Determination of Efficacy of Newly I~~i~~ntroduced Herbicides on ~~Various~~ Weed Floras in Coffee Farm under Rain Fed Production System

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Abstract

Weed is the major limiting factor of coffee (*Coffea arabica* L.) *production in Ethiopia. Weeds in coffee cause a 65% yield reduction in the country. Nowadays, the expense of weed management has been a principal issue in Ethiopia's economic analysis of coffee production. Herbicide is the best weed management option in coffee production. Thus, the newly introduced herbicide verification trial was conducted on-site at the Hawassa Agricultural Research Center and Awada Coffee Research sub-center site in 2024, during the cropping season, to evaluate the efficacy of the newly introduced herbicide. The experiment consists of five (5) treatments of Wanda 48%SL (Glyphosate 48% g/l SL) test herbicide and XTrim 48%Sl, True killer, and Gly care 480%g/l SL, as a standard check and weedy control as a negative control. The herbicides effectively reduced weed density and improved weed control efficiency compared to weedy control. The tested herbicide Wanda 48%SL (Glyphosate 48 g/l SL) was fully controlled in the experimental plot, similar to a standard herbicide with one-time application for one season. This result suggested that one-time application at vigorous weed growth is mandatory to achieve full control throughout the season equivalent to standard control herbicides. Therefore, Wanda 48%SL (Glyphosate 48g/l SL) at 3 L/ha within 250L/ha water with one-time application per season is recommended to control weeds in coffee as an alternative management option. According to this study, all the evaluated herbicides can control coffee weeds, without different control duration. ~~-~~All standard checks True killer, Glycare 480% g/l SL, XTrim 48% SL, and the tested herbicide Wanda 48%SL (Glyphosate 48g/l SL) controlled weed species within 7 to 21 days.*

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Keywords: *Coffea arabica*, ~~Efficacy~~efficacy, ~~Herbicides~~herbicides, Sidama, Wanda 48%SL, ~~Weed~~ weed density, ~~Verification~~ verification

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1. INTRODUCTION

Coffee (*Coffea arabica* L.) is the perennial commercial crop and backbone of a country's economy and the second most traded commodity in terms of volume and value, behind oil (Girma, 2011). Therefore, it is essential to maintain a balance in trade between developed and developing countries. It offers over 25% of Ethiopia's population's income, accounting for 70% of foreign exchange profits and 10% of government revenue (Tsegaye *et al*., 2000). The most consumed type of coffee is arabica, making up more than 70% of production volume and 90% of worldwide trade value (Tadesse and W/Mariam, 2015).

~~The~~ Ethiopia's ~~country's~~ economy and culture are strongly influenced by coffee. The country's ~~Ethiopia's~~ main export crop is arabica coffee, which makes it a significant contributor in the ~~economic~~ economy ~~contribution to~~ of the country. It is the most important product for the Ethiopian industry and a major source of foreign exchange that supports the livelihoods of millions of laborers and farmers. Numerous obstacles, including weed ~~control~~infestation, recurring pests and diseases, depleting soil capacity, and unfavorable weather patterns, have an impact on coffee output. ~~Coffee production was affected by many biotic and abiotic factors in Ethiopia.~~ Coffee diseases cause considerable losses when not treated. According to Cerda *et al*. (2017), 57% yield loss was observed by the infection of disease-causing organisms on coffee crops. Jima *et al.* (2017) also reported that the most economically important pathogenic coffee diseases are coffee berry disease (CBD), coffee wilt disease (CWD), and coffee leaf rust (CLR), and physiological disorders like coffee branch dieback are caused by pseudomonas syringe and non-pathogenic agents. Similarly, ~~CBD and~~ branch dieback ~~were~~ is causing high-yield loss of coffee production. In the same way, insect pests such as Anthestia bug, ~~and~~ coffee blotch miners, stem borer and berry borer ~~miners~~ are the major ones causing considerable damage. ~~The assessment carried out in Eastern Ethiopia indicated that diseases and insect pests are causing considerable crop losses. CBD is a major disease observed while CWD was considered a minor on a few farmers' coffee farms. Similarly, a major insect pest that affects coffee production in Eastern Ethiopia is coffee stem borer and coffee berry borer. On the other hand~~Moreover, insect pests such as coffee trips, green scales,

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and coffee cushion scales were reported as important coffee production constraints in the country (Fekede and Gosa, 2015).

~~-~~According to Eshete~~e~~u *et al.* (2007) report~~ indicated~~, ineffective weed control is the primary cause of the low average coffee output, causing an average annual yield loss of 60-80%. Weeds are one of the primary factors limiting the nation's coffee production,~~.~~ ~~In coffee, it has been proven to diminish output by 65% and even cause crop failure, ~~depending on the type of weed, the stage at which coffee trees are developing, and the surrounding growth circumstances (Tadesse~~ E~~, 1998). Despite this, most coffee growers rely mostly on hand cutting and digging, which promotes the growth and dispersal of the harmful competitive perennial weeds (Tadesse~~ E~~, 1994). The primary obstacle to ~~Ethiopian ~~the crop productivity, particularly during the wet season, is weed infestation. The climate encourages rapid and abundant growth of weeds and consequently, all crops are heavily infested with weeds. Farmers in the country are aware of a weed problem in their fields but often they cannot cope-up with heavy weed infestation during the peak period of agricultural activities because of labor shortage, hence, most of their fields are weeded late or left un-weeded. The ~~-~~expense of weed management has been a principal issue in the ~~-~~economic analysis of coffee production, particularly in large-scale farms~~ in Ethiopia~~. This is because the weed species are found to be dominant and prevalent in the areas where they favorably and quickly re-appear within the season. Previously, several systemic herbicides have been evaluated by the Jimma Agricultural Research Center and recommended by Tigist and Tadesse (2022), and a newly introduced systemic herbicide was evaluated that beat different weed types in coffee farms of Southwest Ethiopia, in the Jimma area (Tigist~~ B~~ *et al.*, 2024) and Southern Ethiopia, in Sidama (Malkamu~~ F~~, 2024). However, since coffee production has expanded yet now there is a scarcity of systemic herbicides to reduce losses caused due to weed infestation. Often farmers practice ~~Weeding ~~one time weeding ~~at one ~~or left unwedded ~~left ~~which increases infestation of both broad-leaf and grass weeds resulting in low productivity. 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. According to different scholars and previous research reports, using herbicide is ~~-~~an essential part of weed management practice in coffee production in the southern and southwest including Sidama region~~ Ethiopia~~. ~~-~~It also can offer the advantage of taking less time, ~~demanding less ~~labor, and avoiding the ~~-~~potential of diseases spread caused by manual slashing and digging during weed management practices. ~~–~~Therefore, effective systemic herbicides for controlling deep-seated rhizomes, bulbs and tubers, and above-ground running stolen of~~f~~ the perennial sedge and grass weeds are vital. Under such circumstances evaluation of ~~different~~ herbicides with different ~~groups and~~ modes of action ~~is~~are essential.

