

Research Article

Evaluation of Pre-emergence Herbicides Efficacy and Their Combinations on Weeds Population at Ezha Woreda, Central Ethiopia

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Abstract

Chickpea (*Cicer arietinum* L.) is one of the most important pulses cultivated in Ethiopia. Hence, a field experiment was conducted to investigate to evaluate the efficacy of herbicide on weed the population and yield of chickpea at Ezha district. The experiment was laid out in a Randomized Complete Block Design and replicated three times. Pre-emergence (Pendimethalin and S-metolachlor) herbicides were applied alone at a different rate, with their combination as well as supplemented with one time hand weeding, two-time hand weeding, completely weed-free and weedy treatments. Applying the herbicides alone at a different rate reduced the density and dry matter of the weeds in chickpea as compared with control. The higher weed controlling efficacy, Herbicide Efficiency Index, weed Index and yield were recorded from the application of S-metolachlor at 1.0kg ha⁻¹ supplemented by one time hand weeding with five weeks after emergence (65.5%, 2.4%, 13.4% and 2227kg ha⁻¹) and Pendimethalin at 1.0 kg ha⁻¹ with time one hand weeding and hoeing at 5 WAE (65.7%, 2.4% 18.6% and 2098.3 kg ha⁻¹) respectively. The higher weed density and the lower yield was recorded from the control plots (58.7 and 690.3 kg ha⁻¹) respectively. However; weed-free, Hand weeding at 2 and 5 WAE treatments was the most effective for controlling the weeds and increasing the chickpea yield as compared with other treatments. Therefore; based on yield applying S-metolachlor at 1kg ha⁻¹ supplemented by one time hand weeding at five weeks after emergence is the best option of effective chickpea production for extensive farming and complete weed-free, Hand weeding at 2 and 5 WAE were recommended for intensive farming methods.

Keywords

Chickpea, Herbicides Efficacy, Weed Population, Yield

1. Introduction

Chickpea (*Cicer arietinum* L.) is the third-largest produced food legume globally, after common bean (*Phaseolus vulgaris* L.) and field pea (*Pisum sativum* L.) [1]. The main chick-pea-producing countries in the World are India, Australia,

Burma, Turkey, Russia, Pakistan, United States, Iran, Mexico, Tanzania, Canada, Argentina, Spain, Yemen, Syria, and Ethiopia ranks fourth having greatly increased production in recent years and accounts for over 3.67% of world production

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during 2017 crop growing season [2]. Mean yields of chickpea have varied widely among producing countries and range from 500–600 kg/ha. India, the largest producer has had stable mean yields of about 0.9 t/ha and has a global share of 64.7%. The high yields of 30 t/ha in Mexico are largely due to the fact that most of the crop is irrigated and grown over the cool winter season [2]. Chickpea is a valued crop that provides nutritious food for an expanding world population and will become increasingly important with climate change [3]. It is an annual legume that is the most important crop and its productivity is very low in Ethiopia [4]. Chickpea (*Cicer arietinum* L.) accounts for more than 17% of legumes in Ethiopia with a production of 0.47 million tons on an area of 258,486.29 ha with the engagement of over one million households [5]. Chickpea is also an important export commodity where both export volume and export earnings of the country are increasing, especially in the last decade [6]. Ethiopia is the leading producer, consumer, and exporter of chickpea in Africa, and is among the top ten most important producers in the world.

The importance of chickpea-based infant follow-on formula meets the WHO/FAO requirements on complementary foods and also the EU regulations on follow-on formula with minimal addition of oils, minerals, and vitamins. It uses chickpea as a common source of carbohydrate and protein hence making it more economical and affordable for the developing countries without compromising the nutrition quality [7]. Chickpea is a poor competitor to weeds because of slow growth rate and limited leaf development at early stage of crop growth and establishment). The bulk of the crop variety in the country is dominated by the sweet Desi type, and the Kabuli type is also grown in limited areas. In Ethiopia chickpeas are consumed widely fresh as green vegetables, sprouted, fried roasted and boiled. It is also ground into flour to make baby feed mixed with other cereals, soup bread and meat. It is also used to rehabilitate depleted fallow lands through utilizing crop rotation system [8]. The critical period for controlling weeds in chickpea is during the seedling stage and into flowering, as chickpea plants are slow to emerge and grow. Uncontrolled weed growth during this period leads to a greater than 10% reduction in yield. the critical weed-free period is around 17–60 days after emergence, depending on the environment [9].

Poor weed management is one of the most important yield limiting factors in chickpea, some other factors are brackish irrigation water, hungry and discarded soils, lack of promising cultivars, improper fertilization, pest and diseases are responsible for much reduction in yield of chickpea [10]. The initial 60 days' period considered being the critical for weed crop competition in chickpea but continuously facing the scarcity of labor and increase in labor cost, manual weed control has become a difficult task. Suitable herbicide for effective control of mixed weed flora is required for better adoption in this crop by farmers [11]. Chickpea, being slow in

its early growth and short stature plant, is highly susceptible to weed competition and often considerable losses may occur if weeds are not controlled at proper time and integrated weed management practices can be achieved by application of herbicides and hoeing twice at 20 and 40 days after the crop germination [11]. Chickpea, being slow in its early growth and short stature plant, is highly susceptible to weed competition and often considerable losses may occur if weeds are not controlled at proper time and integrated weed management practices can be achieved by application of herbicides and hoeing twice at 20 and 40 days after the crop germination [11].

