Journal of Agricultural Sciences and Engineering
J. Agri. Sci. Eng.

Original Article: Effect of weeding method on weed infestation and yield of Aloe vera (Aloe barbadensis Mill.) in Hawassa, Sidama region, South Ethiopia

Banchiamlak Nigussie Tefera*

Ethiopian Institute of Agricultural Research (EIAR), Wendo Genet Agricultural Research Center, Plant Protection Department, Wendo Genet, Ethiopia

Citation Banchiamlak Nigussie. Effect of weeding method on weed infestation and yield of Aloe vera (Aloe barbadensis Mill.) in Hawassa, Sidama region, South Ethiopia, Journal of Agricultural Sciences and Engineering, 2024, 6(1), 8-15.

https://doi.org/10.48309/jase.2024.182860

ARTICLE INFO

Received: 2023-07-18
Accepted: 2023-10-25

Checked for Plagiarism: Yes.

Language Editor:
Fatimah Ramezani

Editor who approved publication:
Dr. Amin Baghizadeh

***Corresponding Author:**
Banchiamlak Nigussie Tefera
(titigonidae@yahoo.com)

Keywords:
Aloe vera, Medicinal plant, Ethiopia, Weeding method, Herbicide, Gel yield.

ABSTRACT

Aloe vera, *Aloe barbadensis* Mill is a highly important and extensively cultivated medicinal plant in the folk medicine and cosmetic industry. Weeds have impact on medicinal plants yield. The effect of weeds on medicinal plants accounted for approximately 45% yield loss. Thus, the aim of this study was to evaluate weeding method for *Aloe vera* plant and to improve the yield of *Aloe vera*. Nine different weeding methods were arranged, including herbicide and weedy check. The experimental trial was laid out in a randomized complete block design with three repetitions at Hawassa location. Data were subjected to analysis of variance. The results recorded 30 weed species belonging to 14 families associated with the *A.vera* plant in Hawassa. The highest weed density was recorded in the Weed-Check plot (WD=5.00). The lowest number of monocot and dicot weeds was recorded in HWH4 (MW=1.33; (DW=0.33). Higher fresh and dry leaf weight were recorded for HWH3 (FLW=165.88g) and HWH4 (DLW=126.32g), respectively**.** Higher gel weight was recorded in HWH3 (GW=227.99g). A significantly lower weed density was recorded when weeds were removed up to 60 DAP at 15 days interval. Therefore, hand weeding and hoeing four times after transplanting *Aloe vera* suckers was the most effective weeding method for *Aloe vera*.

Introduction

Aloe barbadensis belongs to the family Aloeaceae and is one of the specific species among the 400 species of *Aloe vera*. It originates in tropical Africa and is cultivated in Asia, Europe, America, and other countries with warm climates [1]. The name *Aloe vera* derives from the Arabic word "Alloeh" which means, "shining bitter substance" and Vera which means "true" in Latin [2, 3]. *Aloe vera* has succulent leaves arranged in a rosette. It has yellow tube-like flowers that cluster on the stem. The leaves are gray to green and sometimes have white spots on their surfaces. They have sharp, pinkish spines along their edges and are the source of the colorless gel found in many commercial medicinal products. For thousands of years, humans have been using *Aloe vera* in folk medicine for its therapeutic properties, especially on skin. It is first documented use by human dates back to an Egyptian papyrus from 3500 B.C. [4]. *Aloe vera* has been used for vigor, wellness, and medicinal purposes since ancient times in India.

Aloe spp. are used in the production of soap, shampoo, hair wash, toothpaste, and body cream in the cosmetic industry [5]. Many herbal drugs and drinks have been formulated using *A. vera* to maintain good health. The gel from *Aloe vera* has been very effective for the treatment of sores and wounds, skin cancer, skin disease, colds and coughs, constipation, piles, asthma, ulcer, diabetes, and various fungal infections [5, 6, 7, 8]. *Aloe vera* can be separated into latex and gel products. The gel serves as the water and energy storage component of the plant that represents 70-80% by weight of the whole leaf weight [9]. The gel from the leaves of Aloe vera is a common ingredient in many beauty products, as it hydrates and soothes hair and skin. The gel from the leaves of *Aloe vera* is consumed as a juice or tonic that aids digestion.

A weed is any plant grows unnecessarily. Weeds are the most irrelevant plants involved in the utilization of land and water resources, and thus adversely affect human welfare [10].