~~-~~Hence, the use of non-selective broad-spectrum chemicals becomes important to kill all weeds emerging before they ~~may~~ cause harm to crops. Glyphosate for many years has been used as the most important non-selective herbicide to control all types of weeds before planting.

Having above mentioned points, the verification test was conducted following Pesticide Testing ~~guidelines~~ Guidelines developed by the Ethiopian Institute of Agricultural Research (EIAR) to evaluate the efficacy of newly introduced herbicides ~~for verification was done is~~ Wanda 48%SL (Glyphosate 48g/l SL*)* ~~herbicide~~ compared with already registered herbicide Gly care 48% g/l SL., XTrim, and true killer as standard control for control perennial ~~grasses,~~ and annual ~~perennial broad leaves and annual~~ grasses and broad ~~leaves~~ leaved weeds in ~~Coffee~~ coffee ~~at~~ in Sidama Regional ~~state~~State, ~~-~~Hawassa ~~agricultural~~ Agricultural ~~research~~ Research ~~center~~ Center on station and Awada ~~agricultural~~ Agricultural ~~research~~ Research ~~sub~~Sub-center ~~in Ethiopia~~. Wanda 48%SL (Glyphosate 48g/l SL) is a non-selective herbicide used to control all broads, grass, and sedge weeds of coffee, currently verified at Hawassa Agricultural Research Center. The objective of the study was to verify the efficacy of the new formulation Wanda 48 % SL (Glyphosate 48 g/l SL) on the control of ~~all~~ weeds in ~~Coffee~~ coffee~~perennial commercial crops~~.

2. MATERIALS AND METHODS

2.1. Descriptions of the Study Area

The verification test was conducted at Hawassa Agricultural Research Center (HARC) and Awada Agricultural Research Sub-Center (AARC) in coffee (*Coffea arabica* L.) farms during 2024 (Figure 1). HARC is found in Sidama ~~regional~~ Regional ~~state~~ State ~~in~~ at Hawassa~~ city, Ethiopia~~, 288 km to southern Addis Ababa. It is located at 07° 03'52''N latitude, ~~and~~ 038° 28' 52 'E longitude and ~~with~~ an elevation of 1700 meters above sea level (masl) ~~and t~~The area receives a total of 1000 to 1200 mm rainfall in bimodal raining pattern with short rains (belg rains) coming from April to May and long rains (meher rains) coming from July to October. The mean annual minimum and maximum temperatures of the area~~s~~ were 16.5 °C and 29.2 °C, respectively. ~~Likewise, the research was carried out at the Awada Agricultural Research Sub-Center, which~~AARC is ~~was~~ found~~ed in 1997 on a 31-ha area of land near Yirgalem town,~~ at distances of 319 km from Addis Ababa, and 45 km from ~~south of~~ Hawassa to south at Yirgalem. It is located at 6° 3' N latitude, 38° 3' E longitude, and 1740 masl altitude. The average annual minimum and maximum temperatures ~~is~~ are 11°C~~, the average maximum temperature is~~ and 28°C, with~~ and the average annual~~ 1335 mm rainfall~~ is 1335 mm~~. According to Mesfin and Bayetta (2008), the two main soil types in the center are chromatic-cambisols and eutrophic tools, both of which are excellent for producing coffee.

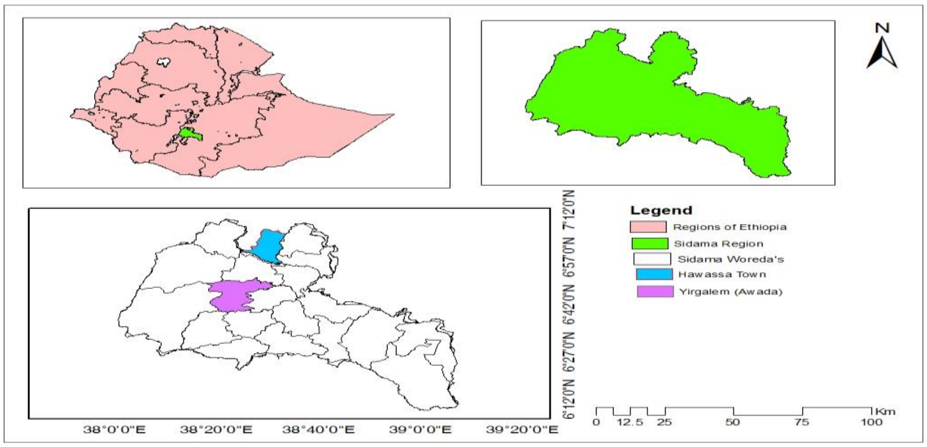

Figure -1. Maps of study areas

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2.2. Materials and Procedure

The herbicide test was conducted at Hawassa Agricultural Research Center on-station. The trial was conducted at two locations via the on-station of Hawassa Agricultural Research Center and Awada coffee Coffee research Research subSub-center. The study was laid out on already established coffee experimental plots with a naturally infested field where the noxious perennial and annual grasses, perennial broad-leavedf weeds perennial sedges, and annual broad-leaf weeds were abundantly growing.

