YIELD AND GROWTH RESPONSE OF WHEAT VARIETIE (*Triticum Aestivum* ***L.***) TO WEED CONTROL METHODS IN ADAMI TULU JIDO KOMBOLCHA WOREDA, OROMIA REGINAL STATE, ETHIOPIA.

M.Sc. THESIS

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YIELD AND GROWTH RESPONSE OF WHEAT VARIETIE (*Triticum Aestivum* ***L***.) TO WEED CONTROL METHODS IN ADAMI TULU JIDO KOMBOLCHA WOREDA, OROMIA REGINAL STATE, ETHIOPIA.

A Thesis Submitted to the department of Plant Sciences,
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MASTER OF SCIENCE IN AGRICULTURE (AGRONOMY)

By

Kemal Gemechu Uti

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APPROVAL SHEET

MADDA WALABU UNIVERSITY

SCHOOL OF GRADUATE STUDIES

As thesis research advisor, I hereby certify that I have read and evaluated the thesis entitled "Yield and Growth Response of Wheat Varieties (*Triticum Aestivum L.*) To Weed Control Methods in Adami Tulu Jido Kombolcha Woreda, Oromia Reginal State, Ethiopia." prepared under my guidance by Kemal Gemechu. I recommend that it can be submitted as fulfilling the thesis requirement.

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As members of the Board of Examiners of the M.Sc. Thesis Open Defense Examination, we certify that we have read and evaluated the thesis prepared by Kemal Gemechu and examined the candidate. We recommend that the Thesis be accepted as it fulfilling the Thesis requirements for the Degree of Master of Science in Agronomy.

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DEDICATION

This thesis is dedicated to my almighty God and then to all my family and friends for their contribution to the success of my MSc. study in Agronomy.

STATEMENT OF THE AUTHOR

By my signature below, I declare affirm that this Thesis is my own work. I have followed all ethical and technical principles of scholarship in the preparation, data collection, data analysis and completion of the thesis.

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BIOGRAPHICAL SKETCH

The author, Kemal Gemechu, was born on June 22, 1993, to his parents, Mr. Gemechu Uti and Mrs. Aashia Mekika, in *Senbaro* Kebele, *Zuway Dugda* District, Arsi Zone, and Oromia National Regional State, Ethiopia. He attended *Senbaro* Primary School for his elementary education and *Ketar Fua Fuate* High School for his secondary education. He joined and attended grades 11 and 12 at *Batu Preparatory School from 2011 to 2012*.

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LIST OF ACRONYMS AND ABBREVIATIONS

ANOVA	Analysis of Variance
ATJK	Adami Tulu Jido Kombolcha
CSA	Central Statistics Agency
FAO	Food and Agriculture Organization
HI	Harvest Index
LSD	Least Significant Difference
MoA	Ministry of Agriculture
OD	Oil dispersible
RCBD	Randomized Complete Block Design
SAS	Statistical Analysis System
WCE	Weed control efficiency

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Abstract

Weed is among the various biotic factors constraining wheat productivity in Ethiopia in general and Central Mid-rift valley of Ethiopia in particular. To combat the problem various weed control option identified under different agroecologies for different wheat varieties. Although wheat production is commonly practiced under highland and midland parts of the country, currently it is advancing to lowland parts of the country as a result of the adoption of lowland wheat varieties. This invited identification of appropriate wheat variety and effective and economical weed control method. *The study was conducted at Adami Tulu Jido Kombolcha (ATJK) district at two sites (Adami tulu research center) and (Galo Heraphe farmers field) during the crop growing season of 2022 to study the response of different wheat varieties under different weed control methods. A randomized complete block design of three replications and twelve treatments comprised from three wheat varieties(Balcha, Daka, and Wane)and four weed control method (two times hand weeding (30 DAE and 45 DAE), Pallas 45% OD 0.5 L/ha Herbicides (30 DAE), Pallas 45% OD (30 DAE) plus one time hand weeding (45 DAE), and weedy check (zero weeding)). Study result showed that Nikandiraphysaladis and Daturastramonium were found dominant broad leaf weeds at Adami Tulu site, while Setaria pumila (33%) and Avenafatua (18%) were among the grass weed species abundant at the Galo Heraphe location. The weed control methods were significantly influenced wheat yield between the study sites. The least grain yield was recorded from the plots treated with unweeded check (136.12 kg/ha) and (1232.23kg/ha) whereas the highest yield was recorded from plots treated with two times hand weeding (2514.43) and (2733.44kg/ha) followed by Pallas plus one time hand weeding (2370.99kg/ha) and (2442.9kg/ha) without significant difference at Adami Tulu and Galo Heraphe site respectively. Application of two times hand weeding and Pallas plus one time hand weeding showed grain yield advantage 94% and 49% over unweeded control (zero weeding) at Adami Tulu and Galo Heraphe sites, respectively. Maximum mean grain yield of 2073.14 kg was recorded for the Balcha wheat variety followed by the Daka wheat variety (1899.62 kg). However, there was no discernible difference between the two. Finally, Pallas with one-time hand weeding was found quite effective in controlling major broadleaf and grass weed species observed in wheat fields and it was found economically feasible among the weed control methods considered. Among the wheat varieties Balcha and Daka were found high yielders in the study area and recommendable under the study area and similar agro ecologies.*

1. Introduction

Wheat (Triticum aestivum L.) is one of the most important food crops of the world and a member of the family Poaceae that includes major cereal crops of the world such as maize, wheat and rice. After South Africa, Ethiopia is the second largest wheat producer in sub-Saharan Africa (FAO 2015).It is a staple food in the diets of several Ethiopian, providing about 15 percent of the caloric intake for the country's over 90 million population (FAO 2015), placing it second after maize and slightly ahead of teff, sorghum, and enset, which contribute 10-12 percent each (Minot et al., 2015).Wheat is produced by close to 5 million smallholder farmers, which makes about 35 percent of all small farmers in the country. It accounts close to 17 percent of acreage of arable land and a fifth of all cereal food crops produced in the country (CSA, 2013/14). Wheat is mainly grown in the highlands of Ethiopia, which lie between 6 and 16° N and 35 and 42° E, at altitudes ranging from 1500 to 2800 meters above sea level and with mean minimum temperatures of 6℃ to 11℃ (MOA, 2012).

In Ethiopia, wheat covered an area of 1,897,405.05 ha with a total production of 57,801,305.96quintals with yield average of 30.46qt/ha during 2021 main cropping season (Meher) (CSA, 2021). In Oromia region wheat covered, an area of 996,364.40ha with a total production of 32,877,497.09 quintal's which 33.00 qts/ha and in East Shewa zone, 113,038.75ha which produce 3,751,494.28 Quantal (CSA, 2021). Out of the total grain crop area, 81.19% (10,538,341.91) hectares) was under cereals. Teff, maize, sorghum and wheat took up 22.56% (about 2,928,206.26 hectares), 19.46% (about 2,526,212.36 hectares), 12.94% (1,679,277.06 hectares) and 14.62% (1,897,405.05 hectares) of the grain crop area, respectively. As to production, the tables paint similar picture as that of the cropland area. Cereals contributed 88.36% (about 302,054,260.58 quintals) of the grain production. Maize, teff, wheat and sorghum made up 30.88% (105,570,935.92 quintals), 16.12% (55,099,615.14 quintals), 16.91% (57,801,305.96 quintals) and 13.22% (45,173,502.18 quintals) of the grain production, in the same order.

Although wheat has a great nutritional and economic importance, its productivity has been constrained due to various biotic and abiotic factors(Haidari et al.,2014).Among the biotic factors weeds are one of the major constraints in wheat production as they reduce productivity due to competition, allopathy and by providing habitats for pathogens as well as serving as alternate host for various insects, fungi and increase harvest cost (Abbas *et al*.,2009).Studies indicated that crop losses due to weed competition throughout the world are greater than those resulting from combined effects of insect pests and diseases (Amare *et al*.,2014).The total global potential loss due to pests varied from about 50% in wheat. The total annual loss in agriculture produce, weeds account for 45% (Mohamed *et al*., 2014).

Weed infestation has been reported as a major constraint to wheat production in Ethiopia in both the peasant and the state farm sectors. Weeds are generally defined as plants growing where are unwanted, they differ in the damage that they cause to crops, and this is governed by their growth habit, vigor, seed production, regenerative capacities and time of germination. Weeds can also increase harvesting costs, reduce quality of product (Bibi *et al*, 2008). Apart from increasing the production cost, weeds also intensify the disease and insect pest problem by serving as alternative hosts, and uncontrolled weed growth throughout the crop growth caused a yield reduction of 57.6 to 73.2% (Tesfay *et al*, 2014).Weeds are one of the major constraints of wheat production and weed control is the key factor in increasing yield (Lopez-Granados, 2011; Shahzad *et al*., 2012).