Weed control has always been placed in the center of the agricultural activity by farmers since ancient times [12]. Wide spread use of synthetic herbicides, while in the other, weed suppression is largely based on mechanical, physical and ecological methods [12]. In intensive agriculture, which largely depends on herbicides for weed control, indiscriminate use of herbicides could cause adverse changes on soil micro flora, poor quality crop production, human and animal health problems [13]. One of the most important, yet often neglected weed management strategies is to reduce the number of weed seeds present in the field in which soil is used as a weed seed bank, and thereby limit potential weed populations during crop production can be accomplished by managing the weed seed bank found in soil [14]. Germination phase of the crop is the appropriate time when the herbicide is to be applied for weed management and become effective in the pulse crops. Application of pendimethalin at 1000g ha⁻¹ applied as pre-emergence is a very common herbicide which is used to control all type of weeds. Integrated weed management is an alternative for improving the pulse production [13]. Therefore, this research was conducted with the objective of to evaluate the efficacy of herbicide on weed the population and yield of chickpea in Gurage zone, Central Ethiopia.

2. Materials and Methods

2.1. Description of the Study Area

The experiment was conducted at Tageme fruit and vegetable farming site, at Ezha district in Gurage Zone of Central Ethiopia Regional state. The experimental site is located at 08°44'01.2" N latitude, 37°11'58.6"E longitude, and an altitude of 1960 meters above sea level. The rainfall pattern of this area was characterized by bimodal distribution with small rainy season *belg* (March-June) and main rainy season *meher* (July- November) with an annual average rainfall of 1500-2300 mm. The mean maximum temperature was 14 to 30 °C. the soil pH was ranging from 6.0 to 8.0.

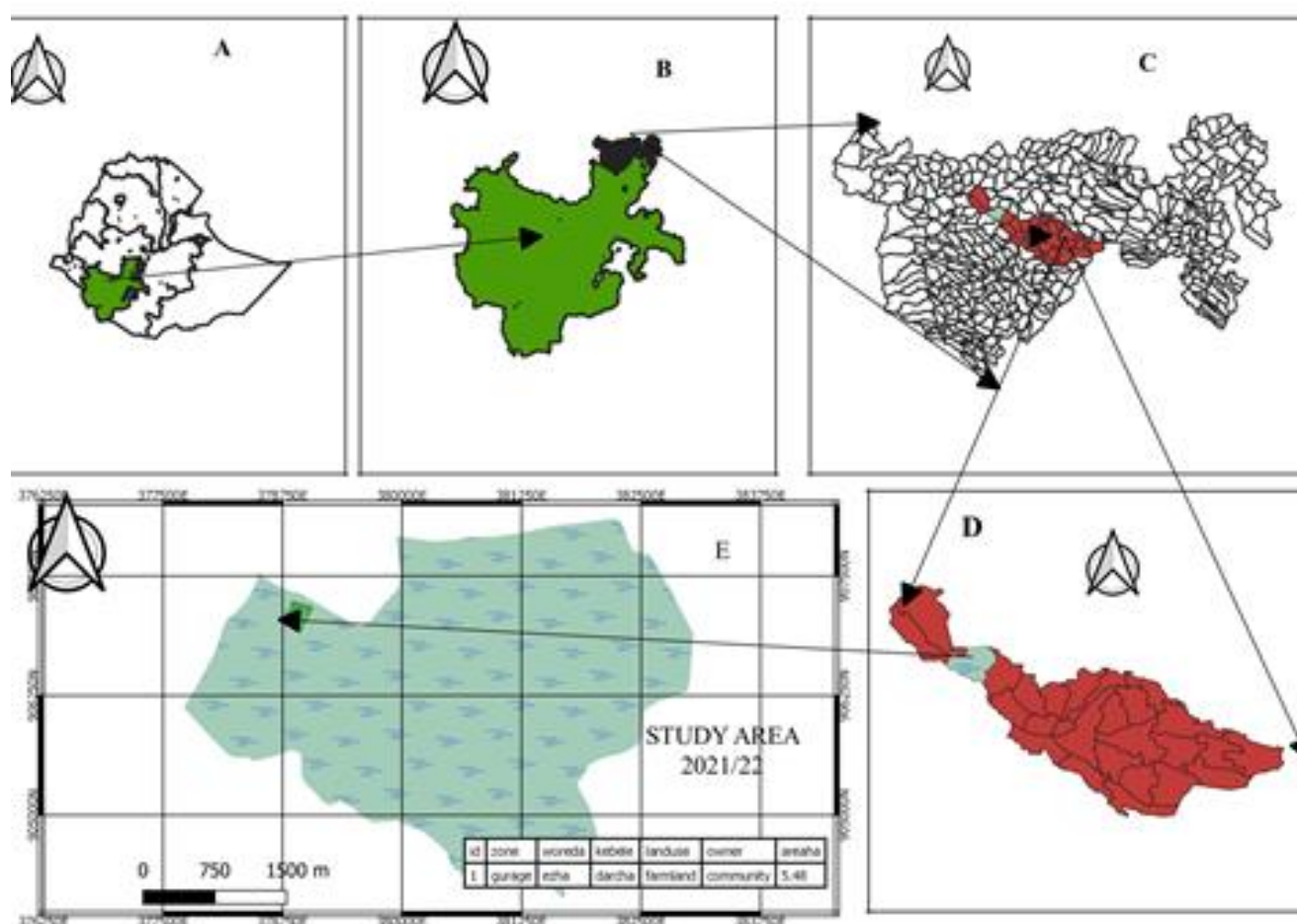


Figure 1. Map showing the experimental site of Ezha Woreda, Gurage, and Southern Ethiopia.