Weeds affect crop yield depending on the crop type, regions in which they grow, and various biotic and abiotic factors. In general, weeds cause approximately 10% yield loss in poor countries and 25% yield loss in the least developed countries [11, 12]. Weeds play a significant role in harboring insects, serving as alternate hosts for some diseases, and increasing the cost of production [13]. They account for nearly 45% of losses caused by different pests [10].

Apart from weed and insect pests, *Aloe vera* is severely damaged by fungal rust disease at the Wondo Genet Agricultural Research Center. Therefore, this fast-expanding *Aloe vera* industry urgently needs insect pests, diseases, and weed-free production of the plant. Weeds can cause damage to agricultural crops, including medicinal plants. For instance, weeds can create a favorable habitat for the proliferation of other pests, such as arthropods, mites, and pathogens which serves as a host for them. Currently, the yield losses caused by weeds are greater than those from other agricultural pests, such as diseases, insects, and nematodes. Weeds can affect medicinal plants, like other crops, to utilize nutrients, soil moisture, and space that ultimately reduce plants growth, yield, and quality of medicinal products. Therefore, the aim of this study was to evaluate different weed control methods and increase yield for *Aloe vera* plant.

Materials and Methods

Site description

The study was conducted in Green Mark Herbs company site during the 2013 Ethiopian Calendar cropping season in Hawassa city, Ethiopia. Green Mark Herb company site is located at $7^{0}05'$N latitude and $39^{0}29'$E longitude. The altitude of the experimental area was 1,652 m above sea level. The average annual rainfall is 964 mm and average temperature range from 12.94 °C to 27.34 °C.

Experimental treatments, design, and procedures

Aloe vera suckers were raised in polyethylene tubes filled with a 1:2:1 ratio of forest soil, sand, and top soil. After two months of establishment in the nursery, suckers that were disease-free were transplanted in a well-prepared experimental field. An experimental plot was prepared with six rows and plants in each row, with a total 36 plants in the plot. The plant spacing was 60 cm between rows and 60 cm within the plants.

The experimental trial was laid out in an RCB design with nine treatments and three repetions. The total area of the trial was 434 m^2 and each plot size was 3m*3m. The spacing between the plot and block was maintained at 1 m and 2 m, respectively. Nine weeding methods were arranged and used as the experimental treatments. The experimental treatments included five weeding methods (one, two, three, four, and five times hand weeding and hoeing at 15 days interval after planting), pre- and post-emergence herbicide (Butrazine 48% SC) spray, weed-free, and weed-check plots (Table 1).

Table 1. Treatments set up and arrangement

No.	Treatment in detail	Code
T1	Pre emergence herbicide (Butrazine 48% SC)	PreEmHerb
T2	One time hand weeding and hoeing at 15 DAP	HWH1
T3	Two times hand weeding and hoeing at 15, 30 DAP	HWH2
T4	Three times hand weeding and hoeing at 15,30, 45 DAP	HWH3
T5	Four times hand weeding and hoeing at 15,30,45,60 DAP	HWH4
T6	Five times hand weeding and hoeing at 15,30,45,60, 75 DAP	HWH5
T7	Post emergence herbicide (Butrazine 48% SC) at 90 DAP	PostEmHerb
T8	Complete hand weeding and hoeing (Weed free up to harvest)	WeedFree
T9	Weedy check (no weed control)	WeedCheck

DAP= days after planting

Data collection and analysis

Sampling units were taken from the middle four rows to collect yield and yield contributing characteristics such as plant height, branch number, leaf diameter, sucker number, fresh weight, dry weight, and gel weight. A 0.5 m b x 0.5 m quadrat was used on two places randomly in each trial plot to determine the major weed species growing in association with *Aloe vera* plant. Weed density and weed type (monocot and dicot weeds) were separated and counted. The collected weed species were taken to the protection laboratory for further identification using keys, handbooks, and Google image searches. Weed density (WD) data was collected using the following formula: total number of individuals of a species in all quadrates divided by the total number of quadrates used. The collected data were statistically analyzed using SAS software version (9.4) and the mean difference was tested at a significant level of. 5%.