Hand weeding is the major weed control practice on smallholder farms (Vissoh *et al.*, 2004). Hand weeding is the oldest method of weed control and consists of hand pulling, hand slashing and hoeing of weeds. Though manual and physical methods of weed control are very effective in Ethiopia, however, on-availability of labor during peak period under intensive farming, high labor cost; regeneration of weeds, which require frequent operation, and weeds cannot effectively be managed merely due to crop mimicry (Kebede *et al*, (2000). Therefore, the use of chemical weed control has become necessary (Marwat, *et al* 2008) and this has created a scope for using herbicides and they are becoming more popular in developing countries like Ethiopia. Weed management systems that depend heavily on herbicides are now accepted as unsustainable and it has created a problem of evolution of herbicide resistant weeds (Riaz M, et al, 2006) and Amit JJ et al, 2008). Hence, development of more comprehensive and sustainable weed management system is warranted for economic production of wheat. Moreover, control of weeds by a single method usually does not give positive results and may not be socio-economically acceptable. Therefore, the experiment was conducted with the objective of delineating the influence of hand weeding and the application of post-emergency herbicides and herbicide applications supplemented by hand weeding of wheat weed control on wheat varieties to see the responses on yield and yield components of rain-fed wheat in the Adami Tulu Worada central rift valley of Ethiopia.

1.2. Objective

1.2.1. General objective

- To evaluate the response of wheat varieties to different weed control methods.

1.2.2. Specific objective

- To identify economically significant weed control method for wheat crop.
- To identify major problematic weed species of wheat crop at study area.

2. Literature review

2.1. Origin and Distribution of Wheat

Wheat (Triticum aestivum) is believed to have originated in the Near East, in the areas now occupied by Syria, Turkey, Afghanistan, Iraq and Iran. Grains of domesticated wheat were found in the archaeological remains in Ali Koshi in Iranian Khusistan, dating back to 6 500 BC, as well as in Anatolia in Turkey, dating back to 5 500 BC. Cultivation of wheat spread from its origin to India, Pakistan and China in the east, to the Mediterranean countries in the west and the U.S.S.R and other countries in the north. In South Africa, Jan van Riebeeck introduced it in the middle of the 17th century upon arrival in the Cape in 1652. Thereafter, it spread to the Western Cape, South Western Cape and Free State Provinces. Knowledge of T. aestivum cultivation origin has been lost. The precise origin of the wheat plant as we know it today is not known. Wheat evolved from wild grasses, probably somewhere in the Near East. A very likely place of origin is the area known in early historical times as the Fertile Crescent region with rich soils in the upper reaches of the Tigris-Euphrates drainage basin. (Production guideline for wheat.2016).

2.2. Wheat crops

Wheat (Triticum aestivum L.) is one of the globally produced and marketed cereal crops which covers 15% of the total sowing areas of cereal crops in the world (Kiss, 2011). It is an important industrial and food grain which ranks second among the most important cereal crops in the world after rice and traded internationally (Asadallah, 2014; Falola et al., 2017). In sub-Saharan African countries, wheat is also a strategic commodity, which generates farm income and improves food security status (Amentae *et al*., 2017; Minot *et al*., 2015; Negassa *et al*., 2013). Many African countries are producing wheat for both consumption and sale, but the level of production and sale is varied between countries. Ethiopia is one of the largest wheat producers in terms of total wheat area cultivated and total production (CSA, 2012). Wheat and wheat products represent 14% of the total calorie intake in the country, which makes wheat the second-most important food

2.3. Economic importance of wheat

Wheat (Triticum aestivum L.) is the first important and strategic cereal crop for the majority of world's populations. It is the most important staple food of about two billion people (36% of the world population). Worldwide, wheat provides nearly 55% of the carbohydrates and 20% of the food calories consumed globally (Breiman and Graur, 1995). It exceeds in acreage and production every other grain crop (including rice, maize, etc.) and is therefore, the most important cereal grain crop of the world, which is cultivated over a wide range of climatic conditions and the understanding of genetics and genome organization using molecular markers is of great value for genetic and plant breeding purposes.

2.4. Factors affecting wheat yield loss

2.4.1. Wheat yield losses due to weed competition

Weeds are the most significant pest in wheat worldwide (Oerke 2006). Previous estimates of global wheat yield loss due to weeds were 9.8% (Cramer 1967) and 12.3% (Oerke et al. 1994). In 2006, Oerke estimated the worldwide potential wheat loss to be 23.0% with a range of 18% to 29% and actual loss of 7.7% with a range of 3% to 13%. The Weed Science Society of America (WSSA) Weed Loss Committee generated reports in 1984 (Chandler et al.) and 1992 (Bridges) that summarized crop losses due to weeds across the United States and Canada. Chandler et al. (1984) reported an estimated 9% to 20% wheat yield loss with an average of 13% across the United States and 5% to 15% wheat yield loss across Canada due to weeds. Bridges (1992) reported 1% to 20% wheat yield loss due to weeds across the United States using then-current management (i.e., best management practices [BMPs] with herbicides); BMPs but no herbicides resulted in 3% to 60% wheat yield loss. In a summary of yield loss due to weeds in Canada, Swanton et al. (1993) reported 5% to 15% wheat yield loss

2.4.2. Weed problem

Weeds are the most universal of all crop pests, proliferating each year on every farm in Africa (Obuo*et al.*, 1997). African soils contain 100 to 300 million buried weed seeds per ha of which a fraction germinate and emerge each year. (Sibuga, 1997) recommended as weed are the most important pest to be controled in all zones of sub Saharan Africa. 263 weed species belonging to 38 families were found in crop fields in Africa. Broadleaved weed (72%) and grasses (24%) dominated the total weed spectrum, whereas sedges (4%) were minor. Mean weed species richness per field was similar across all agro ecological zones and averaged about 16 per field (Chikoye and Ekeleme, 2001).

Unwedded fields in Nigeria produced between 17 and 30 tons per ha of fresh weed weight (Adigun *et al.*, 1991). Weed problems are more severe in African tropical regions than in Europe and North America because weeds grow more vigorously and regenerate more quickly in the presence of warm climate and higher light intensity. High humidity and high temperature, conditions characteristic of sub-Saharan Africa, favor rapid and excessive weed growth (Akobundu, 1980).

Nevertheless, due to weather, soil type or geographic location, and other pests associated with weeds, it is difficult to estimate, on the large spatial and temporal scales, the yield loss caused by weeds (Oerke*et al*., 1994). The yield loss due to weeds is almost always caused by an assemblage of different weed species, and these can differ substantially in competitive ability (Weaver and Ivany, 1998). Therefore, it is not easy to evaluate the relative importance of different weed species in causing yield loss for producers. Nevertheless, such an evaluation would be valuable both when making management decisions and when setting research priorities.

2.4.3. Common Weed Species Associated with Wheat

Wheat field infested by variety of weed species belonging to different families. The weed flora composition assessment in wheat fields in Ethiopia showed that *Avenaabyssinica* L., *Avenafatua* L., *Bromuspectinatus* L., *Loliumtemulentum* L., *Phalarisparadoxa* L., *Setariapumila* L., and *Snowdeniapolystachya* L. are the major problematic weed species in wheat growing regions (Birhanu, 1985; Rezene, 1985; Tanner and Grief, 1991). The most widely spread and distributed broadleaved weeds and most problematic weeds in wheat crop weeds include: *Amaranthushybridus* L., *Argemonemexicana* L., *Bidenspilosa* L., *Commelinaafricana* L., and *Chenopodium album* L. *Convolvulus arvensis* L.,*Daturastramonium* L.,*GalinsogaparvifloraCav.*, *Guizotiascabra* (Vis) *Chiov*, *Medicagopolymorpha* L., *Polygonumnepalense* L., *Plantagolanceolata* L. and *Scorpiurusmuricatus* L. (Rezene, 1985; Tanner and Giref, 1991).

2.4.4. Weed crop interaction

Weeds are plant which compete for nutrients, space, light and exerts lot of harmful effects by reducing the quality as well as quantity of the crop if the weed populations are left uncontrolled (Alemaw and Agegnehu ,2019).Weeds cause diseases in crops and support the insect pests. In agricultural term, weeds are called pests because they cause damage to the crop. Weeds may reduce about 40-50% grain yield in wheat crop .Among the factors, which adversely affect the yield of wheat crop, weed infestation is the most harmful one but less noticeable. Weeds comprise the most undesirable, aggressive and troublesome element of world's vegetation. Weeds are plants, which grow out of their proper places and whose virtue has not yet been discovered. Weeds also act as reservoir for multitude of pest and diseases, which use them as alternate hosts for food and shelter during the off-season period. Weed density under both rained as well as irrigated conditions were studied for yield losses due to various densities of Melilotusindica L. (Oad et al., 2007).cited in Bogale Ayana, (2020)

Different agricultural pests attack wheat, but weeds remained the major problem play the main role. Weed losses in wheat may occur from initial stages to the last stage of maturity, harvest, threshing, winnowing and storing of wheat grains. Weed plants are more resistant, hardy and making faster growth than wheat and cause great growth and yield loss due to competition before crop harvest. Generally weeds reduce wheat yield by30-50percentage.Losses may reach 100% depending on weed species and density (Tessema and Tanner, 1997).