-Five (5) treatments were used at the -experimental sites including test herbicide WANDA48% SL (Glyphosate 48g/l SL), and three standard checks (Glycare 48%g/l SL), XTrim, and True killer) as described in Table 1, and weedy check were evaluated. Wanda 48% SL, Glycare 48% g/l SL, True Killer, and XTrim 48% SL The plots size were was 10 m x 10 m in size, both on the Hawassa agricultural research center and Awada agricultural research sub-center stations. The testing trail was laid out in non-replicated plotsover locations that, where locations were considered as replications. They are non-selective herbicides that start killing the weeds within weeks after application. The herbicides were sprayed one time within the season at the actively/vigorous growthing stage of the weeds. WANDA48% SL (Glyphosate 48g/l SL)Each of them –was uniformly applied with a rate of 3 liters/ha manually using a knapsack sprayer delivering 250 liters

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You didn't cited table 1, that was my reason to raise the above comments.

of water/ha following the cherry harvesting time of cherry. The herbicides were sprayed one time within the season at the actively growing stage of the weeds. Weeds were identified to species level and counted pretreatment by randomly throwing the quadrant as pre-treatment weed count. After the 7th, 14th, and 21st days of herbicide application, the weed counted as post-treatment by throwing quadrant (0.25 m^2) randomly to the plots. Finally, pre- and post-spray weed counts were subjected to efficacy calculation using the formula of Fleming and Retnakaran (1985) as follows:

$$\text{Efficacy } \% = \frac{1-(\text{Ta} * \text{Cb})}{(\text{Tb} * \text{Ca})} * 100$$

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Where, Ta=post-treatment population in treatment, Cb= Prepre-treatment population in check, Tb= Prepre-treatment population in treatment, Ca= post-treatment population in check., similarly Similarly, the herbicide weed control efficiency (WCE) percentage of weed inhibition (PWI) was can be calculated by using the following formula as suggested by (Mani, *et al*., 1973). Percentage of Weed inhibition (PWI) was calculated using the following formula.

$$\text{Percentage of weed inhiition (PWI)} = \left(\text{NWC} - \frac{\text{NWT}}{\text{NWC}}\right) * 100$$

Where, NWC =number of weeds in the weedy check ,& NWT =number of weeds in are many weeds (0.25m^2) in the weedy check and any particular treatment, respectively. Individual and general weed control score were evaluations done using (1-9 scale score);, 1= no control and 9= (100% control) were determined through visual observation at the 7th and 14th days after treatment application by considering growth reduction, foliar chlorosis, wilting and stunting during the time of assessment.

Moreover, wWeed Control control Efficiency efficiency (WCE) was calculated based on the following formula (Surinder, 2016).

$$\text{WCE} = \frac{\text{Weed count in weedy plot} - \text{wWeed count in treated plot}}{\text{Weed count in weedy plot}} * 100$$

The plot (weedy check) was used for comparison and all other management practices were applied as per their agronomic recommendations uniformly.

Table 1. Treatment description used at an ~~-~~experimental unit of the ~~-~~trial

Trade ~~Name~~ name	Common ~~Name~~name	Active ~~Ingredient~~ ingredient (a.i)	Registration ~~Number~~ number	Shelf lives (year)	~~Application Rate L ha^{-1}~~	
					~~Herbicide~~	~~Water~~
WANDA 48% SL	Glyphosate	Glyphosate 48g/l SL	New	2	~~3~~	~~250~~
True Killer	Glyphosate IPA	480g/l Glyphosate isopropyl amine salt	ET/HR/R127/2021	2	~~3~~	~~250~~
XTrim 48%SL	Glyphosate	Glyphosate 480g/l	ET/HR/SM/R224/2022	3	~~3~~	~~250~~
Glycare 48% SL	Glyphosate IPA	480 g/l Glyphosate isopropyl amine salt	ET/HR/SS/R678/2022	2	~~3~~	~~250~~
~~Weedy check~~	~~-~~	~~-~~	~~-~~		~~-~~	~~-~~

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3. RESULTS AND DISCUSSIONS

3.1. Weed Infestation ~~in Terms of Taxonomy~~

The verification test was conducted ~~under~~ in pre-established coffee (*Coffea arabica* L.)orchards. ~~pre-established in different w~~Weed species belonging to the annual and perennial broad leaf, annual grasses, perennial broad leaf, perennial grass, and sedge, categories were identified. About thirty-three (33) weed species belonging to seventy (17) families were recorded from verification test fields across locations. Among the recorded weed species, 6.1% were sedge, 18.2% were grass, and 75.7% were broad-leaf weed species were 6.1%, 18.2% and 75.7%, respectivelyin order. Likewise, regarding their ontogeny, 54.6% perennial weed species (33.3% broad leaf, 15.2% grass, and 6.1% sedge), while 45.4% annual weed species (42.4% broad leaf and 3% grass) were recorded from the experimental field conducted in the 2024 cropping season pre-stabilized coffee farm at Hawassa Agricultural Research Center on-site and Awada Agricultural Research sub-center (Tables 4 2, and 53). According to the current finding, annual broad-leaf weed species were more prevalently isolated than perennial broadleaf, and compared to the annual and perennial broad-leaf weed species, sedge and annual grass were isolated in smaller numbers.

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Of the seventeen weed families that were recognized and frequently observed in the experimental fields, members of the *Poaceae*, *Amaranthaceae*, *Asteraceae*, and *Fabaceae* families were numbered three to six times speciesnumerically, while the remaining families were counted around two or one species. About ten (10) families and twenty-four (24) weed species were identified by from Hawassa agricultural Agricultural researchers Researchers on-site, while the Awada agricultural research sub-center revealed about thirteen (13) families and nineteen 19 weed species. Similar The reports carried outdone in the Sidama Region of Southern Ethiopia (Malkamu F., 2024) and (Tigist B., 2024; Tigist B. and Tamiru S., 2023) the report from Southwest Ethiopia Jimma Zone (Tigist, 2024; Tigist and Tamiru, 2023), and weed species composition and abundance in the main coffee production systems and regions of Ethiopia (Abera D *et al*., 2022). and Survey of Weed weed flora composition in coffee of East Ethiopia (Hika B *et al*., 2021) were similar to the current finding. Many annual and perennial broad-leaf weed species were more -frequently encountered than grass and sedge species across sites, as the study's findings indicated (Tables 4 and 5).

