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Evaluating Herbicides Efficacy Against Coffee Weeds in Southwest Ethiopia

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Abstract: Weed is the major limiting factor of coffee production in Ethiopia. Weeds in coffee causes 65% yield reduction in the country. Now a day, the expensiveness of weed management has been a principle issue in economic analysis of coffee production in Ethiopia. Herbicide is a best weed management option in coffee production. Thus, newly introduced herbicides verification trial was conducted in Jimma Agricultural Research Center, Agaro and Gera sub center on station in 2020 cropping season to evaluate the efficacy of newly introduced herbicides. The experiment consists six (6) treatments viz., famphosate 480G/L, Goal 200 SL, Zap weeds 200 SL, Bastnate 200 SL, Dat-phosate 41% as standard check and weedy control as negative control. The herbicides effectively reduced weed density and provide good weed control efficiency compared with weedy control. Among tested herbicides Goal 200SL, Zap weed 200Sl and Bastnate 200 SL have been showed gradual performance declination on weed control as compared with standard control herbicide. This result suggested that repeated application after a month is mandatory to achieve full control throughout season equivalent with standard control herbicide. Therefore, Famphosate 480g/l at 4.1 L/ha within 300 L/ha water with one time application per season, and Goal 200SL at 2.25 L/ha with 225L/ha water volume, Zap weed 200SL at 3 L/ha with 200 L/ha water and Bastnate 200 SL at 1 L/ha with in 300L/ha water after a month of first application recommended to control weeds in coffee. According to this study, although all the evaluated herbicides can control coffee weeds, but, the duration of their control is different. Some of them were control weed species within 7 to 21 days; others may stay and become months later.

Keywords: Coffea arabica, Famphosate 480g/L, Goal 200 SL, Bastnate 200 SL, Dat-phosate 41%

1. Introduction

Coffee (*Coffea arabica* L.) is the backbone of the country's economy, which is the second major traded commodity following to Oil both in terms of volume and values [1] and thus plays a vital role in the balancing of trade between developed and developing countries. It accounts 70% of the foreign exchange earning, 10% of the government revenue and provides about 25% income for Ethiopia's population [2, 3]. Arabica coffee is the most widely consumed, dominating over 70% in volume of production and over 90% of trade value globally [4]. Coffee is deep-rooted in both the economy and culture of the country. Arabica Coffee is the major export crop in Ethiopia and its contribution to the national economy is tremendous. It is the leading commodity in Ethiopia's industry and foreign exchange earner from which millions of workers and growers derive their livelihood. Coffee production is affected by various constraints such as weed management, periodic pest and diseases, diminishing of soil capacity and adverse weather condition. Weeds are among the major factors limiting coffee production in the country. Weeds in coffee have been reported to reduce yield by 65% and can cause complete crop failure depending on the type of weeds, growth stage of coffee trees and the prevailing growth conditions [5].

Despite, majority of coffee farmers heavily depend on manual slashing and digging which encourage the multiplication and spread of the noxious competitive perennial weeds [6, 7]. Currently, expensiveness of weed management has been a principle issue in economic

analysis of coffee production particularly in large scale farm in Ethiopia. This is because of the weed species those are found as dominant and prevalent in the areas where they favorably and quickly re-appear within the season. Hence, uses of effective systemic herbicides for controlling deep seated rhizomes, bulbs and tubers and above ground running stolen of the perennial sedge and grass weeds is vital. Under such circumstance evaluation different herbicides with different groups & mode of action is essential. Herbicide an essential part of weed management practice in coffee production at Southwest Ethiopia, It also can offer an advantage of taking less time, demanding less labour and avoid potential of diseases spread that causes during manual slashing and digging weed management practices. Previously, several systemic herbicides have been evaluated by Jimma Agricultural Research Center. And recommended Tigist and Tadasse [8] However, since, coffee production be come expanded yet now there is scarcity of systemic herbicides to reduce losses caused due to weed infestation. Having above mentioned points the studies was conducted following Pesticide Testing guidelines developed by Ethiopian Institute of Agricultural Research (EIAR) to evaluate the efficacy of newly introduced herbicides such as (Famphosate 480G/L, Goal 200 SL, Zap weed 200 SL and Bastnate 200 SL herbicide comparing with already registered herbicide Dat-phosate 41% as standard control for control perennial grasses, perennial broad leaves and annual grasses and broad leaves weeds in Coffee at Jimma Southwest, Ethiopia.