Weed control method

2.5. Physical method of weed control

The tools for weed control are most often used alone to uproot, cut, or otherwise kill vegetation that is not wanted or needed. Existing vegetation usually must be removed from a field before flowering and before, it is suitable to grow crops. The physical methods of weed control are any technique that uproots, buries, cuts, smothers, or burns vegetation (Gupta, 1983).

2.5.1. The effects of hand weeding and its frequency on crops and weeds

Hand weeding is the major weed control practice on smallholder farms (Vissoh*et al.*, 2004). Hand weeding is the oldest method of weed control and consists of hand pulling, hand slashing and hoeing of weeds. The relative cost involved along with unavailable of labor during the peak periods of farm operations and tediousness of the manual operation under high temperature and high humidity are some of the drawbacks of this system (Sullivan, 2003). Smallholder farmers spend 50-70% of their total labor time hand weeding (Chikoye*etal.*, 2007).Women contributes more than 90% of the hand weeding labor for most crops (Ukekje*et al*., 2004). Farm children (69%) of between the ages of 5-14 are forced to leave school and are used in the agricultural sector especially at peak period of weeding (Ishaya*et al.*, 2008).

2.6. Effects of herbicides on weed, yield attributes and yield of crop

Herbicides should be used in combination with good preventative, physical and cultural practices. A wide variety of herbicides is available for both annual grassy and broadleaf weed control in wheat. The effectiveness of the herbicide will depend upon a number of application and environmental factors. Most herbicides are recommended at a range of rates either to facilitate control of weeds in a window of growth stages or under differing densities. Weed control is always easier and less disruptive to the crop when done at an early growth stage on the weeds. Decreasing the water carrier volume can increase the danger of spray drift result in inadequate coverage of the weed species and cause yield damage. Weed can be controlled by different methods but chemical weed control in wheat was best in producing higher grain yield than hand weeding. (Bogale Ayana, 2020). A wide variety of herbicides is available for both annual grassy and broadleaf weed control in wheat. Application of grassy and broad leaf herbicides increased grain yield and yield components of wheat. (Bogale Ayana, 2020).

2.6.1. Types of herbicide used in wheat

Weeds pose serious problem to grain production in Ethiopia especially cereal production in Ethiopia is hampered due to the aggressiveness of both grass and broad leaf weeds (SARC, 2016). This might due to multiple factors such as: herbicides currently in use are ineffective, resistance development of some weed biotypes, unavailability or inaccessibility of herbicides in amount, type and at required time, increasing cost of herbicides, weed flora shift due to continuous mono-cropping of cereals and frequent use of one type of herbicides, morphological similarity of weed species with the cereal crops (especially at early stage), introduction of farm machineries that aggravate the dissemination of weed seeds and continuous return to the soil-seed bank, etc. (Rezene and Yohannes, 2003).

Selective herbicides are effective in controlling target weeds but inefficiency may arise in case the weeds develop resistance to certain selective herbicides and due to uncontrolled factors that may reduce the efficiency of the chemicals

2.6.2. Economic feasibility of herbicide usage

Comparisons of the economics of different weed control technologies indicate that herbicides reduce the labor requirement for control to between one-tenth and two-thirds of the requirement for manual weeding (Benson, 1982). The overall reduction in production costs associated with herbicides is caused by a massive reduction in the labor required for weeding from 39.2 to 1.3 person-days per hectare (Mengesha *et al*., 2014). The use of herbicides to remove weeds required only 2 hours of labor per hectare (Mengesha*et al*., 2014). Research with maize herbicides in Nigeria demonstrated that the use of herbicides reduced the need for labor at the peak period by 29-42% (Ogungbile and Lagoke, 1986).

Chemical control is a better alternative to manual weeding because it is cheaper, faster and gives better weed control (Chikoye*et al.*, 2005). Smallholders have conducted numerous experiments that demonstrate the potential positive impacts of the use of herbicides. In cassava, research showed that chemical weed control was over three times cheaper than two timely hand weeding (Akobundu*et al*., 1980). Two properly timed hand weeding were enough to reduce loss caused by weeds in maize plots. However, this weeding method was nearlythree times as expensive as the combined cost of herbicide and labor for spraying (Akobundu*et al.*, 1980). The weed control labor requirement for groundnut production in Zimbabwe was estimated at 107 hours/ha on a plot without herbicide application and 0.4 hours/ha on a plot treated with herbicides (Benson *et* *al*., 1982).

An Ethiopian study showed that herbicides resulted in 97% greater wheat yield in comparison to the farmer practice of one hand weeding (Tanner and Grife, 1991). In a cotton experiment, the use of a complete herbicide program for field preparation, at-planting pre emergence, and post emergence treatments reduced the number of hours by 700 per hectare, while the use of the pre emergence treatment with hand weeding for field preparation and post emergence reduced the labor requirement by 255 hours per hectare (Lagoke*et al.*, 1992). Use of herbicides in Kenyan weed trials resulted in 33% higher maize yields than farmer practice of hand weeding due to better weed control (Muthamia*et al.*, 2001). In maize experiment conducted in Kenya determined that chemical weeding was one-third the cost of two hand weeding (Maina*et al.*, 2003) whereas in Nigeria, the cost of weed control in rice with herbicides was 50% lower than hoe weeding (Shave and Avav, 2004).

3. MATERIALS AND METHODS

3.1. Description of study area

The study was conducted in two locations in Adami Tulu Jido Kombolcha (ATJK) district from July to October during the main cropping season of 2022, one site was at Adami Tulu Agricultural Research Centre trial station and the second site is at Galo Heraphe Kebele Farmer Field, Both are located in East Shewa Zone, a central part of Ethiopia. Adamitulu Agricultural Research Centre is located in the middle rift valley of Ethiopia, 167 kilometers Away from the capital city of the country, Addis Ababa in the southeastern part of Oromia. The site is located at latitude of 7° 9 N and 38°E and an altitude of 1650 m (m.a.s.l.). as meterological data obtained from adami tulu meterological station indicate the area receives a mean maximum and minimum temperatures of 28.5 and 12.9°C, respectively, and its average relative humidity is 57.25%. In addition, Galo Herape Kebele is located about 26 kilometres from Adami Tulu town, in the direction of north west. The altitude of 1655 m above sea level m.a.s.l. and a latitude and longitude of 7° 9 N and 38° 6' E. The total land area of the district is 1403.3 kilometers square, which is inhabited by 177,492 people, of which more than 79% are living in the rural area (Assefa et al., 2013).

3.2. Treatments and experimental design

The field experiment was laid with factorial arrangement in randomized complete block design (RCBD) with three replications. One plots have eight rows which spaced by 20cm. A spacing of 0.5m and 1m was maintained between plots and block respectively. The plot size was 1.6 m x 2 m (3.2 m^2) and with a total experimental area of 197.6m^2(24.7m*8m). A total of twelve treatments were arranged from the combination of three wheat varieties (Daka, Balcha & Wane) and four weed control methods (1.Pallas +Hand weeding, 2.Pallas herbicide,3.Two times hand weeding &4.unweeded check). Pallas Herbicide and first hand weeding were applied at post emergence stage (30 DAE) and the second hand weeding for both two hand weeding and Pallas + hand weeding at (45 DAE) was applied as per the treatments. Pallas Herbicide was applied with the help of knapsack sprayer nozzle size of 350µm while the volume of water was 200 L/ha-1 pressurized at 40 psi. The amount of herbicides as per the treatment was calculated and measured as registered 0.5L dose to per hectare was converted to the plot size and its dose and time is as registered doses.

Description of some agro ecological wheat varieties

No	Varieties name	year of release	Altitude(m)	Rainfall(mm)	maturity days	Agro ecology	yield potential at research field (ton/ha)
1	Wane	2016	200-2300	750-1500	120	mid land to high land	5-6
2	Balcha	2019	1600-2100	400-500	130	low land to mid land	5.6- 6.5
3	Daka	2018	1600-2200	500-800	75	mid to low land	5-6

Source: KARC 2022

Herbicide information

No	Herbicide	Chemical name	Recommended rate per/ha
1	Pallas 45% OD	Pyroxsulam (45-OD)	0.5L

The treatments arrangement of the experiment was consisting of 12 treatments.

- T1 = Daka wheat Variety(DV) + Pallas (P) (30DAE)+Hand Weeding (HW) (45DAE)
- T2 = Daka wheat Variety (DV)+ Pallas (P) (0.5L/ha) 30DAE
- T3 = Daka wheat Variety (DV) + Two Hand Weeding (HW) (30DAE)+(45DAE)
- T4 = Daka wheat Variety (DV) + Zero weeding (ZW)
- T5 = Wane wheat Variety (WV) + Pallas (P) (30DAE)+Hand Weeding (HW) (45DAE)
- T6 = Wane wheat Variety (WV) + Pallas (P) (30DAE)
- T7 = Wane wheat Variety (WV) + Two Hand Weeding (HW) (30DAE)+(45DAE)
- T8 = Wane wheat Variety (WV) + Zero weeding (ZW)
- T9 = Balcha wheat Variety (BV) + Pallas (P) (30DAE)+Hand Weeding (HW) (45DAE)
- T10 = Balcha wheat Variety (BV) + Pallas (P) (30DAE)
- T11 = Balcha wheat Variety (BV) + Two Hand Weeding (HW) (30DAE)+(45DAE)
- T12= Balcha wheat Variety (BV) + Zero weeding (ZW)

DV = Daka Wheat Variety, WV = Wane Wheat Variety, BV = Balcha Wheat Variety, HW = Hand Weeding, ZW = Zero Weeding, 30DAE = 30 Day after Crop Emergency, 45DAE=45Day after Crop Emergency.

