators was observed in weed free plots (5.20), closely followed by one application of Obest 8EC at three Weeks After emergence (4.87), and while the number of cultivators was the lowest yield was recorded in the weed control plot (2.6). This is due to the greater effectiveness of these treatments in controlling weeds. A reduction in tiller number and productive tiller number due to increased weed density was also reported previously by [6] supports the present results. [8, 12] Reported similar results that under low competition between weeds and crop for resources that enhanced productive tillers. [3] Also stated that increase in number of fertile productive tillers relatively better weed control which ultimately facilitated by more translocation of photosynthetic towards reproductive growth due to lower weed wheat competition. [10] Also reported that effective weed control methods could reduce dry matter of weed and increased number of wheat productive tillers.

### 3.2.4. The number of Grain per Spike

The number of seed per spike depends on the weed management method. The highest number of seed per spike was recorded in the weed free plot (19.60), followed by one times application of Obest 8EC at three weeks after emergence + one times hand weeding at five weeks after emergence (18.33). While the lowest number of seed per spike was recorded in the weed control plot (15.73). This result is consistent with [16, 30] who observed that effective weed control increased the

amount of nutrients available to the crop, ultimately increasing the number of thorn-bearing shoots. The results showed that the number of panicles per panicle increased significantly compared to the weed control measure. The higher number of seed per spike in weed-free plots may be due to efficient use of water, nutrients, light and space, as well as decreasing weed density and weed dry weight in plots without weed. Similar results have also been reported by [28] increase in number of grains per spike can be attributed to availability of nutrients and greater spike length of wheat. According to [1] the number of seeds per spike increased with decreased weed competition. The poor grain filling due to presence of weeds was reported to be due to reduced tillering, ear formation, and stem weight and height reduction in wheat [13].

### 3.2.5. Spikelet's per Spike

Different weed control methods influenced the Kernel per spike significantly the highest number of Kernel per spike was recorded from Weed free plot (54.27), followed by one times application of Obest 8EC at three weeks after emergence + one times hand weeding at five weeks after emergence (53.27) whereas the lowest Kernel per spike was recorded in one application of Pallas 45 OD at three Weeks After Emergence + one time Hand Weeding at five Weeks After Emergence (35.40). A significantly higher number of Kernels might be the result of easily accessible growth factors nutrients, moisture, space and light for individual plants that retained more flowers and higher net assimilation rate in the absence of competition from weeds. Also, the development of more vigorous leaves under low weed infestation might have helped to improve the photosynthetic efficiency of the crop and supported a higher number of kernels. A similar result was reported by [9, 13].