2.2. The Experimental Materials and Treatment Composition

The experiment was conducted in a randomized complete block design with three replications with a total of 48 treatments. The treatments of each experimental plot were 3.6 m x 2.4 m (8.64m²). To reduce inter plot effect the gangway distance between block and plots were 1.5m and 1m respectively. The experiment was conducted with chickpea Kabuli type variety (Hora), which is larger sized and high market price, the crop was characterized by white-colored with ram's head shape, thin seed coat, smooth seed surface, white flowers, and lack of anthocyanin pigmentation on the stem and planted at

40 cm by 40cm inter and intra row spacing. The prepare-emergence herbicides; five stars (Dual Gold 960 EC) and Pendimethalin 450 EC were applied onto the soil as per emergence treatment immediately after sowing. The spraying was made using a Knapsack sprayer with a flat nozzle. Hand weeding (hand weeding and hoeing) was conducted in the assigned plots as per the treatment. To reduce exposure, the herbicide was applied with the safety role principle. After the application of each herbicide, the knapsack was washed by water after the next herbicide application. All agronomic practices were applied at the recommended methods and NPSB fertilizer was applied at the rate of 100kg ha⁻¹ for all plots at the time of sowing.

Table 1. Herbicide used and their common, trade and chemical.

Common Name	Trade name	Chemical name
S-metholachlor	Five star (Dual Gold 960EC)	[2-chloro-6`-ethyl-N-(2-methoxy-1-methylethyl) acet-o-toluidide]
Pendimethalin	Pendamet 450 EC	[N-(1-ethylpropyl)-2, 6-dinitro-3, 4-xylylidine]

2.3. Treatments Distribution

The experiment consisted of 16 treatments viz.

S-metholachlor at 1.0 kg ha⁻¹, S-metholachlor at 1.5 kg ha⁻¹, S-metholachlor at 2.0 kg ha⁻¹, Pendimethalin at 1.0 kg ha⁻¹, Pendimethalin at 1.25 kg ha⁻¹, Pendimethalin at 1.5 kg ha⁻¹, S-metholachlor at 1.0kg ha⁻¹+ pendimethalin 1.0kg ha⁻¹, S-metholachlor 1.0kg ha⁻¹+ pendimethalin at 0.75 kg ha⁻¹, S-metholachlor at 0.75kg ha⁻¹+ pendimethalin at 1.0 kg ha⁻¹, S-metholachlor at 0.75kg ha⁻¹+pendimethalin at 1.25kg ha⁻¹, S-metholachlor at 1.0 kg ha⁻¹ + one hand weeding and hoeing at 4-5 WAE, Pendimethalin at 1.0 kg ha⁻¹ + one hand weeding and hoeing at 4-5 WAE, Two hand weeding at 2 and 5 WAE, One hand weeding and hoeing at 2 WAE, Weed free check and Weedy check.

2.4. Data Collected

Weed community:

Weed populations were collected as bimodal sampling methods in diagonal sampling methods by quadrat. The size of the quadrat is (0.25 m × 0.25 m) the quadrat was laid randomly two times in each plot.

Weed density: Weed density was recorded by throwing a quadrat (0.25 m × 0.25 m) randomly at two places in each plot at the time of weed removal for early competition and about 15 days before the expected harvest time in the case of late competition to avoid possible foliage and seed shedding. The weed species found within the sampling quadrat were identified, counted, categorized (broadleaved, grass, and sedges), and expressed in m⁻².

Weed dry biomass: While recording weed density the biomass was harvested from each quadrat and the harvested weeds were placed into paper bags separately. The samples were sun-dried for 3-4 days and thereafter were placed in an oven at 65 °C temperature till their constant weight and subsequently, the dry weight was measured. The dry weight was expressed in g m⁻².

Parameters for weed control

Weed control efficiency (WCE): It was calculated from weed control treatments in controlling weeds and using the following formula:

$$WCE = \frac{WDC - WDT}{WDC} \times 100$$

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

Weed index (WI) – It was measured from a particular treatment as compared with a weed-free treatment and expressed as a percentage of yield potential unweeded-free and calculated with the help of the following formula:

$$WI = \frac{X - Y}{X} \times 100$$

Where; WI= Weed Index, X= Yield in complete weed-free, Y= Yield in a particular treatment.

Herbicide Efficiency Index (HEI)-It is weed killing potential of herbicides treatments and their phytotoxicity on the crop and it was be calculated by:

$$HEI = \frac{YT - YC}{YC} \times 100 / \frac{WDT}{WDC} \times 100$$

Where YT = yield from treatment; YC = yield from control; WDT = weed dry matter in treatment; WDC = weed dry matter in control.

2.5. Data Analysis

The data collected and measured parameters from the experiment at different growth stages were subjected to statistical analysis as per the experimental designs for each experiment using SAS (Statistical Analysis Software) version 9.2 to analyze the data using ANOVA and GLM procedures. Mean separation of significant treatments was carried out using the least significant difference (LSD) test at a 5% level of probability [15].

3. Result and Discussion

3.1. Weed Community

The result showed that experimental fields were infested with 17 weed species and eight families were found, including broad-leaved, sedge, and grass weeds (Figure 2). Sedge and Grassy weeds were highly dominated and infest than grass weeds and broad-leaved weeds. From the data, *Cyperus rotundus* L accounted for the highest number, and *Cyperus brevifolius* Rottb. and *Cynodon dactylon*. This may be because Sedge and Grassy weeds more species are more tolerant to adverse environmental factors than broad leaves weeds. The result is in line with [16] reported that environmental and weeding frequency major factors that influenced weed species.