Results and Discussion

Crop data

The present study indicated no significant difference between means of plant height due to weeding control methods. Higher plant height was documented in one-time weeded treatment (PH=28.66 cm), whereas the minimum plant height was recorded in the four times Hand Weeding and Hoeing (PH=24.46 cm). Statistically, the plant height of *Aloe vera* was similar for all weeding times of the treatments. Weed control methods significantly affected the number of *Aloe vera* suckers and branch numbers. The number of suckers was higher in the treatment HWH3 (NS=3.86), whereas the lowest sucker number (NS=0.73) was recorded in weedy check treatment. Branch number was higher in the one-time weeding and hoeing treatments (BN=10.73) and lower in the three-time weeding and hoeing treatments (BN=8.26). The weeding method significantly affected the diameter of *Aloe vera* leaves. The maximum leaf diameter (LD=45.20 cm) was documented in one-time weeded treatment. The minimum leaf diameter (LD=34.86 cm) was recorded both in pre-emergence herbicide and weed-free plots. The fresh and dry leaf weight of *Aloe vera* was significantly affected by weeding methods. The highest fresh weight was obtained in HWH3 (FLW=165.88 g) and the lowest in PreEmHerb (FLW=95.50g), whereas the maximum dry weight was recorded in HWH5 (DLW=126.32 g) and the lowest in HWH1 (DLW=0.00 g). In this weed experimental trial, rust disease incidence was high on *A. vera* plant. Disease incidence data for *A. vera* were highly influenced by the weeding control methods. The maximum disease incidence was recorded on PostEmHerb (DI=9.34) treatment, and the lowest was in PreEmHerb (DI=7.61).

Table 2. Mean performance of weeding method for different agronomic traits

Treatment	PH (cm)	NS	BN	LD (cm)	DLW (gm)	FLW (gm)	DI	GW (gm)
PreEmHerb	25.73	0.933	8.40a	34.86	102.21b	95.50	7.61	131.79
HWH1	28.66	2.80	10.73b	45.20	0a	152.65	9.24	203.61
HWH2	27.45	2.53	9.06ab	41.13	56.40ab	141.19	8.77	208.11
HWH3	27.45	3.86	8.26a	43.60	51.67ab	165.88	9.12	227.99
HWH4	24.46	1.46	9.80ab	38.86	44.60ab	126.03	8.54	184.01
HWH5	27.06	2.80	8.73a	41.66	126.32a	117.85	9.32	184.35
PostEmHerb	27.20	1.46	9.06ab	37.53	94.49ab	120.94	9.34	187.27
WeedFree	25.53	1.60	9.53ab	34.86	102.88b	107.25	9.33	143.42
WeedCheck	26.26	0.73	8.66a	38.66	30.86ab	143.85	9.33	206.87
LSD (5%)	8.21	3.16	1.78	13.572	96.247	81.646	2.3264	121.12
CV	17.8	90.4	1.30	19.80	82.11	36.24	15.00	37.54

PH=plant height, NS=number of suckers, BN=branch number, LD=leaf diameter, DLW=dry leaf weight, FLW =fresh leaf weight, DI=disease incidence, GW=gel weight

Aloe gel weight

The weight of the *Aloe vera* gel was significantly influenced by weeding methods. The highest gel weight was obtained in HWH3 (GW=227.99g) and the minimum was recorded in preEmHerb (GW=131.79g). The current study revealed that the highest gel weight was recorded in the treatment of hand weeding and hoeing three times after transplanting the *Aloe vera* suckers (Table 2).

Previous studies have reported that the essential oil content of unweeded rose-scented geranium and coriander leaves decreases by 20–28.6% [14, 15]. Another study reported that the occurrence of weeds might also alter the chemical essential oil profile of herbs [16]. However, the highest yields of linalool (63.88%) and oxygenated monoterpenes (75.05%) were achieved in the weeded treatment of basil plants [17]. In the present study, the gel weight of the weeded and unweeded treatment plots was (GW=143.42) and (GW=206.87), respectively. The graph indicates that the gel weight of *A. vera* was significantly different among the weeding methods. Hand weeding and hoeing three times, twice, and once showed higher gel weights. The lowest gel weight was recorded in the pre-emergence herbicide and weed-free plots. In contrast, the gel weight in the weedy check plot was higher than the herbicide sprayed treatments (Figure 1).