**Table 3.** Effect of Integrated Weed Management on growth parameters during the 2022 and 2023 cropping seasons.

| No | Treatments                                                | PH(cm)              | SL(cm)                | ET(No)              | NSPS(No)              | GPS(No)            |
|----|-----------------------------------------------------------|---------------------|-----------------------|---------------------|-----------------------|--------------------|
| 1  | Weedy check.                                              | 75.13 <sup>bc</sup> | 7.40 <sup>abcde</sup> | 2.60 <sup>f</sup>   | 15.73 <sup>a</sup>    | 47.00 <sup>a</sup> |
| 2  | Weed free check                                           | 80.87 <sup>a</sup>  | 8.27 <sup>a</sup>     | 5.20 <sup>a</sup>   | 19.60 <sup>a</sup>    | 54.27 <sup>d</sup> |
| 3  | 1HW at 3WAE.                                              | 67.53 <sup>fg</sup> | 6.67 <sup>de</sup>    | 3.40 <sup>def</sup> | 16.73 <sup>def</sup>  | 47.93 <sup>e</sup> |
| 4  | 2HW at 3WAE and 5WAE                                      | 73.47 <sup>c</sup>  | 6.67 <sup>de</sup>    | 4.20 <sup>bcd</sup> | 18.13 <sup>abcd</sup> | 36.87 <sup>g</sup> |
| 5  | 1appl. Of Pallas 45 OD at 3WAE                            | 70.07 <sup>de</sup> | 6.53 <sup>e</sup>     | 3.70 <sup>cde</sup> | 17.20 <sup>cdef</sup> | 45.33 <sup>f</sup> |
| 6  | 1 appl. of Obest 8EC at 3WAE.                             | 75.47 <sup>b</sup>  | 7.93 <sup>abc</sup>   | 4.87 <sup>ab</sup>  | 18.93 <sup>ab</sup>   | 44.67 <sup>f</sup> |
| 7  | 1 appl. of 2,4- D at 3WAE                                 | 66.13 <sup>g</sup>  | 6.80 <sup>cde</sup>   | 3.27 <sup>ef</sup>  | 16.20 <sup>ef</sup>   | 37.67 <sup>g</sup> |
| 8  | 1 appl. of Obest 8EC at 3WAE + 1HW at 5WAE                | 79.13 <sup>ab</sup> | 8.00 <sup>ab</sup>    | 4.53 <sup>ab</sup>  | 18.33 <sup>abcd</sup> | 53.27 <sup>c</sup> |
| 9  | 1 appl. of Pallas 45 OD at 3WAE + 1HW at 5WAE             | 70.93 <sup>d</sup>  | 7.07 <sup>bcde</sup>  | 4.20 <sup>bcd</sup> | 17.60 <sup>bcde</sup> | 35.40 <sup>h</sup> |
| 10 | 1 appl. of 2,4- D at 3WAE + 1 appl. of Obest 8EC at 4WAE. | 70.87 <sup>d</sup>  | 7.73 <sup>abcd</sup>  | 4.53 <sup>abc</sup> | 18.60 <sup>abc</sup>  | 50.47 <sup>b</sup> |

| No | Treatments                              | PH(cm)              | SL(cm)               | ET(No)             | NSPS(No)             | GPS(No)            |
|----|-----------------------------------------|---------------------|----------------------|--------------------|----------------------|--------------------|
| 11 | 1 appl. of 2,4- D at 3WAE + 1HW at 5WAE | 68.87 <sup>ef</sup> | 7.07 <sup>bcde</sup> | 3.60 <sup>de</sup> | 16.93 <sup>def</sup> | 47.33 <sup>e</sup> |
|    | Mean                                    | 72.01               | 7.284                | 4.045              | 17.61                | 46.381             |
|    | LSD (5%)                                | 10.838              | 19.05                | 10.81              | 9.4                  | 10.81              |
|    | CV (%)                                  | 21.49               | 28.44                | 11.69              | 14.69                | 15.02              |

### 3.2.6. Thousand Grain Weight

Thousand grain weights were significantly influenced by weed control method. The highest thousand grain weight was recorded in one time application of 2,4- D at three Weeks After Emergence + one time application of Obest 8EC at four Weeks After Emergence (28.08 g), followed closely by weed-free plots (27.68g). The minimum amount of 1,000 grain weight was determined from weed control (16.07g). Timely weeding, herbicide application, and supplementing manual weeding can create a favorable environment for crops and ultimately improve grain enlargement. It's entirely possible that weed-free crops produced strong grains that eventually weighed more than a thousand grains; [2] also reported that test seed weight decreased with increasing weed density in the central highlands of Ethiopia. Similar results from [28] reported that lower thousand grain weight in weedy check and availability of nutrients and better plant growth might be the reason for heavier grains in high fertilizer levels and best weed controlled plots.

### 3.2.7. Aboveground Dry Biomass

Aboveground Biomass results showed that the main effect of weed control had a significant impact on aboveground biomass of wheat weight. The highest biomass was recorded in weed-free plots (13472.22 kg ha<sup>-1</sup>). The lowest aboveground biomass yield was recorded in the weed control plot (6472.22 kg ha<sup>-1</sup>). [21] Reported that good suppression of weed growth through cultural and herbicidal control measures reduces competition with weeds for light, space, water, and nutrients, allowing plants to utilize all resources efficiently, resulted in an increase in dry biomass production. Similar results were reported from [1] who stated that decreasing the biological yield in wheat might be due to weed competition as a consequence of depletion of nutrient supply and water by weeds, which resulted in reduced growth, seed and straw yields of crop plants. However, it is suggested that high seed rates were found to increase yield in well-watered conditions, whereas the reverse was true with low soil moisture [23] weed control methods increased biological yield of wheat reducing the weed infestation [31].