2. Materials and Methods

2.1. Descriptions of the Study Area

The study was conducted at Jimma Agricultural Research Center (JARC/Melko). JARC is found in Oromiya regional state in Jimma zone, Ethiopia, 360 km to southwest of Addis Ababa. It is located at 07°46''N latitude and 36°47'E longitude with an elevation of 1753 meter above sea level (masl) receiving average annual rainfall of 1572mm. The area experience has mean daily minimum and maximum temperature of 11.6°C and 26.3°C, respectively. The major soil type of the center is chromic nitosol and cambiosl of upland and fluvisol of bottom land [9]. Similarly, the study was conducted at Gomma (Agaro) and Gera districts of Jimma zone in southwestern Ethiopia (7°37′–7° 56′N and 36°13′–36° 39′E). The area receives an annual rainfall in the range of 1480 to 2150 mm, with the main rainy season between June and September. Mean daily minimum and maximum temperatures are 12°C and 28°C, respectively.

2.2. Experimental Materials and Procedure

Five herbicides and weedy control plot were used as treatment during conducting the study. the experiment consists six (6) treatments such as famphosate 480G/L (4.1 Lit ha^{-1}), Goal 200 SL (3.3 Lit ha^{-1}), Zap weeds 200 SL (3.0 Lit ha^{-1}), Bastnate 200 SL (1.0Lit /ha), Dat-phosate 41% (3.0 Lit ha^{-1}) (Table 1). The trial was laid down on naturally infested fields where the noxious perennial grasses, perennial broad leaf weeds perennial sedge and annual broad leaf weeds were abundantly growing on 10m × 15m plot size.

Table 1. *Description of tested herbicides.*

Trade Name	Common Name (active ingredient)	Application Rate (Liter ha^{-1})	
		Herbicide	Water Volume
Famphosate 480g/l	Glyphosate 41% SL	4.1	300
Goal 200 SL	L- Glufosinate -ammonium 20% SL	2.25	225
Zap Weed 200 SL	Glufosinate -Ammonium 200g/L SL	3.0	200
Bastnate 200 SL	Glufosinate-ammonium 200G/L SL	1.0	300
Dat-phosate 41%	Glyphosate 41%	3.0	250
Weedy control	-	-	-

Different weed data were collected as per planned. Number of weeds physiologically dead, total days of physiological death, chlorosis and necrosis of each weed species, general weed control evaluated based on 1-9 scale where 1= no control and 9 = 100% control, individual and general weed control were determined by visual observation at the 7^{th}, 14^{th} and 30^{th} days interval after treatment (herbicide) application based on symptoms such as wilting, stunting chlorosis, necrosis and total death of herbicide sprayed plots compared with not-sprayed (weedy check) plot [10]. On the other hand, to determine the weed density weeds were counted by throwing the 1m × 1m quadrant three times on each plots before herbicide spraying and average number of weeds counted from three qudrate and mean number of weeds per three was used at the end. The weeds were categorized as broad leaves weeds, sedge and grass weeds based on their leaf morphological characteristics. This was the way of determining weed density of the crop and efficiency of herbicides to control weeds. Similarly, the herbicide weed control efficiency (WCE) can be calculated by using the following formula as suggested by [11]. Percentage of Weed inhibition (PWI) was calculated using the following formula.

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

Where, NWC &NWT are number of weeds (m^2) in the weedy check and any particular treatment, respectively. Individual and general weed control evaluations (1-9 scale score), 1= no control and 9= (100% control) were determined through visual observation at 7^{th}, 14^{th} and 30^{th} days' after treatment application by considering growth reduction, foliar chlorosis, wilting and stunting during the time of assessment.

Weed Control Efficiency (WCE) and Weed dry weight was calculated based on the following formula Thakra *et al* [12]. and Surinder [13].

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

OR

$$\text{WCE} = \frac{\text{DMC} - \text{DMT}}{\text{DMC}} * 100$$

Where DMC- Dry matter of weeds in control (un treated) plot, DMT- Dry matter of weeds in a treatment after 30 days of treatment by harvesting all weeds within 1m × 1m quadrant area at ground level three times per plot [14].