Table 2. Weed ~~Species~~ species ~~Observed~~ observed in ~~The~~ the ~~Experimental~~ experimental ~~Fields~~ field ~~at~~ of Awada ~~Site~~ site

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Scientific ~~Name~~ name	Family	Common ~~Name~~ name	Morphology	Life ~~Cycle~~ cycle
Achyranthes aspera L.	*Amaranthaceae*	Devils horsewhip	~~Broadleaf~~Bl	~~Perennial~~
Amaranthus greecizens L.		Pigweed	Broadleaf	A~~nnual~~
Bidens pilosa	*Asteraceae*	Black Jack	Broadleaf	Annual
Galinsoga parviflora		Gallant Soldier	Broadleaf	Annual
Commelina benghalensis L.	*Commelinaceae*	Wandering Jew	Broad leaf	Perennial
Merremia emarginata	*Convolvulaceae*	Kidneyleaf morning glory	Broadleaf	Perennial
Cyperus brevifolius	*Cyperaceae*	Mullumbimby couch	~~Sedge~~ S	Perennial
Cyperus rotundus		Purple nut sedge	Sedge	Perennial
Euphorbia hirta L.	*Euphorbiaceae*	AsthmaWeed	Broadleaf	Annual
Chamaecrista pumila	*Fabaceae*	Dwarf cassia	Broadleaf	Perennial
Desmodium intorutum		Green leaf disodium	Broadleaf	Perennial
Medicago polymorpha		Toothed bur clover	Broadleaf	Annual
Leucas martinicensis	*Lamiaceae*	White wort	Broadleaf	Annual
Marsilea quadrifolia Hook.	*Marsileaceae*	Water Clover	Broad leaf	Perennial
Oxalis cognuculata L.	*Oxalidaceae*	Creeping wood sorrel,	Broadleaf	Annual
Phyllanthus niruri L.	*Phyllanthaceae*	Store breaker	Broadleaf	Annual
Cynodon nlemfuensis Vanderyst	*Poaceae*	Star grass	~~Grass~~ G	Perennial
Oplismenus hirtellus (L.)		Basket grass,	Grass	Perennial
Galium~~m~~ aparinae	*Rubiaceae*	Cleavers	Broadleaf	Annual

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Note: Bl=broad leaf, G=grass, S=sedge, a=annual, p=perennial

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Table 3. Weed ~~Species~~ species ~~Observed~~ observed in the ~~Experimental~~ experimental ~~Field~~ field ~~at~~ of Hawassa ~~Site~~ site

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Scientific ~~Name~~ name	Family	Common ~~Name~~ name	Morphology	Life ~~Cycle~~ cycle
Ruellia ~~Prostrate~~ prostrate poir	*Acanthoceae*	Prostrate wild petunia	Broadleaf	Perennial
Achyranthes aspera L.	*Amaranthaceae*	Devils horsewhip	Broadleaf	Perennial
Alternantherria caracasana		Khakiweed	Broad leaf	Perennial
Cyathula prostrat (L.) Blume.		Pasture weed	Broad leaf	Annual
Bidens pilosa	*Asteraceae*	Black Jack	Broad leaf	Annual
Conyza bonariensis L.		Hairy horseweed	Broad leaf	Annual
Galinsoga parviflora		Gallant Soldier	Broad leaf	Annual
Commelina benghalensis L.	*Commelinaceae*	Wandering Jew	Broad leaf	Perennial
Commelina latifolia L.		Day flower	Broad leaf	Annual
Convolvulus arvensis L.	*Convolvulaceae*	Field bindweed	Broad leaf	Perennial
Bracheria mutica	*Poaceae*	Para grass	Grass	Perennial
Cynodon nlemfuensis Vanderyst		Star grass	Grass	Perennial
Digitaria abysinica		African couch grass	Grass	Perennial
Oplismenus hirtellus (L.)		Basket grass,	Grass	Perennial
Paspalum conjugatum		Carabao grass	Grass	Perennial
Poa annua L.		Annual bluegrass	Grass	Annual
Antigonon leptopus Hook.	*Polygonaceae*	Coral vine	Broad leaf	Perennial

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Fallopia convolvulus (L.)		Climbing knotweed	Broad leaf	Annual
Portulaca oleracea	*Portulacaceae*	Common purslane	Broad leaf	Annual
Galium~~m~~ aparinae	*Rubiaceae*	Cleavers	Broad leaf	Annual
Lantana camara	*Verbenaceae*	Common lantana	Broad leaf	Perennial

Table 4. ~~Taxonomy of w~~Weed~~ specie~~s observed in the verification test site~~ across location~~s~~.~~

Scientific ~~Name~~ name	Family	Common ~~Name~~ name	Morphology	Life ~~Cycle~~ cycle
Ruellia Prostrate poir	*Acanthoceae*	Prostrate wild petunia	Broad leaf	Perennial
Achyranthes aspera L.	*Amaranthaceae*	Devils horsewhip	Broad leaf	Perennial
Alternantherria caracasana		Khakiweed	Broad leaf	Perennial
Amaranthus greecizens L.		Pigweed	Broad leaf	Annual
Cyathula prostrat (L.) *Blume.*		Pasture weed	Broad leaf	Annual
Bidens pilosa	*Asteraceae*	Black Jack	Broad leaf	Annual
Conyza bonariensis L.		Hairy horseweed	Broad leaf	Annual
Galinsoga parviflora		Gallant Soldier	Broad leaf	Annual
Commelina benghalensis L.	*Commelinaceae*	Wandering Jew	Broad leaf	Perennial
Commelina latifolia L.		Day flower	Broad leaf	Annual
Convolvulus arvensis L.	*Convolvulaceae*	Field bindweed	Broad leaf	Perennial
Merremia emarginata		Kidney leaf Morning glory	Broad leaf	Perennial
Cyperus brevifolius	*Cyperaceae*	Mullumbimby couch	Sedge	Perennial
Cyperus rotundus		Purple nut sedge	Sedge	Perennial
Euphorbia hirta L.	*Euphorbiaceae*	Asthma Weed	Broad leaf	Annual
Chamaecrista pumila	*Fabaceae*	Dwarf cassia	Broad leaf	Perennial
Desmodium intorutum		Green leaf disodium	Broad leaf	Perennial
Medicago polymorpha		Toothed bur clover	Broad leaf	Annual
Leucas martinicensis	*Lamiaceae*	White wort	Broad leaf	Annual
Marsilea quadrifolia Hook.	*Marsileaceae*	Water Clover	Broad leaf	Perennial
Oxalis cognuculata L.	*Oxalidaceae*	Creeping wood sorrel,	Broad leaf	Annual
Phyllanthus niruri L.	*Phyllanthaceae*	Store breaker	Broad leaf	Annual
Bracheria mutica	*Poaceae*	Para grass	Grass	Perennial
Cynodon nlemfuensis Vanderyst		Star grass	Grass	Perennial
Digitaria abysinica		African couch grass	Grass	Perennial
Oplismenus hirtellus (L.)		Basket grass,	Grass	Perennial
Paspalum conjugatum		Carabao grass	Grass	Perennial
Poa annua L.		Annual bluegrass	Grass	Annual
Antigonon leptopus Hook.	*Polygonaceae*	Coral vine	Broad leaf	Perennial
Fallopia convolvulus (L.)		Climbing knotweed	Broad leaf	Annual
Portulaca oleracea	*Portulacaceae*	Common purslane	Broad leaf	Annual
Galium~~m~~ aparinae	*Rubiaceae*	Cleavers	Broad leaf	Annual
Lantana camara	*Verbenaceae*	Common lantana	Broad leaf	Perennial