### 3.2.8. Grain Yield

Grain yield was significantly influenced by different weed

management practices during the 2022 and 2023 growing seasons. Among weed control methods, the highest grain yield was recorded in weed-free plots (4966.68kg ha<sup>-1</sup>), followed by one times application of Obest 8EC at three weeks after emergence + one times hand weeding at five weeks after emergence (4509.81kg ha<sup>-1</sup>), while the lowest grain yield was recorded in a weed checky plots (1094.8kg ha<sup>-1</sup>). The high grain yield can be attributed to the low dry weight of weeds and the efficient use of resources. The lowest grain yield was mainly due to weed infestation, high dry matter accumulation in weeds, and presence of different weed species in weedy plots. The results revealed that as the herbicide mixture ratio increased as the yield decreased, the treated plots had higher grain yields than the weed control plots and the herbicide treated plots. This may be because weed infestation is reduced and a favorable environment is provided for proper growth and development of the crop and a desirable degree of yield traits. [27, 32] Reported that the highest grain yield was obtained under weed-free treatments, but the lowest grain yield was obtained in weed control plots in southern Ethiopia. The result of this study was similar with [26] which stated that different herbicidal treatments had a significant effect on grain yield of wheat. The greatest reduction of yield was occurred when no herbicide was applied. Increased in yield in herbicides treated plots were due to the efficient weed control and thus the crop utilized all the available resources. These results are in confirmation with the work of [30] who reported that herbicidal treatments significantly increased grain yield in wheat. [1] Also stated that maximum grain yield was at weed free due to less weed population, better nutrient and water use efficiency but minimum at weedy check.

### 3.2.9. Harvest Index

The effect of different weed control methods on harvested index, an indicator of the efficiency of assimilate partitioning, were statistically significant. The variations in harvested index under different treatments may be due to variations in grain yield and yield-related parameters. The highest harvested index was recorded in one times application of Obest 8EC at three weeks after emergence + one times hand weeding at five weeks after emergence (50.46%), while the lowest harvested index (22.31%) was obtained in the onetime Hand Weeding at three Weeks After Emergence plot. The result also clearly indicated that harvest index was lower at higher total biomass production. Similar findings were reported from [1] concluded

that harvest index increased with decreased in weed competition. [31] Was also reported that significant variation in harvest index of wheat due to weed control treatments.

### 3.2.10. Yield loss

The main effects of herbicides and their frequencies with hand weeding effects were highly significant at on yield loss of wheat. The combined effects of weed free thought season gave no significant yield loss as compared to other interactions and also minimum yield loss was obtained from the interaction effects of one time application of Obest 8EC at three

Weeks After Emergence + one time hand weeding at five Weeks After Emergence (0.22%) followed by one time application of Obest 8EC at three Weeks After Emergence (3.01%) as compared to weed free treatments. The highest yield loss obtained from weedy check plots as a result of higher weed density and competition. The finding was in conformity with the work of [2] reported that highest yield loss was at weedy check and under poor weeds control. On the other hand, [20] reported a yield reduction as high as 80% in wheat due to weed competition throughout the crop growing season.

**Table 4.** combined data analysis of Integrated Weed Management on Thousand Kernel Weight, biomass, grain yield, and harvest index.