3. Results and Discussion

3.1. Weed Infestation in Terms of Taxonomy

In the experimental was conducted under field in different weed species belonging to the annual broad leaf, grasses and sedge and perennial broad leaf, sedge, and grass categories were identified. Twenty-three (23) weed species belonging to twelve (12) families were recorded within the experimental fields across locations. Among the recorded species 8.70% sedge, 26.10%, grass and 65.23% were broad leaved weed species, respectively. This result is consistent with Surinder, [13] conclusion that these are the major weed species that are prevalent growing (infected) in coffee crops. Similarly, in terms of their life cycles 43.48% perennial, 52.17% annual and 4.35% were biennial weed recorded from the experimental fields (Table 2). This result is in line with Tadesse and Tesfu who characterize and reported the major weeds species growing abundantly in coffee [15] As study result showed number of perennial grasses is greater than annual grasses whereas annual broad leaved were more prevalent than perennial and biennial broadleaved species across sites.

Table 2. *Taxonomy of weed species observed in the experimental site across locations.*

Scientific Name	Family	Common Name	Life cycle	Morphology
Cyperus cyperiodes		Small flower ubrela sedge	Perennial	sedge
Cyperus rotundus		Purple nut sedge	Perennial	sedge
Digitarai abyssinica		African coach grass	Perennial	Grass
Echinocloa colona	Poaceace	Jungle rice	Perennial	Grass
Paspalum comjugatum		Bufallo grass	Perennial	Grass
Snowdenia polystachya		Ethiopian grass	Annual	Grass
Cynodon dactylon		Star grass	Perennial	Grass
Bracharia mutica		Para grass	annual	Grass
Hydrocotyle Americana	Apiaceae	Indian pennywort	Perennial	Broadleaf
Commelina benghalensis	Commelinaceae	Tropical spiderwort	perennial	Broad leaf
Ageratum conyzoides		Goat weed	Annual	Broad leaf
Bidens pilosa	Asteraceae	Black jack	Annual	Broad leaf
Galinsoga parviflora		Gallant soldier/ potato weed	Annual	Broad leaf
Conyza albida		Asthma weed	Annual	Broad leaf
Alternantherra caracasana	Amarathaceae	Paper thorn	Perennial	Broad leaf
Capsella bursa-pastoris	Brassicaceae	shepherd's purse	Annual	Broad leaf
Brassica tournefortii		African mustard	Annual	Broad leaf
Plantago lanciolata	Plantagnaceae	Narrow leaf plantain	Annual	Broad leaf
Portulaca oleracea	Portulacaceae	duckweed	Annual	Broad lead
Cynoglossum lanceolatum	Boraginaceae	Hounds tongue	Biennial	Broad leaf
Galium aparinae	Rubiaceae	Cleavers/bed straw/ catch weed	Annual	Broad leaf
Polygonum arvensis	Polygonaceae	Knot weed and knot grass	Perennial	Broad leaf
Trifolium repens	fabaceae	Clover /trefoil	Annual	Broad leaf

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

Weed density and percentage of weed reduction data after herbicides application presented in (Table 2). Current verification trial result indicated that weed density has been affected due to herbicides application. All herbicides; Goal 200 SL; Zap weed, 200 SL and Bastnate 200 SL effectively reduced the weed density as compared with weed check (Table 3). However, the levels of reduction vary with experimental plots based on herbicides characteristics. Variation in weed density was due to varying mode of action of herbicides. Among four tested herbicides famphosate 480g/l herbicide is non-selective systemic herbicide whereas the rest three herbicides namely: Goal 200 SL; Zap weed, 200 SL and Bastnate 200 SL are non-selective, partially systemic and contact which showed chlorosis and wilting of weeds within 3-7 days quicker than famphosate 480g/l and Dat- phosate standard check herbicide.