Table 5. Weeds ontogeny and morphology~~composition and~~ percentage ~~of morphological classification~~ record across locations

Weed ontogeny	Morphological classification based on their visible plant structures					
	Broad ~~Leaf~~leaf		Grass		Sedge	
	Frequency	%	Frequency	%	Frequency	%
Annual	14	42.4	1	3	0	0
Perennial	11	33.3	5	15.2	2	6.1
Total	**25**	**75.6**	**6**	**18.2**	**2**	**6.1**

3.2. Effect of Herbicides on Weed Density and Percentage of Weed Reduction

Weed density and percentage of weed reduction data after herbicide application were presented in (Table ~~3~~6). The ~~current~~ verification trial result indicated that herbicide application ~~has~~ was affected weed density. The candidate herbicide Wanda 48% SL (Glyphosate 480 g/l SL) effectively reduced the weed density compared to weed check. ~~The candidate herbicides Wanda 48% SL and standard check Glycare 48% g/l SL, True Killer, and XTrim 48% SL were non-selective herbicides that started to kill the weeds within weeks days after application (DAA).~~ Wilting and change of weed species color to yellow was started at 3-5 DAA while dead or killing weed species was ~~started~~ observed on average at 5-7 DAA. About 70% of the weed population was killed ~~after~~ at 7 DAA~~, while most of the weeds were killed between 7-9 DAA~~. More than 95% of the weed population ~~was~~ were killed at 14 DAA, and 99.9% ~~were~~ at 21 DAA. The lower weed density mean value of ~~7~~ seven followed by 9, 13, and 17 per 100 m2 ~~was~~ were recorded from the plots treated with true killer, wanda48% SL, Glycare480g/l Sl and XTrim 48% SL respectively at the 21st day ~~evaluation time~~ after herbicide application across locations compared with weedy control. In contrast, the weedy check plots recorded the highest weed population mean value (9105/100 m^2) (Figure 2.). Different results on the percentage of weed inhibition or ~~percentage of weed~~ reduction were ~~also~~ recorded in the present verification trials. A~~s a result, shown a~~t Hawassa ~~on site indicated by individual weed species~~, the weed reduction percentage mean value ranged from 65.2-85.9%, 90.3-96.3%, and 96.7-100% were obtained from plots treated with Wanda 48% SL ~~test herbicide and~~, True killer, Glycare and XTrim 48%SL ~~standard check herbicides~~, compared with untreated plots ~~untreated~~ at 7th, 14th, and 21st DAA, respectively (Table 6 and 7). Almost the

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same trended result was revealed at the Awada coffee Coffee research Research subSub-center when the individual weed species reduction percentage mean values was were 65.2-73.1 %, 93.1-94.3, and 99.7-99.9% at 7th,14th and 21st DAA, respectively (Figure 32; Table 6 & 7). -The tested herbicide and standard check performed well on weed density reduction and weed reduction percentage compared with untreated plots. The present finding is similar to the report of Firde T. and Bidira T. (2024) done at the Jimma zone, Southern Ethiopia on the pre-verification trial of herbicide against weeds in coffee (*Coffea arabica* L.).

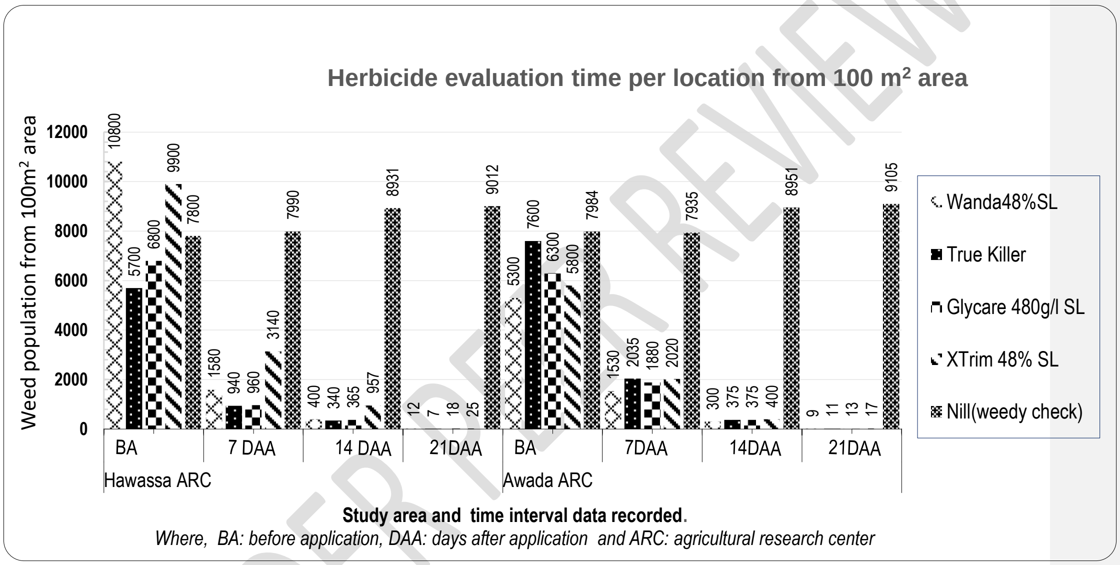

Figure 2. Effect of herbicide on weed population across study -sites at time of application, 7, 14, and 21 days after application.