Ageratum conyzoides L., *Argemone ochroleuca* L., *Amaranthus spinosus* L., *Bidens pilosa* L., *Cassia pumila* Lam., *Convolvulus arvensis* L., *Cynodon dactylon* L., *Cyperus brevifolius* Rottb., *Commelina diffusa* L., *Cyperus rotundus* L., *Datura stramonium* L., *Dichanthium annulatum* (Forsk.)

Stapf., *Digitaria ternata* (A. Rich) Stapf, *Eclipta alba* (L.) Hassk, and *Setaria glauca* (L.) P. Beauv.

3.2. Weed Density at Harvest

Application of herbicide was highly significant (P<0.01) on weed density at harvesting time. The higher weed density was recorded at a weedy check and one time hand weeding, and hoeing at 2 WAE, Pendimethalin at 1.25 kg ha⁻¹ Pendimethalin at 1.0 kg ha⁻¹ and S-metholachlor at 1.0 kg ha⁻¹ weed

control methods which is 54.57, 47, 39.3, 39.63 and 41.1 weed density respectively followed by S-metholachlor at 0.75kg ha⁻¹+pendimethalin at 1.25kg ha⁻¹, S- metholachlor at 0.75kg ha⁻¹+ pendimethalin at 1.0 kg ha⁻¹, S-metholachlor at 1.0kg ha⁻¹+ pendimethalin at 0.75 kg ha⁻¹, S-metholachlor at 1.0kg ha⁻¹+ pendimethalin at 1.0kg ha⁻¹, Pendimethalin at 1.5 kg ha⁻¹ and S-metholachlor at 1.5 kg ha⁻¹ weed control methods whereas the lowest weed density was recorded from combined weed control methods such as Two hand weeding at 2 and 5 WAE, Pendimethalin at 1.0 kg ha⁻¹ + one time hand

weeding and hoeing at 5 WAE and S-metholachlor at 1.0 kg ha⁻¹ + one hand weeding and hoeing at 5 WAE which is 24.33, 27.56 and 26.13 weed density at harvesting (Figure 2). The result was in line work of [17] reported that combination of herbicide and cultural weed control methods reduces offers a stronger weed-control system. [18] reported a maximum weed density recorded from a weedy check. [19] and [20] reported herbicides supplemented with hand weeding improved weed controlling ability.