The lower weed density mean value 9.67 followed by 17.67, 28.33 and 51.67 per m^2 was recorded from the plot treated with Famphosate 480g/l Goal 200SL, Zap weed 200Sl and Bastnate 200 SL respectively at 30^{th} day evaluation time after herbicide application across locations compared with weedy control while the highest weed population mean value ($543/m^2$) was recorded in the weedy check plots (Table 3). Different results on percentage of weed inhibition (PWI) or percentage of weed reduction (PWR) was also recorded in the present verification trials. As

a result indicated weed reduction percentage mean value ranged from 39.46% - 98.14%, 37.12% - 96.20%, 42.97% - 94.23% and 56.95%- 90.71% were obtained from plots treat with Famphosate 480g/l Goal 200SL, Zap weed 200Sl and Bastnate 200 SL herbicides respectively as compared with plot treated with Dat-phosate 41% standard check herbicide which revealed the highest weed reduction percentage which ranged from (37.73% - 98.40%) (Table 3). All tested herbicides performed well on weed density reduction and weed reduction percentage compared with untreated plot.

Table 3. *Effect of herbicide on weed population and percentage of weed reduction.*

Location	Treatment Evaluation time per Locations											
	Famphosate 480g/l				Goal 200 SL				Zap Weed 200SL			
	BA	at 7th	at 14th	at 30th	BA	at 7th	at 14th	at 30th	BA	at 7th	at 14th	at 30th
Jimma	478	317	111	10	526	329	83	21	509	292	67	29
Agaro	444	309	98	6	439	218	69	13	439	221	59	22
Gera	477	319	113	13	525	327	81	19	525	327	71	34
Mean	466	315	107	10	497	291	78	18	491	280	66	28

Table 3. *Continued.*

Location	Treatment Evaluation time per Locations											
	Bastnate 200 SL				Dat-Phosate 41%				Weedy Control			
	BA	At 7th	at 14th	at 30th	BA	at 7th	at 14th	at 30th	BA	at 7th	at 14th	at 30th
Jimma	488	223	73	60	515	278	73	15	518	608	613	543
Agaro	461	211	43	27	368	213	67	12	425	448	461	457
Gera	497	239	79	68	414	283	117	22	573	588	593	561
Mean	482	224	65	52	432	258	86	16	505	548	556	520

3.3. Effect of Herbicide on General Weed Control

General weed control was evaluated via visual observation based on 1-9 scale and percent weed control after 14 and 30 days of herbicides application. Accordingly all testes 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 result showed that all herbicides showed good performances on general weed control compared with standard control herbicide. The test herbicides showed different performance on weed control. The weed control percentage range mean value (57.41% to 92.59%, 77.80% - 94.45%, 73.15% - 78.70% and 75% - 72.22%) obtained from the plots treated with Famphosate 480g/l Goal 200SL, Zap weed 200Sl and Bastnate 200 SL herbicides respectively at 14th and 30th day evaluation time after herbicide application across locations which were to some extent similar with the weed control percentage mean value (64.83% to 94.45%) obtained from the plots treated with Dat-phosate 41% standard check herbicide at fourteen and thirty days after herbicide application, respectively (Table 4). The present verification trial result suggested that except Famphosate 480g/l the rest three herbicides showed gradual performance declination on weed control as compared with standard control herbicide. This might be because of the fact that those herbicides have partial systemic and contact mode of action and unlike standard control herbicide its active ingredient has short persistence in the soil (short persistence).

Table 4. *Mean Effect of Herbicides on General Weed Control.*

Location	Treatment Evaluation time per Locations											
	Famphosate 480g/l				Goal 200 SL				Zap Weed 200SL			
	at 14th		at 30th		At 14th		at 30th		at 14th		at 30th	
	Scale score (1-9)	%WC	Scale score (1-9)	%WC	Scale score (1-9)	%WC	Scale score (1-9)	%WC	Scale score (1-9)	%WC	Scale score (1-9)	%WC
Jimma	5.0	55.56	8.0	88.90	7.0	77.80	8.5	94.44	6.5	72.22	7.0	77.78
Agaro	5.5	61.11	8.5	94.44	7.5	83.33	9.0	100.0	7.3	80.6	7.5	83.3
Gera	5.0	55.56	8.5	94.44	6.5	72.22	8.5	88.90	6.0	66.67	6.75	75.00
Mean	5.17	57.41	8.33	92.59	7.00	77.78	8.67	94.45	6.60	73.16	7.08	78.70