3.3. Experimental procedure and crop management

The land was plough two times to a fine tilth-using tractor. The plots were arranged as per the layout and leveled manually. Wheat seed with the recommended rate of 150kg/ha was drilled in rows spaced 20 cm. The recommended rate of 150 kg ha-1 of urea and 100 kg ha1 of NPZnB was applied. Urea (46% N) was applied at two doses (split application) i. e 2/3 of it at time of sowing by mixing with full dose of NPSZnB and 1/3 was applied at tillering stage. Weed controlling was done in the treatment arrangement. The weeds in weedy check plots were neither weeded by hand nor treated by herbicide to keep the plots with weeds. Plot-wise harvesting was done at the crop physiological maturity. The harvested sample was sun-dried for eight days and threshed.

3.4. Plant sampling and data analysis

3.4.1. Crop data

Phonological parameters

Days to 50% heading (No): It was recorded when 50% of the plants in plots exhibit heading.

Growth parameters

Plant height

Plant height was measured from the base to the tip of the plant (main shoots) for 10 randomly selected plants using tap meter from each plot before 15 days of harvesting.

Spike length (cm): It was recorded from 10 plant spikes, which are randomly select from each plot. Each spike was measured in cm before 15 days of harvesting using scale from the base of the spike to the apex.

Yield and Yield components

Effective tillers per plant (No): It was determined at physiological maturity of plants per plot by counting the effective tillers.

Number of spikelet's per spike (No): Each 10 spike was threshed separately after harvesting and grains of each spike would be counted and averaged

Number of seed per spike (No): Each 10 spike was threshed separately after harvesting and grains of each spike was counted and averaged

Thousand-grain weight (TGW) (g): Number of thousand grains was counted using digital seed counter from a bulk of shelled grain and weighed using sensitive balance from a plot at harvest at 12.5 % moisture by using grain moisture tester.

Grain moisture content (%): Moisture content of threshed grain measured by using grain moisture tester.

Total above ground biomass (kg ha^{-1}): Total stand clipped at ground level from net area of each plot and the weight determined by using common balance.

Grain yield (kg ha^{-1}): it was determined from grain obtained from net harvestable area, measured weighed using sensitive balance, adjusted to 12.5% moisture level by using grain moisture tester, and will be converted to kg ha^{-1}.

Harvest index: It was calculated as the ratio of grain yield to above ground dry biomass per plot and multiplied by 100.

$$\mathrm{HI} = \frac{\text{Grain yield}}{\text{Biomass yield}} * 100$$

3.4.2. Weed data

Weed population (No):): It was determined by counting the total number of weeds in the 1 m × 1 m quadrate thrown randomly before 15 days of harvesting was taken.

Weed dry weight (g): Dry weight of weeds was determined from weeds clipped at ground level before 15 days of harvesting from the randomly thrown quadrates and then oven dried at 105 ^{0C} for 24 hours and recorded.

Weed control efficiency (WCE): Weed control efficiency (WCE) denotes the magnitude of weed reduction due to weed control treatment. It was calculated as:

$$\mathrm{WCE} = \frac{\mathrm{WDC - WDT}}{\mathrm{WDC}} * 100$$

Where, WCE= Weed Control Efficiency; WDC=Weed dry matter in weedy check; and WDT=Weed dry matter in a particular treatment

3.5. Economic analysis

Partial budget analysis was done to determine the economic feasibility of the treatments. It was calculated by taking into account the variable input costs involved and the gross returns obtained from different treatments. Grain yield was adjusted to 90% of yield obtained from trial plots to match with expected yield at farmers' level due to poor crop husbandry, high post harvesting losses and in appropriate harvesting technology and larger area. The gross benefit was calculated as adjusted grain yield (kg ha^{-1}) multiplied by the grain price (37.00 ETB kg) that farmer's gate.

The prevailing local market price (37.00 ETB/kg) at the harvest of wheat was taken to determine gross returns. The relative net returns was calculated by subtracting the cost of treatment that vary (VC) from the gross returns (GR) as described by CIMMYT (1988).

3.6. Statistical analysis

The data were subjected to the analysis of variance (ANOVA) appropriate to the design using SAS version 9. Mean separation was done using Fisher's protected least significant difference (LSD) test at 5% level of significance.

4. Results and Discussion

Weed flora composition

Weed data recorded from the experimental fields showed the existence of diverse weeds species in the area. The weed species were categorized as broad leaf and grass weed species. A total of 22 (16 broadleaf and 6 grasses) weed species belonging to 10 families were recorded. (Table 1). Among grass weed species, *Avena fatua, Setaria pumila, Snodenia polystachia and Setaria verticulata* was the major one. On the other hand, *Guizotia scarba, Nicandira physalodes, Bidens pilosa, Galinsoga parviflora, Datura stramonium, and Amaranthus spp* were the major broad leaf weed species observed in the trial fields across locations. Among broad leaf weeds *Nicandira physalodes* and *Daturastramonium* was dominant weeds at Adami tulu site while *Setaria pumila*, and *Avena fatua* was among grass weed species found abundantly at Galo Heraphe site (table 1.1 &1.2)

Table 1 Scientific names, families, life form and categories of weeds in the area

Scientific name	**family**	**life form/category**
1. Nicandira physalodes	*solonacaea*	Annual(broad leaf)
2. Datura stramonium	*solonacaea*	Annual(broad leaf)
3. Amaranthus spp	*Amaranthaceae*	Annual(broad leaf)
4. bidens pilosa	*Asteraceae*	Annual(broad leaf)
5. Parthiniem hysterophorus	*Asteraceae*	Annual(broad leaf)
6.Tribulus territories	*Zygophylaceae*	Annual(broad leaf)
7.Commelina bengalensis	*Commelinaceae*	Annual(broad leaf)
8.Erucustrem Arabica	*Brassicaceae*	Annual(broad leaf)
9. Galinsoga parviflora	*Asteraceae*	Annual(broad leaf)
10.tagatas minuta	*Asteraceae*	Annual(broad leaf)
11.chenopodiam album L	*Chenopodiaceae*	Annual(broad leaf)
12.solanum nigrum	*Solanaceae*	Annual(broad leaf)

13.portulacum oleracea	*portulacaceae*	Annual(broad leaf)
14. Erucustrem gallium	*Brassicaceae*	Annual(broad leaf)
15. Gazotia scabra	*Asteraceae*	Annual(Broadleaved)
16.Euphorbia serrata L	*Euphorbiaceae*	Annual(broad leaf
17. Cynodon doctylon	*Poaceae*	annual(grass)
18. Setaria verticilata	*Poaceae*	annual(grass)
19.Avena fatua L	*Poaceae*	annual(grass)
20.Setaria pumila	*Poaceae*	annual(grass)
21. Snodenia polystachia	*Poaceae*	annual(grass)
22. Sorghum arundinaceum	*Poaceae*	annual(grass)

Scientific name	**abundance**	**abundance %**	**dominance**
1.Nikandira physaladis	514	26	1
2. Datura stramonium	156	7.8	2
3. Amaranthus spp	265	13.4	3
4. bidens pilosa	7	0.35	5
5. Parthiniem hysterophorus	272	13.7	6
6.Tribulus territories	15	0.7	12

Table 1.1. Weed abundance and dominance in Adami Tulu site

Table 1.2**.** Weed abundance and dominance in Galo Heraphe site

Scientific name	abundance in number		abundance %			
1.*Nikandira physaladis*	4		0. 25		5	
2. *Amaranthus spp* / 7.*Commelina bengalensis*	39	51	2.4	2.5	4	8
4. *bidens pilosa* / 8.*Erucustrem Arabica*	44	37	2.8	1.87	4	9
7.*Commelina bengalensis* / 9. *Galinsoga palmiflora*	11	251	0.7	12.6	6	4
9. *Galinsoga palmiflora* / 10.*tagetas minuta*	158	10	10	0.5	2	10
14.*Eracustrem gallium* / 11. *chenopodiam album L*	105	23	6	1.16	6	9
16.*Cynodon dactylon* / 12.*solanum nigrum*	64	142	4.1	7.1	6	7
17. *Euphorbium* [illegible] / 13.*portulaca oleracea*	2	6	0.1	0. 3	7	11
18. *Setaria verticilata* / 14. *Erucustrem gallium*	25	3	1.5	0. 15	7	13
19.*Avena fatua L* / [illegible]*lystachia*	280	4	17	0. 2	4	14
20.*Setaria pumila* / [illegible]*ctylon*	502	97	32	4.9	3	15
21. *Gazotia scabra* / 17. *Setaria verticilata*	293	124	18	6.27	1	16
Total	1567	1977	100	100		

Weed population

The data analysis result for weed population revealed a significant variation in the interaction between weed control methods and location. Result obtained showed that all weed control practices greatly reduced weed population when compared to weedy control (Table 2).However, the degree of reduction varied depending on the types of practices used. Among the weed control practices the average minimum weed number (8.33) and (8.22) was recorded in plots treated with pallas plus one time hand weeding without significant difference for location followed by two times hand weeding (14.44) and (8.77) that was significant difference at Adami Tulu and Galo Heraphe, respectively. This low weed population might be attributed to the effectiveness of control methods. Whereas, the maximum total weed population (64.00) and (29.00) was observed from weedy check plots at Adami Tulu and Galo Heraphe, respectively. The highest number of weeds could be due to untreated plots promoting weed emergence and development, as well as less competition and more time for weeds to explore nutrients from the soil and crop plants.