Treatments	WDAE25				WDAE55				WDAH			
	Broad leaved	Sedge	Grass	Total weed density	Broad leaves	Sedge	Grassy	Total weed density	Broad leaves	Sedge	Grass	Total weed density
S-metholachlor at 1.0 kg ha ⁻¹	6.66 ^{7b}	7.233 ^{def}	8.5 ^{cde}	22.4c	12.66 ^{7bcd}	18.66 ^{7b}	7.66 ^{7cb}	39 ^{9c}	16 ^{bc}	18.6 ^c	6.5 ^{ab}	41.1 ^c
S-metholachlor at 1.5 kg ha ⁻¹	3.1 ^{ef}	4.8 ^{fg}	6.33 ^{gh}	14.2fgh	11 ^{de}	16.56 ^{7b}	6.33 ^{cd}	34.5 ^{7cde}	12 ^{efg}	17.33 ^{cde}	6abc	35.33 ^{def}
S-metholachlor at 2.0 kg ha ⁻¹	2.16 ^f	4 ^g	4.9 ^h	11.1h	11 ^{de}	9 ^g	4.73 ^{def}	24.7 ^f	12.233 ^{def}	15.06 ^{7ef}	5.3 ^{bc}	32.6 ^{fg}
Pendimethalin at 1.0 kg ha ⁻¹	5.233 ^{bcd}	7.46 ^{de}	8 ^{cde}	20.7cd	14.33 ^{abc}	18 ^b	7.63 ^{cb}	39.97 ^b	14.66 ^{7bcd}	18.633 ^c	6.33 ^{abc}	39.633 ^{cd}
Pendimethalin at 1.25 kg ha ⁻¹	3.9 ^{cdef}	7.167 ^{def}	7.2 ^{efg}	18.27de	11.833 ^{cd}	17.33 ^{bcd}	6.3 ^{cd}	35.5 ^{bcd}	14.5 ^{bcd}	18.233 ^{cd}	6.167 ^{abc}	38.9 ^{cde}
Pendimethalin at 1.5 kg ha ⁻¹	2.2 ^f	5.1 ^{efg}	5.733 ^{gh}	13gh	11.33 ^{cde}	17.66 ^{7bc}	7.3 ^c	36.3 ^{bcd}	14.33 ^{bcd}	16.761 ^{cd}	5.767 ^{bc}	36.867 ^{cde}
S-metholachlor at 1.0kg ha ⁻¹ + pendimethalin at 1.0kg ha ⁻¹	4.167 ^{cdef}	5.4 ^{efg}	5.533 ^{gh}	15.1efg	11.33 ^{cde}	14.667 ^{de}	6.23 ^{cd}	32.2 ^{de}	13.667 ^{cde}	15.6 ^{ef}	6.167 ^{abc}	35.43 ^{def}
S-metholachlor at 1.0kg ha ⁻¹ + pendimethalin at 0.75 kg ha ⁻¹	3.2 ^{def}	6.2 ^{defg}	5.7667 ^{gh}	14.8efg	9.9 ^{def}	15.233 ^{cde}	5.9 ^{cdef}	31.03 ^f	12.967 ^{cde}	15.733 ^{ef}	8.33 ^{bc}	34.03 ^{def}
S- metholachlor at 0.75kg ha ⁻¹ + pendimethalin at 1.0 kg ha ⁻¹	4.667 ^{bcd}	5.833 ^{defg}	5.7667 ^{gh}	16.6efg	10.33 ^{de}	13.667 ^{ef}	6.57 ^{cd}	30.57 ^e	14.167 ^{bcd}	16.067 ^{de}	8.667 ^{bc}	35.9 ^{def}
S-metholachlor at 0.75kg ha ⁻¹ +pendimethalin at 1.25kg ha ⁻¹	4.067 ^{cdef}	5.733 ^{defg}	6.9667 ^{efg}	16.8ef	11.167 ^{de}	15.233 ^{cde}	6.1 ^{cde}	32.5 ^{de}	14.03 ^{bcd}	15.767 ^{def}	5.667 ^{bc}	35.47 ^{def}
S-metholachlor at 1.0 kg ha ⁻¹ + one hand weeding and hoeing at 5 WAE	5.3 ^{bc}	8.2 ^{cd}	8.766 ^c	22.3c	8.333 ^{efg}	11.6 ^{ef}	4.63 ^{def}	24.57 ^f	10.33 ^{efg}	11.467 ^{fg}	4.33 ^c	26.13 ^b
Pendimethalin at 1.0 kg ha ⁻¹ + one hand weeding and hoeing at 5 WAE	4.633 ^{bcd}	8 ^{cd}	9.3667 ^c	22c	7.069 ^{fg}	11.867 ^f	4.17 ^{ef}	23.1 ^f	9.33 ^{fg}	13.567 ^{fg}	4.667 ^{bc}	27.57 ^{gh}
Two hand weeding at 2 and 5 WAE	10 ^a	10.533 ^{bc}	13.233 ^{ab}	33.8b	6.667 ^{gh}	11.267 ^{ef}	3.93 ^d	21.87 ⁱ	8.667 ^{gh}	11.33 ^g	4.33 ^c	24 ^a
One hand weeding and hoeing at 2 WAE	9.667 ^a	11.33 ^b	12.733 ^b	33.7b	15 ^{ab}	22 ^a	9.5 ^{ab}	46.5 ^a	17.33 ^{ab}	21.667 ^b	8 ^a	47 ^b
Weed free check	0 ^g	0 ^h	0 ⁱ	0i	0 ^h	0 ^h	0 ^g	0 ^g	0 ^h	0 ^h	0 ^d	0 ⁱ
Weedy check	11 ^a	16.33 ^a	14.667 ^a	42a	17.167 ^a	23.6 ^a	10.33 ^a	51.1 ^a	20.567 ^a	26 ^a	8 ^a	55.17 ^a
LSD (5%)	2.06	2.54	1.61	3.68	3.047	2.679	1.97	9.7	3.438	2.4856	2.0957	5.18
CV	24.76	21.54	12.57	11.14	17.29	10.88	19.32	5.09	16.1	9.44	22.789	9.11

Figure 2. Effect of herbicide with its combination on weed population.

Means the same letter at the column is not significant difference

key;-WDAE1;- Weed density at 25 days after the crop emergence, WDAE2;-Weed density at 55 days after crop emergence, WDH3;- Weed density at harvesting time

3.3. Effect of Herbicide on Weed Dry Biomass at 55 Days After Emergence

Weed control methods are significantly ($P < 0.01$) effect on weed density at 55 days after chickpea emergence. The higher weed dry biomass was recorded from a weedy check plots which is 50.21 gm⁻¹ followed by One hand weeding and hoeing at 2 WAE, S-metholachlor at 0.75kg ha⁻¹+pendimethalin at 1.25kg ha⁻¹, S- metholachlor at 0.75kg ha⁻¹+ pendimethalin at 1.0 kg ha⁻¹, S-metholachlor at 1.0kg ha⁻¹+ pendimethalin at 0.75 kg ha⁻¹, S-metholachlor at 1.0kg ha⁻¹+ pendimethalin at 1.0kg ha⁻¹, Pendimethalin at 1.5 kg ha⁻¹, Pendimethalin at 1.25 kg ha⁻¹. Pendimethalin at 1.0 kg ha⁻¹, S-metholachlor at 2.0 kg ha⁻¹, S-metholachlor at 1.5 kg ha⁻¹ S- and metholachlor at 1.0 kg ha⁻¹ weed dry biomass is ranging from 37.34 to 25.34gm⁻¹. The lower weed dry biomass was recorded from combined application two-time hand weeding at 2 and 5 WAE, Pendimethalin at 1.0 kg ha⁻¹ + one hand weeding and hoeing at 5 WAE and S-metholachlor at 1.0 kg ha⁻¹ + one hand weeding and hoeing at 5 WAE which is 15.96 gm⁻¹, 18.8 gm⁻¹, and 19 gm⁻¹ respectively (Figure 3). The result was in line with [21] reported that the highest dry weed mass was recorded in weedy check treatment. [22] reported that at 55 days after

emergence weeds the lowest dry weight in plots treated with 1.0 kg ha⁻¹ of s-metolachlor and pendimethalin with one time hand weeding supplementation which might be due to the cumulative effect of herbicide and hand weeding in Cowpea.