Table 4. *Continued.*

Location	Treatment Evaluation time per Locations							
	Bastnate 200 SL				Dat-Phosate 41%			
	at 14th		at 30th		at 14th		at 30th	
	Scale score (1-9)	%WC	Scale score (1-9)	%WC	Scale score (1-9)	%WC	Scale score (1-9)	%WC
Jimma	6.75	75.0	6.0	66.67	5.0	55.56	8.0	88.90
Agaro	7.0	77.78	7.0	77.78	6.0	66.67	8.5	94.44
Gera	6.5	72.22	6.5	72.22	6.5	72.22	9.0	100
Mean	6.75	75	6.50	72.22	5.83	64.82	8.50	94.45

3.4. Effect of Herbicides on Individual Weed Species

The effect of the tested herbicides on individual weed species was presented in (Tables 5, 6, 7, & 8). The present herbicides verification result showed that the tested herbicides provide good control of perennial grasses, perennial broad leaf weeds and perennial sedge, biennial broad leaf and the annual broad leaf weeds within different rage of time based on herbicide nature and mode of actions. Accordingly among tested herbicides Famphosate 480g/l showed weed growth retardation, foliar cholrosis, wilting and stand reduction symptoms on all weed species found in the experimental plots between 7-14 days after herbicide application and provide full control of all weed species found in experimental plot between 21- 30 days after herbicide application which relatively similar with Dat-phosate 41% (standard check) herbicide across locations. Similarly Goal 200SL, Zap weed 200Sl and Bastnate 200 SL herbicides earlier showed growth retardation, foliar chlorosis, wilting and stand performance reduction symptoms on all weed species found in the experimental plots between 3-7, 3-5 and 3-7 days respectively and showed necrosis and full control of some weed species within at three (3) weeks after herbicide application (Tables, 5, 6, 7 & 8). The test herbicides revealed percentage of weed control mean value ranged from 63.74- 94.40%, 65.23-91.30%, 65.40-87.50% and 79.86-73.09% over weedy control and relatively similar with Dat-phosate 41% across locations (Table 8) However after 3 Weeks of herbicides application, some weed species like: *Plantago lanciolata, Hydrocotyle americana, Cynodon dactylon., Portulaca oleracea, Alternantherra caracasana,* and *Trifolium repens were* re-generated within the plots treated with Goal 200SL, Zap weed 200Sl and Bastnate 200 SL herbicides with the same manner at all location.

This indicated that the herbicides haven't long lasting pronounced effect to control re-generation of some weed species after a period of almost one month. This might be because these herbicides have short persistence in the soil, partially systemic and have contact mode of action. This current study result in lines with Asghar et, al. who reported that highest parthenium weed populations of regenerated observed in plots treated with sodium chloride solution and paraquat treated plots. [16]

For these specific characteristics tested herbicides did not provide full season weed control compared standard control herbicide while on the contrary other weed species like: *Snowdenia polystachya, Cyperus spp., Digitaria abyssinica, Commelina spp., Bidens spp., Ageratum spp*., *Bracharia mutica, Echinochloa colona, Bracharia mutica, Galinsoga parviflora*, *Conizia spp., brassica taurnefortii.* Capsella bursa, *Galium aparinae, Polygonum arvensis* and *Amaranthus* were effectively controlled by tested herbicides. As these result indicated that repeated application after a month is required to achieve complete control compared with Dat-Phosate 41% standard control herbicide.

Table 5. *Mean effect of Famphosate 480g/l herbicide on individual weed control over locations.*