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Table 6. Effect of ~~Herbicide~~ herbicides on ~~i~~Individual ~~Weed~~ weed ~~Control~~ control at Awada Research Site

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Weed ~~Species~~ species	Treatment ~~e~~Evaluation ~~t~~Time at Awada Research Site																							
	Wanda 48% SL						True Killer						Glycare 480g/l SL						XTrim 48% SL					
	7th DAA		14th DAA		21DAA		7th DAA		14th DAA		21DAA		7th DAA		14th DAA		21DAA		7th DAA		14thDAA		21DAA	
	SS	PWC	SS	PWC	SS	PWC	SS	PWC	SS	PWC	SS	PWC	SS	PWC	SS	PWC	SS	PWC	SS	PWC	SS	PWC	SS	PWC
Achyranthes aspera L.	7.2	80	9	100	9	100	7.6	84.4	9	100	9	100	7.2	80.0	9	100	9	100	7	77.8	9	100	9	100
Amaranthus greecizens L.	7.2	80	9	100	9	100	7.5	83.3	9	100	9	100	7.2	80.0	9	100	9	100	6.5	72.2	9	100	9	100
Bidens pilosa	7	77.8	9	100	9	100	7.5	83.3	9	100	9	100	7	77.8	9	100	9	100	6.5	72.2	9	100	9	100
Galinsoga parviflora	7.5	83.3	9	100	9	100	7.5	83.3	9	100	9	100	7	77.8	9	100	9	100	7	77.8	9	100	9	100
Commelina benghalensis L.	4	44.4	7.1	78.9	9	100	4	44.4	7.8	86.7	9	100	4	44.4	7	77.8	9	100	4	44.4	7	77.8	9	100
Merremia emarginata	7	77.8	9	100	9	100	7	77.8	9	100	9	100	7	77.8	9	100	9	100	6.5	72.2	9	100	9	100
Cyperus brevifolius	4.5	50	7.5	83.3	9	100	4.5	50	7.8	86.7	9	100	4.5	50.0	7	77.8	9	100	4	44.4	7	77.8	8.9	98.9
Cyperus rotundus	4.5	50	7.5	83.3	8.9	98.9	4.5	50	7.7	85.6	8.9	98.9	4.5	50.0	7.2	80	8.9	98.9	4	44.4	7	77.8	8.9	98.9
Euphorbia hirta L.	6.5	72.2	8.5	94.4	9	100	7	77.8	8.5	94.4	9	100	6.5	72.2	8.8	97.8	9	100	6	66.7	8.6	95.6	9	100
Chamaecrista pumila	6.5	72.2	9	100	9	100	7.5	83.3	9	100	9	100	6.5	72.2	9	100	9	100	6	66.7	9	100	9	100
Desmodium intorutum	4	44.4	6.2	68.9	8.9	98.9	4	44.4	6.1	67.8	9	100	4	44.4	6.2	68.9	8.9	98.9	4	44.4	6	66.7	9	100
Medicago polymorpha	7	77.8	9	100	9	100	7.2	80	9	100	8.9	98.9	7	77.8	9	100	9	100	6.5	72.2	9	100	8.7	96.7
Leucas martinicensis	7	77.8	9	100	9	100	7.2	80	9	100	9	100	7	77.8	9	100	9	100	6.5	72.2	9	100	9	100
Marsilea quadrifolia Hook.	7.5	83.3	9	100	9	100	7.5	83.3	9	100	9	100	7	77.8	9	100	9	100	6.1	67.8	9	100	9	100
Oxalis cognuculata L.	7.5	83.3	8.5	94.4	9	100	7.5	83.3	8.6	95.6	9	100	7.5	83.3	8.5	94.4	9	100	6.6	73.3	8	88.9	9	100
Phyllanthus niruri L.	6.5	72.2	8.5	94.4	8.9	98.9	7	77.8	8.6	95.6	9	100	6.5	72.2	8.5	94.4	8.9	98.9	6.1	67.8	8.2	91.1	9	100
Cynodon nlemfuensis Vanderyst	5.6	62.2	9	100	9	100	5.6	62.2	9	100	9	100	5.6	62.2	9	100	9	100	5.6	62.2	9	100	9	100
Oplismenus hirtellus (L.)	7.5	83.3	9	100	9	100	7.5	83.3	9	100	9	100	7	77.8	9	100	9	100	6.5	72.2	9	100	9	100
Galiumm aparinae	7	77.8	8.5	94.4	9	100	7	77.8	9	100	9	100	7	77.8	8.5	94.4	9	100	6.1	67.8	8	88.9	9	100
Mean	**6.4**	**71.1**	**8.5**	**94.3**	**9**	**99.8**	**6.6**	**73.2**	**8.6**	**95.1**	**9**	**99.9**	**6.3**	**70.2**	**8.5**	**94.0**	**9**	**99.8**	**5.9**	**65.2**	**8.4**	**93.1**	**9**	**99.7**

Where: DAA= days after application, SS=score scale (1-9) and PWC=percent weed control (%)

Table 7. Effect of ~~Herbicide~~ herbicides on i~~I~~ndividual w~~W~~eed c~~C~~ontrol at Hawassa Research Site