3.4. Weed Dry Biomass at Harvest

The statistical analysis of data showed that application of herbicide with their combination significantly ($P \leq 0.01$) effect on dry weight of weed. The higher weed density was recorded from Weedy check and One time hand weeding and hoeing at 2 WAE which is 58.66gm⁻² and 47.33 gm⁻² followed by S-metholachlor at 1.0 kg ha⁻¹, S-metholachlor at 1.5 kg ha⁻¹, Pendimethalin at 1.0 kg ha⁻¹, Pendimethalin at 1.25 kg ha⁻¹, Pendimethalin at 1.25 kg ha⁻¹, S-metholachlor at 1.0kg ha⁻¹+ pendimethalin at 0.75 kg ha⁻¹, S- metholachlor at 0.75kg ha⁻¹+ pendimethalin at 1.0 kg ha⁻¹, S-metholachlor at 0.75kg ha⁻¹+pendimethalin at 1.25kg ha⁻¹ the data was varied from 39.66 gm⁻² to 31.14 gm⁻². The lower dry biomass of weed was recorded from Two hand weeding at 2 and 5 WAE, Pendimethalin at 1.0 kg ha⁻¹ + one time hand weeding and hoeing at 5 WAE and S-metholachlor at 1.0 kg ha⁻¹ + one time hand weeding and hoeing at 5 WAE which is 15.23 gm⁻², 21.93 gm⁻² and 21.43 gm⁻² respectively followed by application of

herbicide at S-metholachlor at 2.0 kg ha⁻¹ and Pendimethalin at 1.5 kg ha⁻¹ which is 24.2 gm⁻² and 27.2 gm⁻² respectively (Figure 3). The result was in line with the finding of [19] and [23] reported that post-emergence herbicides and /or hand weeding and hoeing at tillering stage reduced the dry weight of weeds as compared to herbicides alone. [24] reported that

the weeds that germinated earlier or at the same time as the crop offered a serious competition as they got an opportunity to establish and accumulate higher dry matter weight. [25] reported that maximum weed biomass was found from control in wheat.