Weed Species	Treatment Evaluation Time							
	Famphosate 480g/l				Dat-Phosate 41%			
	at 14th Day		at 30 th Day		at 14th Day		at 30th Day	
	Score (1-9)	% WC	Score (1-9)	% WC	Score (1-9)	% WC	Score (1-9)	% WC
Cyperus cyperiodes	5.5	61.11	8.0	88.89	5.0	55.56	8.0	88.89
Digitarai abyssinica	6.0	66.67	8.5	94.44	5.5	61.11	9.0	100.00
Echinocloa colona	5.5	61.11	8.5	94.44	6.0	66.67	8.5	94.44
Paspalum comjugatum	5.5	61.11	8.5	94.44	5.5	61.11	8.5	94.44
Cynodon dactylon	5.0	55.56	8.0	88.89	5.5	61.11	8.0	88.89
Hydrocotyle Americana	5.0	55.56	8.0	88.89	6.0	66.67	8.5	94.44
Commelina benghalensis	5.0	55.56	8.0	88.89	5.5	61.11	8.0	88.89
Ageratum conyzoides	6.0	66.67	9.0	100.00	6.0	66.67	9.0	100.00
Bidens pilosa	6.5	72.22	9.0	100.00	6.0	66.67	9.0	100.00
Galinsoga parviflora	6.5	72.22	9.0	100.00	6.0	66.67	9.0	100.00
Conyza albida	6.5	72.22	9.0	100.00	6.0	66.67	9.0	100.00
Alternantherra caracasana	6.5	72.22	8.5	94.44	6.0	66.67	8.0	88.89
Brassica tournefortii	6.0	66.67	9.0	100.00	6.0	66.67	9.0	100.00
Plantago lanciolata	5.0	55.56	8.0	88.89	5.5	61.11	8.0	88.89
Bracharia mutica	6.0	66.67	8.0	88.90	5.5	61.11	8.5	94.44
Portulaca oleracea	5.0	55.56	8.5	94.44	5.5	61.11	8.5	94.44
Cynoglossum lanceolatum	6.5	72.22	9.0	100.00	6.5	72.22	9.0	100.00
Polygonumarvensis	6.0	66.67	9.0	100.00	6.0	66.67	9.0	100.00
Trifolium repens	5.0	55.56	8.0	88.89	5.0	55.56	8.0	88.89
Mean		63.74		94.4		63.74		95.03

Table 6. *Mean effect of Goal 200 SL herbicide on individual weed control over locations.*

Weed Species	Treatment Evaluation Time							
	Goal 200 SL				Dat-Phosate 41%			
	at 14th Day		at 30th Day		at 14th Day		at 30th Day	
	Score (1-9)	% WC	Score (1-9)	% WC	Score (1-9)	% WC	Score (1-9)	% WC
Cyperus cyperiodes	6.0	66.67	8.5	94.44	5.0	55.56	8.5	94.44
Cyperus rotundus	6.0	66.67	8.5	94.44	5.5	61.11	8.5	94.44
Cyperus erecta	5.5	61.11	8.0	88.90	5.0	55.56	9.0	100.00
Digitarai abyssinica	5.5	61.11	9.0	100.0	5.5	61.11	9.0	100.00
Echinocloa colona	6.0	66.67	9.0	100.0	6.0	66.67	9.0	100.00
Paspalum comjugatum	5.0	55.56	9.0	100.0	6.5	72.22	8.5	94.44
Cynodon dactylon	6.0	66.67	7.0	77.78	5.0	55.56	8.5	94.44
Hydrocotyle Americana	5.0	55.56	7.5	83.33	6.0	66.67	8.0	88.89
Commelina benghalensis	5.5	61.11	8.5	94.44	5.5	61.11	8.0	88.89
Ageratum conyzoides	6.5	72.22	9.0	100.0	6.0	66.67	9.0	100.00
Bidens pilosa	6.5	72.22	9.0	100.0	6.0	66.67	9.0	100.00
Galinsoga parviflora	6.0	66.67	9.0	100.0	6.5	72.22	9.0	100.00
Conyza albida	7.0	77.78	9.0	100.0	6.0	66.67	9.0	100.00
Alternantherra caracasana	6.0	66.67	8.0	88.90	5.5	61.11	8.0	88.89
Capsella bursa-pastoris	6.5	72.22	8.5	94.44	6.0	66.67	8.5	94.44
Brassica tournefortii	6.0	66.67	9.0	100.0	7.0	77.78	9.0	100.00
Plantago lanciolata	5.0	55.56	7.0	77.78	5.0	55.56	8.5	94.44
Portulaca oleracea	5.5	61.11	7.5	83.33	5.5	61.11	7.5	83.33
Cynoglossum lanceolatum	7.0	77.78	9.0	100.0	6.5	72.22	9.0	100.00
Galium aparinae	5.5	61.11	6.5	72.22	6.0	50.0	8.0	88.89
Polygonum *arvensis*	6.5	72.22	8.5	94.44	7.0	77.78	9.0	100.00
Bracharia mutica	6.0	66.67	8.0	88.90	5.5	61.11	8.5	94.44
Trifolium repens	4.5	50.0	6.0	66.67	4.0	44.44	8.0	88.89
Mean		65.23		91.30		63.29		95.17