Weed s~~S~~pecies	Treatment e~~E~~valuation t~~T~~ime at Hawassa Research Site																							
	Wanda 48% SL						True Killer						Glycare 480g/l SL						XTrim 48% SL					
	7th DAA		14th DAA		21DAA		7th DAA		14th DAA		21DAA		7th DAA		14th DAA		21DAA		7th DAA		14thDAA		21DAA	
	SS	PWC	SS	PWC	SS	PWC	SS	PWC	SS	PWC	SS	PWC	SS	PWC	SS	PWC	SS	PWC	SS	PWC	SS	PWC	SS	PWC
Ruellia Prostrate poir	8	88.9	8.8	97.8	9	100	7.7	85.6	8.8	97.8	9	100	8.0	88.9	8.8	97.8	9	100	6.2	68.9	8.5	94.4	9	100
Achyranthes aspera (L.)	7.8	86.7	8.8	97.8	9	100	7.8	86.7	8.8	97.8	9	100	7.8	86.7	8.8	97.8	9	100	6.0	66.7	8.4	93.3	9	100
Alternantherria caracasana	7.7	85.6	8.7	96.7	9	100	7.7	85.6	8.7	96.7	9	100	7.7	85.6	8.7	96.7	9	100	6.0	66.7	8.3	92.2	9	100
Cyathula prostrat (L.)	7.8	86.7	8.8	97.8	9	100	7.8	86.7	8.8	97.8	9	100	7.9	87.8	8.8	97.8	9	100	6.6	73.3	8.5	94.4	9	100
Bidens pilosa	8	88.9	8.7	96.7	9	100	7.6	84.4	8.7	96.7	9	100	8.0	88.9	8.7	96.7	9	100	6.5	72.2	8.4	93.3	9	100
Conyza bonariensis L.	8	88.9	8.8	97.8	9	100	7.5	83.3	8.6	95.6	9	100	8.0	88.9	8.7	96.7	9	100	5.5	61.1	8.3	92.2	9	100
Galinsoga parviflora	8	88.9	8.9	98.9	9	100	7.7	85.6	8.7	96.7	9	100	8.1	90.0	8.8	97.8	9	100	6.4	71.1	8.2	91.1	9	100
Commelina benghalensis L.	6.3	70.0	7.6	84.4	8.6	95.6	6	66.7	7.3	81.1	8.6	95.6	6.5	72.2	7.4	82.2	8.8	97.8	4.6	51.1	7.1	78.9	8.8	97.8
Commelina latifolia (L.)	6.4	71.1	7.6	84.4	8.5	94.4	6	66.7	7.2	80.0	8.5	94.4	6.5	72.2	7.4	82.2	8.9	98.9	4.5	50.0	7.0	77.8	8.9	98.9
Convolvulus arvensis L.	8.5	94.4	8.6	95.6	9	100	7.5	83.3	8.6	95.6	9	100	8.5	94.4	8.6	95.6	9	100	6.6	73.3	7.9	87.8	9	100
Bracheria mutica	7.8	86.7	8.8	97.8	9	100	7.8	86.7	8.4	93.3	9	100	7.8	86.7	8.7	96.7	9	100	6.5	72.2	8.3	92.2	9	100
Cynodon nlemfuensis -Vanderyst	6.5	72.2	8.8	97.8	9	100	6.5	72.2	8.5	94.4	9	100	6.5	72.2	8.8	97.8	9	100	5.2	57.8	8.2	91.1	9	[illegible]
Digitaria abysinica	7.8	86.7	8.8	97.8	8.9	98.9	7.8	86.7	8.6	95.6	8.9	98.9	7.8	86.7	8.0	88.9	8.9	98.9	6.4	71.1	7.8	86.7	8.9	98.9
Oplismenus hirtellus (L.)	7.8	86.7	8.8	97.8	9	100	7.8	86.7	8.5	94.4	9	100	7.8	86.7	8.7	96.7	9	100	7.0	77.8	8.4	93.3	9	100
Paspalum conjugatum	8.2	91.1	8.8	97.8	9	100	8.2	91.1	8.6	95.6	9	100	7.9	87.8	8.6	95.6	9	100	6.6	73.3	7.8	86.7	9	100
Poa annua (L.)	7.7	85.6	8.8	97.8	9	100	7.7	85.6	8.4	93.3	9	100	7.7	85.6	8.7	96.7	9	100	6.5	72.2	8.2	91.1	9	100
Antigonon leptopus Hook.	7.6	84.4	8.7	96.7	9	100	7.6	84.4	8.7	96.7	9	100	7.8	86.7	8.6	95.6	9	100	6.5	72.2	8.4	93.3	9	100
Fallopia convolvulus (L.)	7.8	86.7	8.8	97.8	9	100	7.8	86.7	8.5	94.4	9	100	7.8	86.7	8.5	94.4	9	100	6.0	66.7	7.9	87.8	9	100
Portulaca oleracea	8	88.9	8.8	97.8	9	100	7.9	87.8	8.8	97.8	9	100	8.1	90.0	8.6	95.6	9	100	6.0	66.7	8.4	93.3	9	100
Galium~~m~~ aparinae	8	88.9	8.9	98.9	9	100	7.8	86.7	8.3	92.2	9	100	8.3	92.2	8.3	92.2	9	100	6.7	74.4	8.0	88.9	9	100
Lantana camara	7.7	85.6	8.8	97.8	9.	100	7.7	85.6	8.1	90.0	9.	100	7.8	86.7	8.5	94.4	9.	100	6.8	75.6	8.6	95.6	9.	100
Mean	**7.7**	**85.4**	**8.7**	**96.3**	**9.0**	**99.9**	**7.5**	**83.5**	**8.5**	**94.0**	**9.0**	**99.9**	**7.7**	**85.9**	**8.5**	**94.6**	**9.0**	**99.8**	**6.1**	**68.3**	**8.1**	**90.3**	**9.0**	**99.8**

Where: DAA= days after application, SS=score scale (1-9) and PWC=percent weed control (%)

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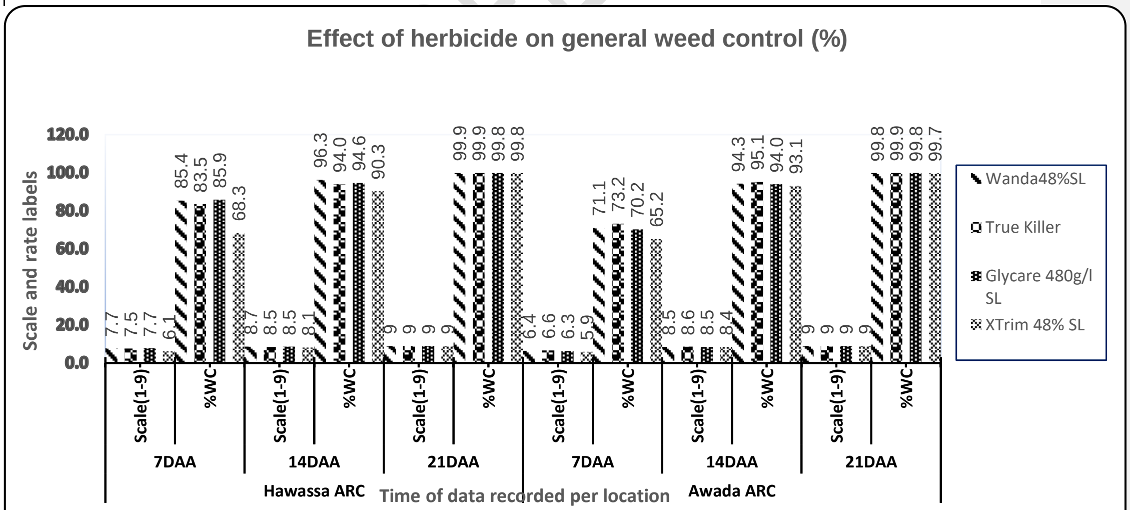
3.4. Effect of Herbicide<u>s</u> on General Weed Control