Treatments	WDRB25				WRRB 55				Weed dry biomass at harvesting							WCI%	WCE%	HCI%	GY(kg ha ⁻¹)
	Broad leaves	sedges	Grass weeds	Total	Broad leaves	sedges	Grass weeds	Total	Broad leaves	sedges	Grass weeds	total weed							
S-metholachlor at 1.0 kg ha ⁻¹	7.167 ^{ab}	10.767 ^{cd}	7 ^{de}	24.93c	10.67 ^{ab}	15.83 ^{bc}	6.53 ^c	33.03 ^{bc}	15.33 ^{bc}	8 ^b	16.33b	40 ^{cd}	50.1 ^{bcd}	34.8 ^{ab}	1.72 ^{bcd}	1091 ^{cd}			
S-metholachlor at 1.5 kg ha ⁻¹	2.8 ^{cd}	8.2 ^{ab}	5.9 ^{ef}	16.93fg	10 ^{bcd}	10.7 ^{ab}	4.66 ^{ef}	25.367 ^a	10.9 ^{ab}	6.47 ^{bc}	14bc	33 ^a	36.6 ^{de}	43.4 ^{de}	2.21 ^{abc}	1635.3 ^{cd}			
S-metholachlor at 2.0 kg ha ⁻¹	2.8 ^{cd}	7.2 ^b	4.43 ^a	13.467g	8 ^{de}	14.57 ^{bcde}	5.67 ^{de}	28.23 ^{de}	9.67 ^{hi}	5.2 ^{de}	9.33df	22.5 ^f	19.6 ^f	61.4 ^c	2.4 ^{ab}	2265.7 ^{ab}			
Pendimethalin at 1.0 kg ha ⁻¹	4.5 ^{bc}	11.567 ^{cd}	7.167 ^{de}	23.23cd	10.07 ^{abcd}	14.33 ^{bcde}	6.06 ^{de}	30.47 ^{bc}	14.5 ^{bcd}	7 ^{bcd}	17.3b	40.8 ^c	52 ^{ab}	29.9 ^f	1.37 ^{cd}	1230.7 ^{cd}			
Pendimethalin at 1.25 kg ha ⁻¹	3.4 ^c	9.7 ^{ab}	6.73 ^{ef}	19.83cd	7 ^{def}	14.77 ^{bcde}	5.67 ^{de}	27.43 ^{de}	13 ^{def}	6.167 ^{bcd}	14.87b	34 ^{ab}	42.16 ^{cde}	41.8 ^{de}	1.8 ^{bcd}	1491 ^{cd}			
Pendimethalin at 1.5 kg ha ⁻¹	2.167 ^{cd}	9.3 ^{ab}	5.167 ^{ef}	16.367fg	9 ^{bcde}	11.67 ^{defg}	4.67 ^{de}	25.33 ^e	6.1 ^{abcd}	6.8 ^{bcd}	14.23b	34.7 ^{cd}	35.4 ^a	40.5 ^{efg}	2.09 ^{abc}	1666.3 ^c			
S-metholachlor at 1.0 kg ha ⁻¹ + pendimethalin at 1.0kg ha ⁻¹	3.267 ^{cd}	8.167 ^{ab}	4.667 ^{ab}	16.1fg	8 ^{de}	12.33 ^{def}	5.83 ^{de}	26.17 ^{de}	11.97 ^{efg}	4.97 ^{de}	15b	31.9 ^a	20.9 ^{de}	45.3 ^{de}	2.27 ^{abc}	2038.7 ^b			
S-metholachlor at 1.0kg ha ⁻¹ + pendimethalin at 0.75 kg ha ⁻¹	3.667 ^c	9.967 ^{ab}	5.3 ^{ab}	18.933ef	8 ^{de}	14.40 ^{cd}	5.63 ^{de}	28.067 ^{de}	11.4 ^{ab}	5.3 ^{cd}	14.44 ^b	31.1 ^a	40 ^{de}	46.6 ^d	1.68 ^{bcd}	1539 ^{cd}			
S- metholachlor at 0.75kg ha ⁻¹ + pendimethalin at 1.0 kg ha ⁻¹	3.66 ^c	10 ^{ab}	4.567 ^{ab}	18.233ef	9 ^{bcde}	12.90 ^{bcde}	5.67 ^{de}	27.43 ^{de}	11 ^{ab}	5.63 ^{cd}	14.33 ^b	31 ^a	38.4 ^{de}	46.7 ^d	1.8 ^{bcd}	1593 ^c			
S-metholachlor at 0.75kg ha ⁻¹ +pendimethalin at 1.25kg ha ⁻¹	2.667 ^{cd}	9.133 ^{ab}	6.367 ^{def}	18.167ef	10.03 ^{bcd}	14.9 ^{bc}	4.93 ^{de}	29.87 ^{de}	12.13 ^{efg}	5.37 ^{de}	15.57 ^b	33.1 ^a	42.5 ^{cde}	43.4 ^{de}	1.8 ^{bcd}	1481.3 ^{cd}			
S-metholachlor at 1.0 kg ha ⁻¹ + one hand weeding and hoeing at 5 WAE	3.9 ^{bc}	10.5 ^{de}	7.7 ^{cd}	22.133cde	5.5 ^{ef}	9.67 ^{ef}	3.83 ^f	19 ^f	8.17 ^{jk}	2.93 ^f	10.33 ^{cd}	20.2 ^g	13.4 ^g	65.3 ^{bc}	2.4 ^{ab}	2227 ^{ab}			
Pendimethalin at 1.0 kg ha ⁻¹ + one hand weeding and hoeing at 5 WAE	3.66 ^c	12.133 ^c	8.3 ^c	24.133c	5.3 ^{ef}	9 ^{ef}	4.5 ^{ef}	18.83 ^f	9.03 ^g	4.9 ^{de}	8 ^{ef}	20 ^g	18.6 ^f	65.7 ^{bc}	2.4 ^{ab}	2098.3 ^b			
Two hand weeding at 2 and 5 WAE	8.33 ^a	17.167 ^{ab}	12.33 ^{ab}	37.833b	4.33 ^f	7.93 ^g	3.7 ^f	15.97 ^f	6.83 ^b	2.73 ^g	5.67 ^g	15.2 ^g	9.3 ^g	73.8 ^b	2.8 ^a	2338 ^{ab}			
One hand weeding and hoeing at 2 WAE	8.35 ^a	16.67 ^{ab}	11.767 ^{ab}	36.767b	11.67 ^{ab}	17 ^a	8.67 ^b	37.33 ^b	16.33 ^b	8 ^{bc}	23 ^a	49 ^b	62 ^{ab}	15.03 ^g	1 ^d	887 ^{ef}			
Weed free check	0 ^f	0 ^f	0 ^f	0g	0 ^f	0	0	0	0 ^f	0 ^f	0 ^f	0 ^f	0 ^f	100 ^a	0 ^f	2582.3 ^a			
Weedy check	10.33 ^a	19.667 ^a	13.667 ^a	43.667a	14.667 ^a	24.87	10.67 ^a	50.2 ^a	19.33 ^a	13.33 ^a	26 ^a	58.7 ^a	67.3 ^a	100 ^a	0 ^f	690.3 ^f			
LSD	3.34	1.78	1.59	4.1	3.99	4.11	1.36	4.7	1.92	3.81	2.64	5.98	14	0.9	10.9	355.3			
CV	24.85	10.02	13.71	11.68	24.85	19.23	14.95	10.68	10.06	27.2	16.74	11.6	24.6	13.9	34	12.7			

Figure 3. Effect of herbicide on weed dry biomass at 25 and 55 days at harvesting, Weed index, Weed control efficiency and Herbicide Efficiency Index.

Means with the same letter at the column is not significant difference

KEY:- WDRB25, and 50, Weed dry biomass, WDRBA, Weed dry biomass at harvesting, WI, Weed index, WCE, Weed control efficiency, HEI, Herbicide Efficiency, HCI, Herbicide Efficiency Index

3.5. Weed Index

Application of herbicide with their combination is significant ($P \leq 0.01$) effect on weed index. The highest weed index was recorded from (67.1%) in weedy check followed by One-time hand weeding with hoeing at 2 WAE. Whereas the lower weed index was recorded from two time hand weeding at 2 and 5 WAE, S-metholachlor at 1.0 kg ha⁻¹ + one time hand weeding and hoeing at 5 WAE, Pendimethalin at 1.0 kg ha⁻¹ + one time hand weeding and hoeing at 5 WAE and S-metholachlor at 2.0 kg ha⁻¹. S-metholachlor at 1.0 kg ha⁻¹ + pendimethalin at 1.0 kg ha⁻¹, S-metholachlor at 2.0 kg ha⁻¹ which is 9.3%, 13.4%, 18.6%, 19.6%, 20.9% and 19.6% respectively. moderate weed controlling index was recorded from S-metholachlor at 1.0 kg ha⁻¹. S-metholachlor at 1.5 kg ha⁻¹. Pendimethalin at 1.0 kg ha⁻¹. Pendimethalin at 1.25 kg ha⁻¹. Pendimethalin at 1.5 kg ha⁻¹, S-metholachlor at 1.0 kg ha⁻¹ + pendimethalin at 0.75 kg ha⁻¹, S-metholachlor at 0.75 kg ha⁻¹ + pendimethalin at 1.0 kg ha⁻¹, S-metholachlor at 0.75 kg ha⁻¹ + pendimethalin at 1.25 kg ha⁻¹ which is ranging from 52% to 35.4% weed index (Figure 3) The result in line with the finding of [26] reported that uncontrolled weed growth throughout the crop growth period caused a yield reduction of 72% in wheat. [27] reported that combination of several weed control methods is the most

effective approach.