Table 7. *Mean effect of Zap weed 200 SL herbicide on individual weed control over locations.*

Weed Species	Treatment Evaluation Time							
	Zap weed 200 SL				Dat-Phosate 41%			
	at 14th Day		at 30th Day		at 14th Day		at 30th Day	
	Score (1-9)	% WC	Score (1-9)	% WC	Score (1-9)	% WC	Score (1-9)	% WC
Cyperus cyperiodes	6.0	66.67	8.0	88.89	5.0	55.56	8.0	88.89
Cyperus rotundus	6.25	69.44	7.75	86.11	5.5	61.11	8.5	94.44
Cyperus erecta	6.0	66.67	8.0	88.89	5.0	55.56	8.0	88.89
Digitarai abyssinica	6.5	72.22	8.5	94.44	5.75	63.89	8.5	94.44
Echinocloa colona	6.0	66.67	80.	88.89	6.0	66.67	9.0	100.00
Paspalum comjugatum	5.5	61.11	7.25	80.56	6.0	66.67	8.5	94.44
Cynodon dactylon	6.0	66.67	8.0	88.89	5.0	55.56	8.5	94.44
Hydrocotyle Americana	5.0	55.56	7.0	77.78	6.0	66.67	8.0	88.89
Commelina benghalensis	5.5	61.11	7.0	77.78	5.5	61.11	8.0	88.89
Ageratum conyzoides	6.0	66.67	9.0	100.00	6.0	66.67	9.0	100.00
Bidens pilosa	6.75	75.00	9.0	100.00	6.0	66.67	9.0	100.00
Galinsoga parviflora	6.5	72.22	9.0	100.00	6.0	66.67	9.0	100.00
Conyza albida	7.0	77.78	9.0	100.00	6.0	66.67	9.0	100.00
Alternantherra caracasana	5.0	55.56	7.0	77.78	5.0	55.56	8.0	88.89
Capsella bursa-pastoris	6.5	72.22	8.5	94.44	6.0	66.67	8.5	94.44
Brassica tournefortii	6.25	69.44	9.0	100.00	6.5	72.22	9.0	100.00
Plantago lanciolata	5.0	55.56	6.75	75.00	5.0	55.56	8.5	94.44
Portulaca oleracea	5.5	61.11	7.0	77.78	5.5	61.11	7.5	83.33
Cynoglossum lanceolatum	6.75	75.00	9.0	100.00	6.5	72.22	9.0	100.00
Galium aparinae	4.5	50.00	6.0	66.67	5.5	61.11	8.0	88.89
Polygonum *arvensis*	6.5	72.22	8.5	94.44	6.5	72.22	9.0	100.00
Trifolium repens	4.5	50.00	6.0	66.67	5.0	55.56	8.0	88.89
Mean	5.89	65.40	7.88	87.50	5.69	63.26	8.48	94.19

Table 8. *Mean effect of Bastnate 200 SL herbicide on individual weed control over locations.*