General weed control was evaluated via visual observation based on a 1-9 scale and percent weed control after 7,14 and 21 days of herbicide application. Accordingly, all test herbicides effectively controlled the annual and perennial broad leaves, grasses, and sedge weeds which predominantly infested the experimental plots across locations. ~~As present herbicide verification observation~~<u>The</u> result showed that herbicide<u>s</u> showed good performance on general weed control compared with weedy check. The weed control percentage ~~range~~ mean value<u>s</u> <u>ranging from</u> 71.1% to 99.9% <u>were</u> obtained from the plots treated with Wanda 48%Sl (Glyphosate 48% g/l SL) ~~herbicide~~ at 7th, 14th, and 21st day ~~evaluation time~~ after herbicide application across locations, which were all most similar~~,~~ with the weed control percentage mean value<u>s</u> ~~65.2% to 99.8%~~ of XTrim 48%SL <u>(65.2% to 99.8%)</u>, ~~70.1% to 99.8% of~~ Gly Care 480g/l SL <u>(70.1% to 99.8%)</u>, and ~~73.2% to 99.9% of~~ True Killer <u>(73.2% to 99.9%)</u>~~were obtained from the plots treated standard check herbicide across location, respectively~~ (Figure 3). The present verification trial result suggested that it has the same efficacy level as a standard check which is in line with the findings of ~~(~~Malkamu ~~F.,~~ <u>(</u>2024) in the Sidama region and ~~(~~Tigist ~~B.~~and Tamiru ~~S.,~~ <u>(</u>2023) ~~done~~ in the Jimma zone ~~in southern and~~



Where ; DAA=days after application; ARC=agricultural research center and WC =weed control

~~southwest Ethiopia for weed control in the coffee farm~~.

Figure 3. Effect of hHerbicides on gGeneral wWeed cControl in at different tTime iIntervals.

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3.5. Effect of Herbicides on Weed Control Efficiency

The tested candidate herbicide recordeddiscovered a 99.85% weed control efficiency mean value, which is almost similar to the average of values 99.75%, 99.8%, and 99.85% obtained from standard check herbicides namely XTrim48%SL, Glycare 480% g/l SL, and True Killer across locations, respectively (Table 8). This result indicates that the test herbicides have has the same weed control efficacy as standard checks, and the farmers can use either one of them depending on the availability of the herbicides for different weed species of sedge, grass, and broadleaf during the active growth stage of the weed in the coffee farms of non-organic producers. This finding agrees with the report of Malkamu F (2024) Verification on verification trial of new herbicides against broad leaf, grass, and sedge of the coffee farm at in Sidama region, Southern Ethiopia, and Firde T and Bidira T (2024) on pre-verification trial of herbicide against weeds in coffee (*Coffea arabica* L.) at Jimma, Southwest Ethiopia.

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Table 8. Herbicides weed control efficiency rate (WCE %).

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Experimental site	Treatment eEvaluation Time per Location of 1m^2 Area at 21 Days After ApplicationDAA over test locations from 1 m^2 area									
	Wanda 48g/l SL		True Killer killer		Gly care 480g/l SL		XTrim 48%SL		Nill (Weedy check)	
	WD	WCE	WD	WCE	WD	WCE	WWD	WCE	WD	WCE
Hawassa ARC on-site	0.12	99.9	0.07	99.9	0.18	99.8	0.25	99.7	9012	-
Awada ARC on-site	0.09	99.8	0.11	99.8	0.13	99.8	0.17	99.8	9105	-
Mean	**0.11**	**99.85**	**0.09**	**99.85**	**0.16**	**99.8**	**0.21**	**99.75**	**9058.5**	**-**

Where WD: weed density; m^2: meter square; WCE: weed control efficiency percentage and ARC: agricultural research center

4. CONCLUSION AND RECOMMENDATION

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The present verification trials of ~~the~~ WANDA 48g/l SL (Glyphosate IPA 48g/l SL**)** revealed promising results in controlling annual and perennial sedge, ~~perennial~~ grasses, ~~perennial~~ broad-leaf weeds~~, annual grass, and annual broad leaf weeds~~ species in coffee (*Coffea arabica* L.). The herbicide effectively reduced the weed density compared with the ~~-~~weedy control. The newly introduced candidate herbicide WANDA 48g/l SL ~~(Glyphosate IPA 48g/l SL)~~ starts weed killing after 5-7 days as compared with standard control herbicides (True killer,~~-~~Gly care 48%g/l SL, and XTrim 48%SL) the same wise and provide full control between 14-21 days after application. The newly tested herbicide was found effective in providing weed-free coffee for a single season with one application per season. ~~-~~This indicated that this herbicide can reduce the weed population equivalent to the standard checks, likewise at a season. ~~Repeated application after a month is not required to achieve full control throughout the season.~~ This indicates that the herbicide has long-lasting effects on weed control in coffee fields.

Therefore, as a ~~-~~weed ~~-~~management option for coffee, if it is financially feasible and accessible to farmers, the new chemical WANDA 48 g/l SL ~~(Glyphosate IPA 48 g/l SL)~~ is advised for use in the farm to minimize the broadleaved, grassy, and sedge ~~weed~~ population ~~of broadleaved, grassy, and sedge weeds~~ that are critical to coffee production. In this case, the weeds are aggressive because of the ~~-~~continuous application of selective herbicides and the resulting development of resistance and inefficiency. Furthermore, most farms in the coffee-potential districts are commercial or adjacent to commercial, making hand weeding inappropriate and challenging during the critical phase of weeding. It is difficult or maybe impossible to provide timely weed management for such large-scale production farms, where hand weeding is expensive, time-consuming, and labor-intensive.

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Thus, it is very wise to recommend the herbicide WANDA 48g/l SL (Glyphosate IPA 48g/l SL**)** as an alternative ~~herbicide~~ for use against major post-emergency annual and perennial broadleaved, grass, and sedge weeds in the current study area ~~of coffee growing~~ and similar agro-ecologies of non-organic-coffee-producers.

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DISCLAIMER (ARTIFICIAL INTELLIGENCE) Author(s)

Hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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