Table 2 : interaction effect of weed control method and location on weed population at Adami Tulu and Galo Heraphe site

location		WCM			
Adam T		HW	P	PHW	ZW
	WP(mean)	14.44^{d}	21.44^{c}	8.33^{e}	64.00^{a}
Gal H	WP(mean)	8.77^{e}	13.44^{de}	8.22^{e}	29.00^{b}
CV	20.95				
f tast	**				
LSD	5.25				

*Note; - Means followed by the same letter within a column are not significantly different at 5% probability level, CV= Coefficient of variance, F-test= probability value, ns, * and ** = non significance, signifance difference & highly signifance difference, respectively.,WCM=weed control methods, HW(2X)=two times hand weeding (30DAE and 45DAE),P=Pallas 45% OD, PHW=pallas+ one times hand weeding (30DAE +45DAE),ZW=zero weeding or unweeded check, WP=weed population*

Weed Dry Weight

The analysis of variance result revealed statistically significant variation in weed control methods, but no difference in location or verities for Weed Dry Weight. The effect of weed control practices on weed dry weight was highly significant. The lowest weed dry weight (161403 kg/ha^{-1}) was recorded in in plots treated with pallas 45 OD plus one times hand weeding even though there was no statistically significantly different from plots treated with two times hand weeding (196174 kg ha $^{-1}$) table(3). The result obtained is in line with findings of Getachew M, (2022), who stated that the use of herbicides in combination with one times -weeding 30 days after herbicide application resulted in a significant decrease in total weed dry biomass when compared to their sole use. This could be due to the clearance of tolerant weeds that remain alongside crops while herbicide application, this result in minimal weed density and dry matter accumulation from later growing weeds. Whereas the highest weed dry weight (1340830.56kg-1ha) was recorded in weedy check (Table 3) .This high value in dry weight might be attributed to, a high weed density resulted from zero weed control, which ultimately promote emergence, growth and development of weeds. Megarsa et al. (2017) also reported that the maximum weed dry weight in the unweeded control was significantly higher than in the other weed control methods. All treatments significantly reduced weed dry weight (kg ha^{-1}) as compared to weedy check. This is consistent with the findings of Tesfaye et al. (2015), who found that weed management treatments reduced weed dry matter accumulation significantly. Statistically significance difference was observed among treatments for total weed dry weight (kg-1ha) at both study areas.

Table 3: Effect of weed control method on weed dry matter and weed control efficiency

treatments(WCM)	WDW	WCE%
HW(2X)	196174^{c}	86.2^{a}
P	451635^{b}	66.3^{b}
PHW	161403^{c}	87.2^{a}
ZW	1340830.6^{a}	0^{c}
f tast	**	**

CV	42.9	

*Note; - Means followed by the same letter within a column are not significantly different at 5% probability level, CV= Coefficient of variance, F-test= probability value, ns, * and ** = non significance, signifance difference & highly signifance difference, respectively, WDW=Weed dry weight, WCE= Weed Control Efficiency*

Weed control efficiency

The data of weed control efficiency (Table 3) showed that the highest weed control efficacy (90%) was recorded in PHW followed by in HW (88.3%) at Adami Tulu while the highest weed control efficacy (83.4%) was recorded in HW followed by PHW weeding plot (82.4%) at Galo Heraphe site. The calculated weed control efficiency of Pallas herbicide was (72%) and (58%) at Adami Tulu and Galo Heraphe Respectively (table 3). The result obtained was the inverse of the grain yield that was treated by Pallas herbicide, which was 1659.13 and 2387.81 at Adami Tulu and Galo Heraphe respectively; that could be because of the variation in types of weed species that were found in the study area. Weed species recorded at Adami Tulu site were very giant and with high canopy cover which results in smothering effect for the under growing plants including the wheat plant. *Nicandira physaladis and Datura stramonium* were among the commonly recorded weed species at Adami Tulu site.

Phonological parameters

Days to 50% Heading

Days to 50%, Heading was significantly influenced by the interaction of varieties and location while non-significance difference was observed on weed control methods.

The result revealed that the interaction of varieties and location shows highly significant differences for Balcha and Daka varieties and non-significant differences for Wane varieties (Table 4). The longest time (56.97) and (56.95) until to reach 50% heading was observed on Balcha and Daka variety at Adami Tulu site. However, there is no significant difference for varieties. While, the longest time (55.45) and (54.83) until to reach 50% heading was observed on Daka and Balcha variety at Galo Heraphe site. However, there is no significant difference for wheat varietis. In contrast to this, statistical analysis of the variance indicated that the shortest time (53.08 days) and (53.58) required for 50% heading was observed in Wane variety at both respective location (Table 4)

Table 4: The interaction effects between location and varieties on Days to 50 % heading of wheat crop

LOC	Varieties		
	B	D	W
AT DFH (mean)	56.97[a]	56.95[a]	53.08[c]
GH DFH (mean)	54.83[b]	55.45[b]	53.58[c]
CV	2.14		
f taste	*		
LSD	0.935		

*Note; **-** Means followed by the same letter within a column are not significantly different at 5% probability level, LSD = Least Significant difference and CV= Coefficient of variance, F-test= probability value, ns, * and ** = non significance, signifance difference & highly signifance difference, respectively, DFH=Days to 50% Heading, AT =Adami Tulu site, GH= Galo Heraphe site*

Growth parameters

Plant height

Plant height was considerably influenced by weed control methods and varieties, however there was no significant difference based on location. The analysis of variance result indicated that statically significant ($P<0.05$) variation was observed on plant height of wheat varieties. The maximum plant heights of 61.78cm, 59.37 cm, and 55.15cm were recorded for the Daka, Balcha, and Wane wheat varieties, respectively. Maximum plant height was recorded for the Daka wheat variety with a mean of 61.78cm, followed by the Balcha wheat variety with a mean of 59.37cm, but there is no statically significant difference between them (table 6). Minimum plant height (55.15cm) was recorded for Wane wheat variety (Table 6). This was due to genetic variation. This is consistent with the findings of Tesfaye et al. (2022), who discovered that the types evaluated, varied in plant height. The plant height was also affected by weed management methods and ranged from 62.85 cm to 55.88 cm. The tallest mean plant height (62.85 cm) was recorded for unweeded plots, while the shortest plant height (55.88) was recorded from Pallas-treated plots followed by Pallas (30 DAE) plus one time hand weeding (45 DAE) (56.34) (Table 5). With no significant difference. Result obtained is similar with Getachew M. (2022) findings who determined that the highest plant height (88.37 cm) was obtained from weedy check and lowest plant height (81.6 cm) for weed-free check. The higher plant height in the unweeded plot could be due to harsh competition among plants, which encourages them to stretch in quest of light, as well as a lack of plentiful growth stimulating Factors in the weedy plot, which allowed the plants to increase in height. In the unwedded plots, competition for sunlight and space between weeds and crop resulted in tall plant height. Similarly, Salahuddin et al., (2016) observed that competition between weeds and wheat plant enforced the plant to grow.

Table 5: Effect of weed control methods on plant height of wheat

treatments(WCM)	PH
HW(2X)	60.82[a]
P	55.88[bc]
PHW	56.34[b]
ZW	62.85[a]
Mean	58.9
cv	10.10
p	*
LSD	3.45

*Note; - Means followed by the same letter within a column are not significantly different at 5% probability level, LSD = Least Significant difference and CV= Coefficient of variance, F-test= probability value, ns, * and ** = non-significance, signifance difference & highly signifance difference, respectively. WCM=weed control methods, HW (2X) =two times hand weeding (30DAE and 45DAE), P=Pallas 45% OD, PHW=pallas+ one times hand weeding (30DAE +45DAE), ZW=zero weeding or unweeded check, PH=plant height,*

Table 6: Effect of wheat varieties on plant height and spike length

treatments(Variety)	PH	SPL
Daka	61.78[a]	7.80[a]
Balcha	59.37[a]	7.75[b]
Wane	55.15[b]	6.65[c]
Mean	58.9	7.39
cv	10.10	7.2
p	*	**
LSD	3.4593	0.3092
CV	10.10	7.20

Note; - Means followed by the same letter within a column are not significantly different at 5% probability level. PH=plant height, SPL=spike length.