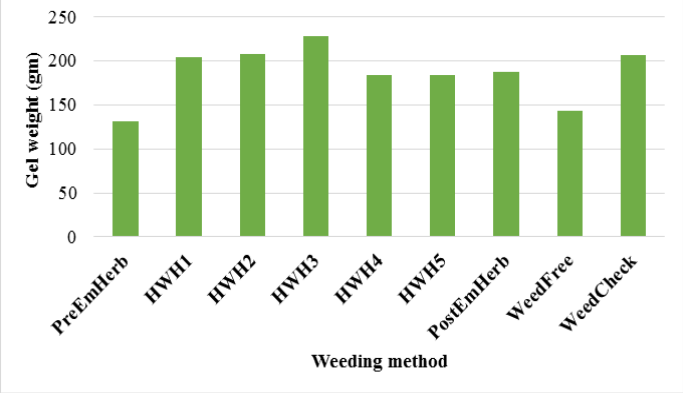

Figure1. Effect of weeding method on gel weight (gm) of *Aloe vera*

Weed data

In the present study, thirty species of weed were recorded in field trial of *Aloe vera* in Hawassa location. Among these, 11 species were monocot weeds and 19 were dicot weeds. The species belong to the following families: Poaceae (6 species), Cyperaceae (4 species), Commelinaceae (1 species), Asteraceae (5 species), Solanaceae (1 species), Primulaceae (1 species), Poaceae (5 species), Amaranthaceae (2 species), Brassicaceae (2 species), Polygonaceae (2 species), Convolvulaceae (1 species), Lamiaceae (1 species), Papaveraceae (2 species), Rubiaceae (1 species), and Scrophulariaceae (1 species) (Table 3).

Weed density

The weed free treatment plot showed maximum weed density (WD=5.00), whereas the minimum weed density was recorded in weedy check plots (WD=0.416), where weeds were not free to compete with the *Aloe vera* plant (Table 4).

Table 3. Weed species recorded in fields of *Aloe vera* experimental trial at Hawassa location

Botanical name	Family
Commelina benghalensis (L.)	Commelinaceae
Bidens Pilosa (L.)	Asteraceae
Cyperus assimilis (Steud)	Cyperaceae
Cynodon nlemfuensis (Vanderyst)	Poaceae
Eragrostis cilianensis (Vignolo ex Janch)	Poaceae
Datura stramonium (L.)	Solanaceae
Anagallis arvensis (L.)	Primulaceae
Cynodon dactylon (L. Pers.)	Poaceae
Galinsoga parviflora (Cav)	Asteraceae
Cyperus esculentus (L.)	Cyperaceae
Amaranthus spinosus (L.)	Amaranthaceae
Cyperus rotundus (L.)	Cyperaceae
Digitaria abyssinica (A.Rich.)	Poaceae
Argemone Mexicana (L.)	Papaveraceae
Cyperus compressus (L.)	Cyperaceae
Dactyloctenium aegyptium (L.)	Poaceae
Achyranthes aspera (L.)	Amaranthacae
Capsella bursa-pastoris (L.)	Brassicaceae
Eruca vesicaria (L.)	Brassicaceae
Glebionis segeta (L.)	Asteraceae
Helminthotheca echioides (L.Holub)	Asteraceae
Sonchus arvensis (L.)	Asteraceae
Convolvulus arvensis (L.)	Convolvulaceae
Lamium amplexicaule (L.)	Lamiaceae
Fumaria officinalis (L.)	Papaveraceae
Phalaris spp (L.)	Poaceae
Polygonum aviculare (L.)	Polygonaceae
Rumex crispus (L.)	Polygonaceae
Galium aparine (L.)	Rubiaceae
Veronica persica (Poir.)	Scrophulariaceae

Table 4. Effect of weeding method on weed species

Treatments	Monocot weeds	Dicot weeds	Weed density
PreEmHerb	10.66	6.00ab	4.166ab
HWH1	5.66	8.00b	3.416ab
HWH2	6.00	8.33b	3.583ab
HWH3	10.00	10.00b	3.833ab
HWH4	1.33	0.33ab	3.083ab
HWH5	5.000	3.00ab	2.000ab
PostEmHerb	11.66	7.66ab	4.833b
WeedFree	7.33	5.00ab	0.416a
WeedCheck	8.00	7.33ab	5.000b
LSD (5%)	10.62	7.56	4.401
CV	84.11	70.64	75.4

The minimum weed density has been reported for linseed crops and black seeds in weeded plots [18]. The weed species count was significantly affected by the weeding method. A higher number of monocot weed species per quadrant was recorded in PostEmHerb (MW=11.66) and the lowest was recorded in HWH4 (MW=1.33). The highest number of dicot weeds per quadrant was recorded in HWH3 (DW=10.00), and the lowest was recorded in HWH4 (DW=0.33). The hand-weeding and hoeing treatments showed a significantly higher number of dicot weeds than the weedy check and other treatments.