3.6. Weed Control Efficiency

Weed control efficiency data shows that weed control methods significant ($P \leq 0.01$) effect on weed density. The higher weed control efficiency was recorded from Weedy check, Two hand weeding at 2 and 5 WAE, S-metholachlor at 1.0 kg ha⁻¹ + one hand weeding and hoeing at 5 WAE and S-metholachlor at 2.0 kg ha⁻¹ which is 100%, 73.8%, 65.7%, 65.3% and 61.4% respectively followed by S-metholachlor at 0.75 kg ha⁻¹ + pendimethalin at 1.25 kg ha⁻¹, S-metholachlor at 0.75 kg ha⁻¹ + pendimethalin at 1.0 kg ha⁻¹, S-metholachlor at 1.0 kg ha⁻¹ + pendimethalin at 1.0 kg ha⁻¹, Pendimethalin at 1.5 kg ha⁻¹, Pendimethalin at 1.25 kg ha⁻¹ and S-metholachlor at 1.5 kg ha⁻¹ controlling efficiency was ranging from 40.5% to 46.7%. The lower weed controlling efficacy was recorded from One hand weeding and hoeing at 2 WAE, Pendimethalin at 1.0 kg ha⁻¹ and S-metholachlor at 1.0 kg ha⁻¹ which is 15.03%, 29.9% and 34.8% respectively (Figure 3) Similar result was obtained by [28] who concluded that the application of pendimethalin at 1.0 kg ha⁻¹ + one time hand weeding remarkably reduced the weed dry matter resulted in increase in weed control efficiency in wheat. [23] stated that higher weed control effi-

ciency was obtained with the application of isoproturon at 1.50 kg ha⁻¹ in wheat.

3.7. Herbicide Efficiency Index

Application of herbicide with their combination is a significant ($P \leq 0.01$) effect on herbicide efficiency index. The higher herbicide index was recorded from Two hands weeding at 2 and 5 WAE which is 2.8% followed by Pendimethalin at 1.0 kg ha⁻¹ + one-time hand weeding and hoeing at 5 WAE, S-metholachlor at 1.0 kg ha⁻¹ + one hand weeding and hoeing at 5 WAE, S-metholachlor at 1.0kg ha⁻¹+ pendimethalin at 1.0kg ha⁻¹, S-metholachlor at 2.0 kg ha⁻¹ and S-metholachlor at 1.5 kg ha⁻¹ which is ranging from 2.4% to 2.09%. Medium herbicide controlling efficiency was recorded from S-metholachlor at 1.0 kg ha⁻¹, Pendimethalin at 1.25 kg ha⁻¹, S-metholachlor at 1.0kg ha⁻¹+ pendimethalin at 0.75 kg ha⁻¹, S-metholachlor at 0.75kg ha⁻¹+ pendimethalin at 1.0 kg ha⁻¹, S-metholachlor at 0.75kg ha⁻¹+pendimethalin at 1.25kg ha⁻¹ control efficiency is ranging from 1.8% to 1.68% whereas the lower weed controlling efficiency index was recorded from One hand weeding and hoeing at 2 WAE, Pendimethalin at 1.0 kg ha⁻¹ and weedy check which is 1%, 1.37% and 0% (Figure 3) The result disagrees with the report of [29] reported that the herbicide efficiency index was increased when the rates of herbicides increased.

4. Conclusion and Recommendation

The experiment was conducted in Gurage zone at Ezha Woreda to evaluate the effect of herbicides and their combinations on yield components and yield of chickpea (*Cicer arietinum* L.). From the result different 17 weed species was identified with different eight families and classified as broad-leaved, sedge and grass weeds in weed community. The highest, dry Biomass at 55 days, dry Biomass at harvesting, weed index, weed control efficiency and herbicide efficiency Index was recorded from Weedy check and One-time hand weeding and hoeing 2 weeks after crop emergence (WAE) followed by integrated weed control methods. The lowest, weed dry biomass at 55 days after crop emergence, weed dry biomass at harvesting, weed index, weed control efficiency, Herbicide Efficiency, and Herbicide Efficiency Index was recorded from Two-time hand weeding at 2 and 5 weeks after crop emergence (WAE) and application of S-metholachlor and Pendimethalin in different rates. For intensive farming methods two-time hand weeding at 2 and 5 weeks after crop emergence and S-metholachlor at 1.0 kg ha⁻¹ + one hand weeding and hoeing at 4-5 weeks after crop emergence recommended to increase yield of chick pea whereas for extensive farming methods integrated weed control methods was recommended to increase the yield of chick pea.

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Data Availability

The data used to support the findings of this study are available and can be requested from the corresponding author.

Conflicts of Interest

The authors declare no conflicts of interest.

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