Spike length

The analysis of variance revealed a significant difference in variety and location, but a non-significant difference in weed control methods for spike length. The analysis of variance result indicated that highly significant ($P<0.05$) variation was observed on spike length of wheat varieties. The longest spike length (7.80cm) was recorded for Daka, wheat variety followed by

Balcha (7.75cm) wheat variety. The shortest spike length (6.65cm) was recorded for Wane wheat variety. (Table 6).

The analysis of variance results also demonstrated highly significant (p 0.05) difference in wheat crop spike length depending on location. The mean longest spike length (7.73 cm) of the wheat crop was recorded at Adami Tulu, and the mean shortest spike length (7.03 cm) was recorded at Galo Heraphe site. This significant difference might be due to the interaction of crops with the environment (Table 7).

Table 7: Effect of location on spike length and effective tiller per plant of wheat crop

location	SPL	ETPP
AdamiT	7.73^{a}	0.80^{a}
GaloH	7.06^{b}	1.18^{b}
mean	7.39	1.01
cv	7.2	46.73
p	**	**
LSD	0.25	0.22

*Note; - Means followed by the same letter within a column are not significantly different at 5% probability level, LSD = Least Significant difference and CV= Coefficient of variance, F-test= probability value, ns, * and ** = non significance, signifance difference & highly signifance difference, respectively.SPL=spike length, ETPP=effective tiller per plant, NsePP=number seed perspike*

Effective Tillers

The analysis of variance result showed significant variation on weed control methods and location, while a non-significant difference was observed on wheat varieties for the effective number of tillers. The analysis of variance indicated that weed control methods had resulted significant difference on effective number of tillers. The number of tillers affected by weed control methods ranged from 1.74 to zero. The maximum number of effective tillers (1.74) was recorded at two times hand weeding treated plots and minimum number of tiller (0) was recorded at the weedy check. Maximum number of effective tiller was recorded at twice hand weeding plots (30DAE) and (45DAE) followed by pallas herbicide (30DAE) plus one hand weeding (45DAE), and pallas herbicide (30DAE), with the mean of 1.74, 1.55, and 0.77 (m^2) respectively while minimum number of tiller was counted at the unweeded plots with the mean of 0 (m^2) (Table 8).

Table 8: Effect of weed control methods on effective tillers of wheat per plant

treatments(WCM)	ETPP
HW(2X)	1.74^{a}
P	0.77^{c}

PHW	1.55[b]
ZW	0[d]
Mean	1.01
cv	46.73
LSD	0.2759
P taste	**

*Note; - Means followed by the same letter within a column are not significantly different at 5% probability level, LSD = Least Significant difference and CV= Coefficient of variance, F-test= probability value, ns, * and ** = non-significance, signifance difference & highly signifance difference, respectively. WCM=weed control methods, HW (2X) =two times hand weeding (30DAE and 45DAE), P=Pallas 45% OD, PHW=pallas+ one times hand weeding (30DAE +45DAE), ZW=zero weeding or unweeded check, ETPP=effective tiller per plant*

Number of Spikelet's Per Spike

The analysis of variance result showed significant variation on weed control methods while non-significant difference was observed on location and varieties for number of spikelet's per spike. The number of spikelets per spike affected by weed control methods was ranged from 9.72 to 14.12. The analysis of variance shows that all weed control methods were significantly different for the number of spikelets per spike of wheat when compared to unweeded control-treated plots, but there is no significant difference between the three remaining weed control methods.

The highest (14.12) was recorded for Pallas treatment, followed by Pallas plus one-hand weeding (13.26). The result showed that the maximum number of spikelets per spike was counted in pallas-treated plots (14.12) and the minimum number of spikelets per spike was counted in unweeded check plots (9.72) (Table 9). This outcome was in line with the findings of Ijaz et al. (2008), who noted that improved weed control boosted the crop's availability of nutrients, which in turn raised the number of tillers with spikes. A key factor in determining wheat production is the quantity of spikelets per spike, in comparison to the unweeded control, the results showed a substantial rise in the spikelet count per spike.

Table 9: Response of weed management practices on yield related parameters of wheat crop

treatments(WCM)	NSPP	NSePP
HW(2X)	12.80[a]	29.2[a]
P	14.12[a]	25.5[b]
PHW	13.26[a]	28.7[a]
ZW	9.74[b]	14.38[c]
Mean	12.48	24.46
cv	23.44	12.8

p	*	**
LSD	1.387	1.48
CV	23.44	12.80

*Note; - Means followed by the same letter within a column are not significantly different at 5% probability level, LSD = Least Significant difference and CV= Coefficient of variance, F-test= probability value, ns, * and ** = non-significance, signifance difference & highly signifance difference, respectively. WCM=weed control methods, HW (2X) =two times hand weeding (30DAE and 45DAE), P=Pallas 45% OD, PHW=pallas+ one times hand weeding (30DAE +45DAE), ZW=zero weeding or unweeded check, NSPP=number spiklet per spike, NsePP=number seed perspike*

Number of Seed per Spike

The analysis of variance result showed significant variation on weed control methods and location while non-significant difference was observed on varieties for Number of Seed per Spike. The analysis of variance indicated that weed control methods had resulted significant difference on Number of Seed per Spike. The number of Seed per Spike affected by weed management methods ranged from 29.2 to 14.38. The maximum number of seed per spike was recorded at two times hand weeding treated plots with number of seed per spike of 29.2 followed by Pallas plus one hand weeding (28.7). However, there is no significant difference between them (table 9) and minimum number of seed per spike (14.38) was recorded at the weedy check. The analysis of variance result also shows that highly significant ($p<0.05$) variation was observed for number of seed per spike of wheat crops on location. The mean maximum number of seed per spike (22.19) wheat crop ware recorded at Adami Tulu, and the mean smallest seed per spike was recorded (26.75) at Galo Heraphe site (Table 10). This significant difference was seen might be due to the interaction of crops to environment.

Table 10: Effect of location on number of seed per spike of wheat crop

location	NsePP
AdamiT	22.19[a]
GaloH	26.75[b]
mean	24.46
cv	12.8
p	**
LSD	1.48

Note; - Means followed by the same letter within a column are not significantly different at 5% probability level, LSD = Least Significant difference and CV= Coefficient of variance, F-test=

*probability value, ns, * and ** = non-significance, signifance difference & highly signifance difference, respectively. NsePP=number seed perspike*

Total above Ground Biomass Yield

The analysis of variance result revealed considerable variation in weed control methods, but non-significant differences in location and verities for total above ground biomass yield. .Total above ground biomass yield as affected by weed control methods ranged from 7625.0kg ha-1 to 4888.8 kg ha-1(Table 11). The highest biomass yield (7625.0kg ha-1) was recorded for twice hand weeding four week +six week after crop emergence treated plots followed by pallas herbicide four week after crop emergency + one hand weeding six week after crop emergence treated plots with mean biomass yield of 6909.7 kgha-1 however, no significant difference was observed between them This is because weeding at the appropriate time can offer a favorable environment for the crop, giving it plenty of opportunities to exploit available resources, resulting in a higher total aboveground biomass yield. It is also plausible that good conquest of weed growth by hand weeding and chemical application leads to low competition by weeds for the same volume of space, quantum of light, and ion of nutrients by which the crop could utilize resources efficiently. The outcome was consistent with Getachew's findings. (2022). However, the lowest biomass was observed at weedy plots, with a mean of 4888.8 kgha-1 associated with all other treatments (Table 11). This lowest total above ground biomass yield might be due to severe weed antagonism with the crop for growth and development factors, which might have constrained the improvement of the crop resulting in minimum dry matter accumulation in crop for lower yield. The findings agreed with those of Bekele et al. (2018), who reported that decreased biomass yield may be due to increased resource competition; this increased competition between increased weed population and low weed control efficacy leads to thin and weak stems, spikelet (spike-1, thousand grain weight (g), and decreased total biomass yield.