Weed Species	Treatment Evaluation Time							
	Bastnate 200 SL				Dat-Phosate 41%			
	at 14th Day		at 30th Day		at 14th Day		at 30th Day	
	Score (1-9)	% WC	Score (1-9)	% WC	Score (1-9)	% WC	Score (1-9)	% WC
Cyperus cyperiodes	6.75	75.00	7.25	80.56	5.0	55.56	8.0	88.89
Digitarai abyssinica	7.5	83.33	8.75	97.22	5.5	61.11	9.0	100.00
Echinocloa colona	7.0	77.78	8.75	97.22	6.0	66.67	8.5	94.44
Paspalum comjugatum	6.75	75.00	8.5	94.44	5.5	61.11	8.5	94.44
Cynodon dactylon	6.5	72.22	8	88.89	5.5	61.11	8.0	88.89
Hydrocotyle Americana	6.5	72.22	6	66.67	6.0	66.67	8.5	94.44
Bracharia mutica	6.0	66.67	7.5	83.33	5.5	61.11	8.5	94.44
Alternantherra caracasana	5.0	55.56	4.0	44.44	5.5	61.11	8.0	88.89
Capsella bursa-pastoris	7.0	77.78	8.5	94.44	6.0	66.67	8.0	88.89
Brassica tournefortii	6.25	69.44	4.5	50.00	6.5	72.22	9.0	100.00
Commelina benghalensis	7.5	83.33	5	55.56	5.5	61.11	8.0	88.89
Ageratum conyzoides	8.5	94.44	5.5	61.11	6.0	66.67	9.0	100.00
Bidens pilosa	9.0	100.00	8	88.89	6.0	66.67	9.0	100.00
Snowdenia polystachya	6.5	72.22	8.0	88.89	5.5	61.11	8.5	94.44
Galinsoga parviflora	9.0	100.00	7	77.78	6.0	66.67	9.0	100.00
Conyza albida	9.0	100.00	7.5	83.33	6.0	66.67	9.0	100.00
Plantago lanciolata	5.5	55.56	4	44.44	5.5	61.11	8.0	88.89
Portulaca oleracea	5.5	61.11	5	55.56	5.5	61.11	8.5	94.44
Cynoglossum lanceolatum	7.5	83.33	9	100.00	6.5	72.22	9.0	100.00
Polygonum arvensis	7.0	77.78	3	33.33	6.0	66.67	9.0	100.00
Trifolium repens	6.0	66.67	4	44.44	5.0	55.56	8.0	88.89
Mean	7.19	79.86	6.58	73.09		63.89		95.06

3.5. Effect of Herbicide on Weed Biomass and Weed Control Efficiency

The result revealed that herbicide application affected above ground weed biomass and weed control efficiency was high when compared with the weedy control (Table 8). The lowest average mean above ground weed biomass (33.67g /m^2) were recorded from the plot treated with the test herbicide Famphosate 480g/l when compared with the weedy control where 1639.67g /m^2 above ground weed biomass was recorded across locations. This result is in line with Hassan et al. who reported a reduced weed biomass due to use of post emergence herbicides for controlling different weed species in experimental plots [17].

The highest weed control value 98.18% followed by 96.63%, 94.59% obtained from Famphosate 480g/l, Goal 200 SL and Zap Weed 200SL herbicides respectively while 96.90% WCE obtained from standard control herbicide. Famphosate 480g/l herbicide provides better control efficiency than standard check herbicide (Table 9).

Table 9. *Herbicides weed control efficiency (WCE%).*

Location	Treatment Evaluation time per Locations										
	Famphosate 480g/l		Goal 200 SL		Zap Weed 200SL		Bastnate 200 SL		Dat-Phosate 41%		Weedy Control
	Weed density / m^2	WCE (%)	Weed density / m^2	WCE (%)	Weed density / m^2	WCE (%)	Weed density / m^2	WCE (%)	Weed density / m^2	WCE (%)	Weed density / m^2
Jimma	10	98.16	21	96.13	29	94.66	60	88.95	15	97.24	543
Agaro	6	98.69	13	97.16	22	95.19	27	94.09	12	97.37	457
Gera	13	97.68	19	96.61	34	93.94	68	87.88	22	96.08	561
Mean	9.7	98.14	17.7	96.63	28.3	94.59	51.7	90.31	16.3	96.90	520.33

4. Conclusion and Recommendation

The present verification trials of the herbicides revealed promising results on against perennial sedge, perennial grasses, perennial broad leaf weeds and annual broad leaf weeds species in coffee. The herbicides effectively reduced the density compared with weedy control. Among newly introduced herbicides Goal 200SL, Zap weed 200Sl and Bastnate 200 SL have been showed gradual performance declination (i.e. some weed species grown in the plots treated with this herbicides earlier) on weed control as compared with standard control herbicide Dat-phosate 41%. This indicated that these herbicides haven't long lasting pronounced effect to control re-generation of some weed species after a period of almost one month. This indicated that repeated application after a month is required to achieve full control throughout season compared with Dat-Phosate 41% standard control herbicide.

Therefore, Famphosate 480g/l at 4.1 L/ha within 300 L/ha water with one time application preseason, and Goal 200SL at 2.25 L/ha with 225L/ha water volume, Zap weed 200SL at 3 L/ha with 200 L/ha water and Bastnate 200 SL at 1 L/ha with in 300L/ha water volume with once reaped application

after about a month of first application recommended to against weeds in coffee.

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Conflicts of Interest

The authors have no conflict of interest.

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