Effect of herbicide on weed species

Pre- and post-emergence herbicide application was sprayed during the experimental trial. In the pre-emergence herbicide-treated plots, lower leaf diameter (LD=34.86), lower disease incidence (DI= 7.61), gel weight (GW= 131.79gm), and higher weed density (WD=4.16) were recorded. In the post-emergence herbicide-treated plots, lower leaf diameter (LD=37.53), higher disease incidence (DI= 9.34), gel weight (GW= 187.79gm), and higher weed density (WD=4.16) were recorded. Higher weed density (WD=4.83) was observed. Monocot weeds were more abundant (MW= 11.66) in the herbicide treated plots. The results of this study showed that pre- and post-emergence herbicide application had no significant effect on weed control of *Aloe vera*. This may be due to the dosage of the herbicide, type of weeds, herbicide tolerance, herbicide application time, and so on. Some researchers have reported hand removal of weeds as the most effective method, even though it is time- and labor-consuming [19, 20]. For aromatic and medicinal plants, manual weed management requires at least 200-600 labor per hour and hectares [21]. However, farmers in Mexico allow goats and lambs to graze on weeds, since these animals do not feed on *Aloe vera* plants [22]. The presence of weed species causes variations in the content and quality of active metabolites, and exerts a significant effect on plant metabolic pathways [23]. This author demonstrated that weeding had a greater effect than N fertilization on the biomass and seed yield of coriander under poor soil conditions [24].

Conclusion

Integrated weed management is greatly needed owing to the increase in herbicide-resistant weeds. In the current study, hand weeding and hoeing four times after transplanting *Aloe vera* suckers were the most effective weeding methods for *Aloe vera*. Significantly, a lower number of weed species was obtained when weeds were

removed up to 60 days after planting at 15 days interval. For better gel weight, the *A. vera* weeds should be hand-weed three to four times at 15 days interval. Both the monocot and dicot weed infestation decreased when the crop was hand-weeded four times. Rust was the major problem during the present field experiment. Picking vigorous suckers and healthy planting materials during *Aloe vera* sucker preparation can reduce the rust disease infection in addition to weed management.

Acknowledgements

We are very thankful to EIAR for awarding fund for this research activity. We also acknowledge WGARC for providing a research site to conduct the field experiment. Finally, we thank the field assistance and daily workers during the field experiment.

Conflict of interest

The Author declares no conflict of interest.

Disclosure Statement

No potential conflict of interest was reported by the authors.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors' contributions

Author contributed to research activity proposal writing, and data collection, drafting, and revising of the paper and agreed to be responsible for all the aspects of this work.

Conflict of interest

No conflicts of interest have been declared.

ORCID

Banchiamlak Nigussie Tefera
https://orcid.org/0000-0001-8459-5619

References

1. Harding TB. Aloes of the world: a checklist, index and code, *Aloe, Cactus and Succulent Society of Rhodesia*; 1979.[Google scholar]
2. Gage D. Aloe vera: Nature's soothing healer. Inner Traditions/Bear & Co; 1996. [Crossref], [Google scholar], [Publisher]
3. Surjushe A, Vasani R, Saple DG. Aloe vera: a short review, *Indian journal of dermatology*; 2008; 53(4):163. [Crossref], [Google scholar], [Publisher]
4. Crosswhite FS, Crosswhite CD. Aloe vera, plant symbolism and the threshing floor, *Desert Plants* 6; 1984; 43-50. [Crossref], [Google scholar], [Publisher]
5. Daodu T. Aloe vera, the miracle healing plant. Health Field Corporation, *Lagos*; 2000; 36. [Crossref], [Google scholar], [Publisher]
6. Djeraba A, Quéré P. In vivo macrophage activation in chickens with Acemannan, a complex carbohydrate extracted from Aloe vera, *International journal of immunopharmacology*; 2000 May 1; 22(5):365-72. [Crossref], [Google scholar], [Publisher]
7. Olusegun A. One hundred medicinal uses of Aloe vera. Good health Inc, *Lagos*; 2000; 76. [Google scholar]
8. Davis RH, Maro NP. Aloe vera and gibberellin. Anti-inflammatory activity in diabetes, *Journal of the American Podiatric Medical Association*; 1989 Jan 1; 79(1):24-6. [Google scholar], [Publisher]
9. Boudreau MD, Beland FA. An evaluation of the biological and toxicological properties of Aloe barbadensis (miller), Aloe vera, *Journal of Environmental Science and Health Part C*; 2006 Jul 1; 24(1):103-54. [Crossref], [Google scholar], [Publisher]
10. Rao BR, Rajput DK, Sastry KP, Bhattacharya AK, Patel RP, Ramesh S. Effect of crop-weed mixed distillation on essential oil yield and composition of five aromatic crops, *Journal of Essential Oil Bearing Plants*; 2007 Jan 1; 10(2):127-32. [Crossref], [Google scholar], [Publisher]
11. Akobundu IO. Weed science in the tropics. Principles and practices. John Wiley; 1987. [Google scholar], [Publisher]
12. Tamado T, Milberg P. Weed flora in arable fields of eastern Ethiopia with emphasis on