Table 11: Effect of weed control methods on Total above ground biomass yield and Thousand-grain weight of wheat crop

treatments(WCM)	TAGBM	TGW
HW(2X)	7625.0^{a}	0.036^{a}
P	6173.6^{b}	0.024^{b}
PHW	6909.7^{ab}	0.028^{b}
ZW	4888.8^{c}	0.023^{c}
Mean	6399.3	0.028
cv	32.3	30.9
p	*	*

LSD	1295	0.006
CV	32.31	30.93

*Note; - Means followed by the same letter within a column are not significantly different at 5% probability level, LSD = Least Significant difference and CV= Coefficient of variance, F-test= probability value, ns, * and ** = non-significance, signifance difference & highly signifance difference, respectively. WCM=weed control methods, HW (2X) =two times hand weeding (30DAE and 45DAE), P=Pallas 45% OD, PHW=pallas+ one times hand weeding (30DAE +45DAE), ZW=zero weeding or unweeded check, TAGBM=total above ground biomass, TGW= thousand grain weight*

Thousand grain weight

The analysis of variance result showed significant variation on weed control methods, while non-significant differences were observed on location and variety for thousand-grain weight. The analysis of variance result indicated that significantly difference ($P<0.05$) variation was observed on thousand grain weight. The thousand-grain weight as affected by weed control methods ranged from (23 to 36) grams. Maximum thousand-grain weight was recorded from plots that received twice hand weeding (30DAE +45DAE), treated plots (36 g), and followed by Pallas herbicide plus one hand weeding plots (28g). The superior 1000-grain weight with two times hand weeding and Pallas herbicide plus one hand weeding treatments was due to weeding at an appropriate time that could provide an encouraging location for the crop, which provides ample opportunity for the crop to exploit available resources that leads to better grain filling, ultimately resulting in more 1000-grain weight. The findings were similar with Getachew's (2022) findings that clodinafop-propargyl 6% + fluroxypyr 12% at 1 kg ha1 + one hand weeding resulted in considerably greater 1000-grain weight than fields treated with two hand weeding at 30 and 45 DAE. The minimum thousand-grain weight ware recorded at the unweeded plots (23g) (Table 11). The lower 1000-grain weight acquired under unweeded check is due to more weeds depleting soil nutrients and higher competition with crop plants for limited resources, resulting in less nutrient mobility to crop plants and a lower grain weight obtained.

Grain yield

The results of the analysis of variance revealed significant variation in the grain yields of wheat varieties as well as the interaction between weed control methods and location. Grain yield was affected significantly by weed control methods and, location. The maximum grain yield (2571.14 and 2646.06 kg ha^{-1}) was recorded in two hand weeded plots, followed by (2338.13 and 2618.70 kg ha^{-1}) Pallas plus one hand weeded plot at Adami Tulu and Galo Heraphe, respectively. However, there is no significant difference between these two weed control methods (table 13). This highest yield might be credited to successful weed control carried out by hand weeding or herbicide treatment at the start of weed growth and supplemented by hand weeding. The results of Megarsa et al. (2017), who found that the highest grain production (4312.5 and 4382.6 kg ha^{-1}) was attained in a two-time hand-weeded plot, were in agreement with this outcome. This maximum yield was due to effective weed control achieved by hand weeding. On the contrary, the minimum yields (136.12 and 1232.23 kg ha^{-1}, respectively) were recorded in weedy checks at Adami Tulu and Galo Heraphe that shows significantly different in location (table 13). The minimum grain yield especially in Adami Tulu might be attributed to maximum infestation of weeds that can heavily compete for resource, which adversely affected grain yield. This is consistent with the findings of (Jarwar et al., 2005), who claim that weeds compete with crop plants for various resources such as water and nutrients, resulting in low yields. (Chaudhary et al., 2008; Dalley et al., 2006). Also reported that high weeds intensity and more competition time with crop plants cause more reduction in crop yield). This also indicates that weeding at proper time definitely enhances crop yields.

The analysis of variance result also indicated that significantly (P 0.05) more variation was observed on the grain yield of wheat varieties. The grain yields of (2073.14kg ha^{-1}, 1899.62 kg ha^{-1}, and 1831.13kgha^{-1}) were recorded on the Balcha, Daka, and Wane wheat varieties, respectively. Maximum grain yield (2073.14 kg) was recorded for the Balcha wheat variety, followed by the Daka wheat variety (1899.62 kg), but there was no significant difference between them. Whereas, the minimum grain yield (1831.13kgha^{-1}) was recorded on the Wane wheat variety (Table 12). This was due to genetical variation.

Table 12: response of wheat varieties on wheat grain yield

treatments(Variety)	GY
Daka	1899.62 [ab]
Balcha	2073.14[a]
Wane	1831.13[b]
Mean	1948.67
cv	16.50
p	*
LSD	186.7
CV	16.50

*Note; - Means followed by the same letter within a column are not significantly different at 5% probability level, LSD = Least Significant difference and CV= Coefficient of variance, F-test= probability value, ns, * and ** = non-significance, signifance difference & highly signifance difference, respectively. GY=grain yield*

Table 13: Effects of weed control methods on wheat grain yield and Harvest Index at Adami Tulu and Galo Heraphe

WCM	Grain Yield (kg/ha)		Harvest Index %	
	Adami Tulu	Galo Heraphe	Adami Tulu	Galo Heraphe
HW	2571.14 [ab]	2646.06[a]	36.2[a]	34[a]
P	1659.13[c]	2387.80[ab]	34.9[a]	37.8[a]
PHW	2338.13[b]	2618.70[ab]	41.3[a]	38.3[a]
ZW(mean)	136.12[e]	1232.23[d]	4.9[c]	22[b]
Mean	1676.13	2221.19	29.32	33.02
CV	16.50		28.6	
p taste	**	**	*	*
LSD	288.92		0.0991	

*Note**; -** Means followed by the same letter within a column are not significantly different at 5% probability level, LSD = Least Significant difference and CV= Coefficient of variance, F-test= probability value, ns, * and ** = non significance, signifance difference & highly signifance difference, respectively, WCM=weed control methods, HW (2X) =two times hand weeding (30DAE and 45DAE), P=Pallas 45% OD, PHW=pallas+ one times hand weeding (30DAE +45DAE), ZW=zero weeding or unweeded check, GY=grain yield, HI=harvest index*

Harvest Index

The effect of weed control methods on the harvest index was significant. There was a highly significant difference among weed control methods at both study sites (Table 13). At Adami Tulu location, PHW yielded a maximum harvest index that was noticeably higher (41.3%), followed by two hand weeding (36.2%) and a Pallas-treated plot (34.9%), although there was no discernible difference between the three. PHW treated plot at the Galo Heraphe location had the greatest maximum harvest index (38.3%), followed by the Pallas herbicide (37.8%) and the two times hand-weeded plot (34%), although there was no discernible difference between them. The variation in harvest index under different treatments might be due to variation in the grain yield and yield-related parameters. Whereas the minimum (4.9% and 22%) was obtained from unweeded check plots at those respective locations, This study concurs with Getachew's study from 2022, which measured the harvest index (40.32%) with the application of clodinafop-propargyl (6% + 12%) at 1.0 kg ha1 with one-hand weeding.

Partial Budget Analysis

Economic analysis of different weed control treatments revealed that wheat weed control by different weed control methods gave different economic return as compared to hand weeding (Table 14&15). The maximum net benefit (70073.05 and 76873.31) ware recorded from two times hand weeded plot at Adami Tulu and Galo Heraphe, respectively. Whereas Application of Pallas 45% gm/lt OD herbicide at the rate of 0.5L ha-1 fetched the highest marginal rate of return (MRR %) (9.93783 And 9.099806) followed by integration of Pallas 45% gm/lt OD at 30 DAE with one time hand weeding at 45 DAE with MRR (%) of (6.268786 and 4.081329) at both respective locations. Thus, it was concluded that even though the use of Pallas 45% gm/lt OD has high marginal rate of return than hand weeding and other treatments, the highest net benefit is obtained from two times hand weeding plot (70073.05 and 76873.31) with the MRR (%) of (4.931881 and 3.3937) followed by pallas + one hand weeding plot (68409.24 and 70642.05) with MRR (%) of (6.268786 and 4.081329) at Adami Tulu and Galo Heraphe site respectively. However, there is no significant yield difference between these two treatments. Therefore from weed control methods Pallas herbicide 30 DAE + one hand weeding 45 DAE is economically feasible at studied location

Table 14: Partial budget analysis for weed management practices at Adami Tulu research site Oromia.

location	WCM	Total Variable Cost	Grain Yield(kg/ha)	Adjusted GY(kg/ha)	gross benefit (ETB /ha)	net benefit (ETB/ha)	MRR (%)	yield safe %
Adami T	ZW	306.27	136.12	122.508	4532.796	4226.526	0	

	P	4943.043	1659.13	1493.22	55249.03	50305.99	9.93783	91
	PHW	10544.73	2338.13	2104.31	77859.73	67315	6.268786	94
	HW	13657.47	2571.14	2314.02	85618.96	71961.49	4.931881	94

Note; - *WCM=weed control methods, HW (2X) =two times hand weeding (30DAE and 45DAE), P=Pallas 45% OD, PHW=pallas+ one times hand weeding (30DAE +45DAE), ZW=zero weeding or unweeded check, GY=grain yield, MRR= marginal rate of return, Cost of pallas, 1700 ETB/kg; cost of pallas; for spraying, 360 ETB/ha; cost of hand weeding for one hectare, 4000 ETB /ha; cost of harvesting,250 ETB/100 kg;; sale price of wheat, 37.00 ETB/kg.*

Table 15: Partial budget analysis for weed management practices at Galo Heraphe kebele Oromia.

location	WCM	Total Variable Cost	Grain Yield(kg/ha	Adjusted GY(kg/ha)	gross benefit (ETB /ha)	net benefit (ETB/ha)	MRR (%)	yield safe %
Galo H	ZW	2772.518	1232.23	1109.01	41033.26	38260.74	0	
	P	6582.573	2387.81	2149.03	79514.07	72931.5	9.099806	48
	PHW	10706.53	2442.9	2198.61	81348.57	70642.05	4.081329	49.5
	HW	14150.24	2733.44	2460.1	91023.55	76873.31	3.3937	54