| No | Treatments                                               | TKW(gm-2)           | AGDBY(Kgha-1)         | GY(kgha-1)           | HI (%)             |
|----|----------------------------------------------------------|---------------------|-----------------------|----------------------|--------------------|
| 1  | Weedy check.                                             | 16.07 <sup>cd</sup> | 6472.22 <sup>h</sup>  | 2116.44 <sup>k</sup> | 33.06 <sup>d</sup> |
| 2  | Weed free check                                          | 27.68 <sup>f</sup>  | 13472.22 <sup>a</sup> | 5518.53 <sup>a</sup> | 26.20 <sup>g</sup> |
| 3  | 1HW at 3WAE.                                             | 25.63 <sup>b</sup>  | 11805.55 <sup>b</sup> | 2460.11 <sup>i</sup> | 22.31 <sup>i</sup> |
| 4  | 2HW at 3WAE and 5WAE                                     | 21.80 <sup>ef</sup> | 10694.44 <sup>c</sup> | 3034.66 <sup>f</sup> | 29.10 <sup>f</sup> |
| 5  | 1appl. Of Pallas 45 OD/Atlantis at 3WAE                  | 22.80 <sup>de</sup> | 10000.00 <sup>e</sup> | 3569.08 <sup>d</sup> | 38.06 <sup>c</sup> |
| 6  | 1 appl. of Obest 8EC at 3WAE.                            | 24.61 <sup>bc</sup> | 9027.77 <sup>g</sup>  | 4512.58 <sup>c</sup> | 37.70 <sup>c</sup> |
| 7  | 1 appl. of 2,4- D at 3WAE                                | 25.91 <sup>b</sup>  | 9583.33 <sup>f</sup>  | 3017.41 <sup>j</sup> | 24.80 <sup>h</sup> |
| 8  | 1 appl. of Obest 8EC at 3WAE + 1HW at 5WAE               | 25.27 <sup>g</sup>  | 7222.22 <sup>j</sup>  | 5010.89 <sup>b</sup> | 50.46 <sup>a</sup> |
| 9  | 1 appl. of Pallas 45 OD/Atlantis at 3WAE + 1HW at 5WAE   | 17.12 <sup>h</sup>  | 8194.44 <sup>i</sup>  | 4022.30 <sup>g</sup> | 38.89 <sup>b</sup> |
| 10 | 1 appl. of 2,4- D at 3WAE+ 1 appl. of Obest 8EC at 4WAE. | 28.08 <sup>a</sup>  | 10416.66 <sup>d</sup> | 4211.61 <sup>e</sup> | 29.42 <sup>f</sup> |
| 11 | 1 appl. of 2,4- D at 3WAE + 1HW at 5WAE                  | 24.09 <sup>cd</sup> | 10416.66 <sup>d</sup> | 3567.41 <sup>h</sup> | 30.74 <sup>e</sup> |
|    | Mean                                                     | 23.09               | 9936.866              | 2969.54              | 32.79              |
|    | LSD (5%)                                                 | 11.4                | 10.57                 | 12.41                | 10.8               |
|    | CV (%)                                                   | 23.57               | 20.81                 | 19.13                | 15.44              |

### 3.3. Economic analysis

Economic analysis of different weed management treatments revealed that weed control in wheat by different weed management methods gave different economic returns as compared to weedy checks [11, 29] The current investigation clearly showed that among the weed management methods, the highest net benefits was obtained from Weed free check treatments (403130.56 birr ha<sup>-1</sup>) followed by One times application of Obest 8EC at three weeks after Emergence + one times hand weeding at five weeks after emergence (367956.74 birr ha<sup>-1</sup>) and One times application of Obest 8EC at three weeks after Emergence treatment (340061.22 birr ha<sup>-1</sup>), while

the lowest net benefits was obtained from weedy check treatment (98531.64birr ha<sup>-1</sup>) followed by One time hand weeding at three weeks after emergence treatments (138201.32birr ha<sup>-1</sup>). The weed management method had significant value in increasing the yield attribute of wheat compared to the weedy check. Economic analysis showed that it concluded the use of One times application of Obest 8EC at three weeks after Emergence + one times hand weeding at five weeks after emergence (367956.74 birr ha<sup>-1</sup>) and One times application of Obest 8EC at three weeks after Emergence treatments (340061.22 birr ha<sup>-1</sup>), is more economical than other treatments with highest marginal rate of return. The similar result was reported from [7, 22] suggested that herbicides combina-

tions with higher seed rates effectively controlled weed infestation in bread wheat and gave higher yield that related directly with high relative net return. All interaction of seed rates

and herbicides application gave higher net benefit over weedy checks.