the occurrence of Parthenium hysterophorus, *Weed Research*; 2000 Dec 5; 40(6):507-21. [Crossref], [Google scholar], [Publisher]
13. Hanson, H., Borlaug N. & Anderson, R.G. (1982). Wheat in the Third World. *West view press*, Inc., Boulder, Colorado. 174. [Crossref], [Google scholar], [Publisher]
14. Kothari SK, Singh CP, Singh K. Weed control in rose-scented geranium (Pelargonium spp), *Pest Management Science: formerly Pesticide Science*; 2002 Dec; 58(12):1254-8. [Crossref], [Google scholar], [Publisher]
15. Pouryousef M, Yousefi AR, Oveisi M, Asadi F. Intercropping of fenugreek as living mulch at different densities for weed suppression in coriander, *Crop Protection*; 2015 Mar 1; 69:60-4. [Crossref], [Google scholar], [Publisher]
16. Rajeswara Rao, B.R., D.K. Rajput, K.P. Sastry, A.K. Bhattacharya, R.P. Patel, and S. Ramesh. 2007. Effect of crop-weed mixed distillation on essential oil yield and composition of five aromatic crops. J Essent Oil Bearing Plants 10(2):127–132. [Crossref], [Google scholar], [Publisher]
17. Sarrou E, Chatzopoulou P, Koutsos TV, Katsiotis S. Herbage yield and essential oil composition of sweet basil (Ocimum basilicum L.) under the influence of different mulching materials and fertilizers, *J Med Plants Stud*; 2016; 4(1):111-7. [Google scholar], [Publisher]
18. Hussain, A, A. Nadeem, I. Ashraf and M. Awan. 2009. Effect of weed competition periods on the growth and yield of black seed (N. sativa L.). Pak. J. Weed Sci. Res. 15(1):71-81. [Google scholar], [Publisher]
19. Carrubba A, Militello M. Nonchemical weeding of medicinal and aromatic plants, *Agronomy for sustainable development*; 2013 Jul; 33:551-61. [Crossref], [Google scholar], [Publisher]
20. Kristiansen P, Sindel B, Jessop R. Agronomic and economic evaluation of weed management methods in organic herb and vegetable production systems. InProceedings of the 11th Australian Agronomy Conference 2003, *CD-ROM. Australian Society of Agronomy*. [Google scholar], [Publisher]
21. Pank F. The influence of chemical weed control on quality characters of medicinal and aromatic plants. InInternational Symposium on Medicinal and Aromatic Plants, *XXIII IHC 306*; 1990 Sep 4: 145-154). [Crossref], [Google scholar], [Publisher]
22. Cristiano G, Murillo-Amador B, De Lucia B. Propagation techniques and agronomic requirements for the cultivation of Barbados aloe (Aloe vera (L.) Burm. F.)—a review, *Frontiers in plant science*; 2016 Sep 23; 7:1410. [Crossref], [Google scholar], [Publisher]
23. Gil A, De La Fuente E, Lenardis A, Ghersa C, Van Baren HC, Di Leo Lira P, Suarez S, López Pereira M. Yield and composition of coriander (Coriandrum sativum L.) essential oils related to soil environment and weed competition. InProc. Annual Conference "New Crops and New Uses: Biodiversity and Sustainability," Phoenix 1998 Nov 8 (pp. 8-11). [Google scholar]
24. de la Fuente EB, Gil A, Lenardis AE, Pereira ML, Suárez SA, Ghersa CM, Grass MY. Response of winter crops differing in grain yield and essential oil production to some agronomic practices and environmental gradient in the Rolling Pampa, Argentina, *Agriculture, ecosystems & environme*nt; 2003 Oct 1; 99(1-3):159-69. [Crossref], [Google scholar], [Publisher]