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5. Conclusion and recommendation

Weeds in general and broad weed species in particular like *Nicandra physalodes* and *Datura stramonium* are the major constraint in wheat production at Adami Tulu site while grass weed species especially *Setaria pumila* and *Avena fatua* are the major constraints at Galo Heraphe site and its control is too important to increase wheat production and productivity. The results indicate that the different weed control methods were a major determinant of yields across the different location of study area. The lowest yield was recorded from the unweeded check treatment (136.12 kg/ha^{-1}) and (1232.23kg/ha^{-1}) whereas the highest yield was recorded from two times hand weeding treatment (2571.14 kg/ha^{-1}) and (2646.06 kg/ha^{-1}) followed by Pallas plus one time hand weeding plot (2370.99kg/ha^{-1}) and (2442.9kg/ha^{-1}) without significant difference at Adami Tulu and Galo Heraphe site respectively. Therefore the application of two times hand weeding or pallas plus one time hand weeding can increase yield by 94% and 49% when we compare with unweeded check (zero weeding) at Adami Tulu and Galo Heraphe site respectively (table 9&10).and from the wheat variety, maximum grain yield (2073.14 $kgha^{-1}$) was recorded for the Balcha wheat variety, followed by Daka wheat variety (1899.62 $kgha^{-1}$), but there was no significant difference between them. Whereas, the minimum grain yield (1831.13$kgha^{-1}$) was recorded on the Wane wheat variety.

From the result of this experiment, it can be concluded that the integration of Pallas with one-time hand weeding was quite effective in controlling major broadleaf and grass weed species observed in wheat fields. From economic analysis, the highest net returns were obtained from two-times hand weeded plots, followed by Pallas plus hand-weeding plots. Whereas the maximum rate of return was obtained from the plot sprayed with pallas at 45% OD alone, followed by its integration with a one-time hand weeding of the plot Thus, Pallas 45% OD post-emergence herbicide plus one time hand weeding is economically feasible. And it's concluded that the wheat varieties Balcha and Daka were the highest yielders in the study area and the area with similar agro ecology. The suggested critical time of the weed control period (30 DAE) was not found suitable at the Adami Tulu trial site due to the smothering effect observed prior to that time as a result of the area's combination of vigorous weed species. However determining the critical weed control period for the Adami Tulu region, as well as other areas with comparable weed species composition and agro ecology warrant further studies.

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Lists of Appendix

Appendix 1: Dependent Variable: DFH

Source	DF	Type III SS	Mean Square	F Value	Pr > F
loc	1	19.0008333	19.0008333	13.66	0.0006
var	2	117.3269808	58.6634904	42.18	<.0001
WCM	3	6.5788502	2.1929501	1.58	0.2072
var*WCM	6	10.7754934	1.7959156	1.29	0.2791
loc*var	2	22.3209784	11.1604892	8.03	0.0010
loc*WCM	3	6.2194972	2.0731657	1.49	0.2289
loc*var*WCM	6	7.8836806	1.3139468	0.94	0.4722

Appendix 2: Dependent Variable: PH

Source	DF	Type III SS	Mean Square	F Value	Pr > F
loc	1	69.8901333	69.8901333	1.97	0.1671
var	2	528.3042537	264.1521269	7.44	0.0015
WCM	3	567.4888186	189.1629395	5.33	0.0030
var*WCM	6	58.9129825	9.8188304	0.28	0.9453
loc*var	2	66.4386755	33.2193377	0.94	0.3995
loc*WCM	3	75.1523207	25.0507736	0.71	0.5536
loc*var*WCM	6	265.2135526	44.2022588	1.24	0.3008

Appendix 3: Dependent Variable: ETPP

Source	DF	Type III SS	Mean Square	F Value	Pr > F
loc	1	2.54380208	2.54380208	11.25	0.0016
var	2	0.97358006	0.48679003	2.15	0.1271
WCM	3	33.81725233	11.27241744	49.87	<.0001
var*WCM	6	1.69489560	0.28248260	1.25	0.2983
loc*var	2	0.88913378	0.44456689	1.97	0.1510
loc*WCM	3	2.01305929	0.67101976	2.97	0.0411
loc*var*WCM	6	1.01644166	0.16940694	0.75	0.6128

Appendix 4: Dependent Variable: SPL

Source	DF	Type III SS	Mean Square	F Value	Pr > F
loc	1	7.72807500	7.72807500	27.23	<.0001
var	2	19.77442827	9.88721414	34.83	<.0001
WCM	3	3.30603463	1.10201154	3.88	0.0145
var*WCM	6	1.07624909	0.17937485	0.63	0.7039
loc*var	2	0.87798569	0.43899285	1.55	0.2234
loc*WCM	3	1.51719497	0.50573166	1.78	0.1632
loc*var*WCM	6	1.12964821	0.18827470	0.66	0.6794

Appendix 5: Dependent Variable: NSPP

Source	DF	Type III SS	Mean Square	F Value	Pr > F
loc	1	5.7824083	5.7824083	0.68	0.4154
var	2	39.6036206	19.8018103	2.31	0.1100
WCM	3	195.2924422	65.0974807	7.60	0.0003
var*WCM	6	59.9009706	9.9834951	1.17	0.3404
loc*var	2	43.6981896	21.8490948	2.55	0.0886
loc*WCM	3	29.0750034	9.6916678	1.13	0.3458
loc*var*WCM	6	66.9166022	11.1527670	1.30	0.2745

Appendix 6: Dependent Variable: NSePP

Source	DF	Type III SS	Mean Square	F Value	Pr > F
loc	1	359.050800	359.050800	36.58	<.0001
var	2	7.416090	3.708045	0.38	0.6874
WCM	3	2582.736871	860.912290	87.71	<.0001
var*WCM	6	102.420065	17.070011	1.74	0.1323
loc*var	2	12.351104	6.175552	0.63	0.5374
loc*WCM	3	102.565084	34.188361	3.48	0.0228
loc*var*WCM	6	74.701483	12.450247	1.27	0.2896

Appendix 7: Dependent Variable: TAGBM

Source	DF	Type III SS	Mean Square	F Value	Pr > F

Source	DF	Type III SS	Mean Square	F Value	Pr > F
loc	1	13046888.02	13046888.02	3.05	0.0871
var	2	38599077.91	19299538.96	4.51	0.0160
WCM	3	77231920.55	25743973.52	6.02	0.0014
var*WCM	6	24481850.79	4080308.46	0.95	0.4661
loc*var	2	11014694.16	5507347.08	1.29	0.2853
loc*WCM	3	4221339.06	1407113.02	0.33	0.8044
loc*var*WCM	6	28272969.21	4712161.53	1.10	0.3752

Appendix 8: Dependent Variable: GY

Source	DF	Type III SS	Mean Square	F Value	Pr > F
loc	1	4834286.31	4834286.31	46.72	<.0001
var	2	717769.14	358884.57	3.47	0.0392
WCM	3	41560394.99	13853465.00	133.89	<.0001
var*WCM	6	308639.28	51439.88	0.50	0.8073
loc*var	2	416398.50	208199.25	2.01	0.1448
loc*WCM	3	2847669.32	949223.11	9.17	<.0001
loc*var*WCM	6	608473.19	101412.20	0.98	0.4491

Appendix 9: Dependent Variable: TGW

Source	DF	Type III SS	Mean Square	F Value	Pr > F
loc	1	0.00032552	0.00032552	4.28	0.0440
var	2	0.00023854	0.00011927	1.57	0.2190
WCM	3	0.00176846	0.00058949	7.75	0.0003
var*WCM	6	0.00094830	0.00015805	2.08	0.0734
loc*var	2	0.00026550	0.00013275	1.74	0.1856
loc*WCM	3	0.00042048	0.00014016	1.84	0.1521
loc*var*WCM	6	0.00036966	0.00006161	0.81	0.5675

Appendix 10: Dependent Variable: WP

Source	DF	Type III SS	Mean Square	F Value	Pr > F
loc	1	2416.84083	2416.84083	87.57	<.0001
var	2	310.53106	155.26553	5.63	0.0064
WCM	3	16238.98427	5412.99476	196.13	<.0001
var*WCM	6	487.66000	81.27667	2.94	0.0158
loc*var	2	17.79657	8.89828	0.32	0.7260
loc*WCM	3	3257.39214	1085.79738	39.34	<.0001
loc*var*WCM	6	212.23602	35.37267	1.28	0.2835

Appendix 11: Dependent Variable: WDW

Source	DF	Type III SS	Mean Square	F Value	Pr > F
loc	1	79111130326	79111130326	1.49	0.2286
var	2	409082793487	204541396743	3.84	0.0283
WCM	3	1.6262061E13	5.420687E12	101.89	<.0001
var*WCM	6	265273495948	44212249325	0.83	0.5519
loc*var	2	59247614290	29623807145	0.56	0.5767
loc*WCM	3	619000946814	206333648938	3.88	0.0146
loc*var*WCM	6	59724098799	9954016466.5	0.19	0.9790