**Table 5.** Economic analysis of weed management practice in 2022 and 2023 main cropping season at Northern Oromia.

| Treatments                                                | GY(kgha-1) | AY(Kgha-1) | TB(birr)      | TC(birr) | NB(birr)      | MRR (%)   |
|-----------------------------------------------------------|------------|------------|---------------|----------|---------------|-----------|
| Weedy check.                                              | 216.44     | 1094.80    | 98531.64      | 0.00     | 98531.64      | 318.18    |
| 1HW at 3WAE.                                              | 2460.11    | 1674.10    | 150668.9<br>1 | 12467.59 | 138201.3<br>2 | 1340.12   |
| 1 appl. of 2,4- D at 3WAE                                 | 3017.41    | 2715.67    | 244410.2<br>1 | 18976.88 | 225433.3<br>3 | 1768.71   |
| 1 appl. of Obest 8EC at 3WAE.                             | 4512.58    | 4061.32    | 365518.9<br>8 | 25457.76 | 340061.2<br>2 | 101845.18 |
| 1appl. Of Pallas 45 OD/Atlantis at 3WAE                   | 3569.08    | 3212.17    | 256973.8      | 27935.19 | 229038.6      | D         |
| 1 appl. of Obest 8EC at 3WAE + 1HW at 5WAE                | 5010.89    | 4509.80    | 405882.0<br>9 | 37925.35 | 367956.7<br>4 | 1680.55   |
| 2HW at 3WAE and 5WAE                                      | 3034.66    | 2731.19    | 245807.4<br>6 | 28935.17 | 216872.2<br>9 | 2759.12   |
| 1 appl. of 2,4- D at 3WAE + 1HW at 5WAE                   | 3567.41    | 3210.67    | 288960.2<br>1 | 30444.47 | 258515.7<br>4 | 1145.51   |
| 1 appl. of Pallas 45 OD/Atlantis at 3WAE + 1HW at 5WAE    | 4022.30    | 3620.07    | 325806.3<br>0 | 33402.78 | 292403.5<br>2 | 1386.06   |
| 1 appl. of 2, 4- D at 3WAE+ 1 appl. of Obest 8EC at 4WAE. | 4211.61    | 3790.45    | 341140.4<br>1 | 34434.64 | 306705.7<br>7 | 1021.91   |
| Weed free check                                           | 5518.53    | 4966.68    | 447000.9<br>3 | 43870.37 | 403130.5<br>6 | 918.91    |

Key: MRR= maximum rate of return, GY=grain yield, AY=adjusted yield, TC=total cost, TB=total benefit NB=net benefit

## 4. Recommendation

The current research finding indicated that the weed management method had significant value to increase the yield attribute of wheat as compared to the weedy check. The highest weed control efficiency was obtained from Weed free plot (94.64%), followed by One times application of Obest 8EC at three weeks after Emergence + one times hand weeding at five weeks after emergence (93.28%) closely followed one times application of 2, 4-D at three Weeks After Emergence + one times application of Obest 8EC at four Weeks After Emergence (91.65%) treatments. As economic analysis showed that the highest net benefit were obtained from One times application of Obest 8EC three weeks after Emergence + one times hand weeding at five weeks after emergence (367956.74birr ha<sup>-1</sup>) and One times application of Obest 8EC at three weeks after Emergence treatment (340061.22birr ha<sup>-1</sup>). Finally the outcome of the study was handling weeds with the usage of

One times application of Obest 8EC at three weeks after Emergence + one times hand weeding at five weeks after emergence and One times application of Obest 8EC at three weeks after Emergence treatment is recommended for the study area.

## Abbreviations

|       |                                     |
|-------|-------------------------------------|
| HW    | Hand weeding                        |
| OARI  | Oromia Agricultural Research Center |
| FIARC | Fitche Agricultural Research Center |
| YL    | Yield Loss                          |
| WAE   | Weak After Emergence                |

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## Conflicts of Interest

The authors declare no conflict of interest.

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