

Determination of Critical Weed Competition Period for *Stevia rebaudiana* Cultivation

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Abstract

Original Research Article

The experiment was conducted during 2019/2020 at Wondogenet agricultural research center, Sidama region Ethiopia. It was initiated to find a critical weed competition period for *Stevia rebaudiana* production as weed management plays a great role in agriculture. The experiment was arranged in a randomized complete block design (RCBD) and consisted of three replication and fourteen treatments. *Stevia rebaudiana* growth and yield, as well as weed data, were assessed during the experiment and subjected to ANOVA using SAS computer software version 9.3, and differences between means were assessed at 5% probability level. Stevia plant height, branch number, and leaf yield were affected significantly due to treatments effects. Weed-free season treatment showed significantly higher stevia fresh yield (6.1 ton/ha) and dry yield (1.20 ton/ha) which was similar to the significantly higher results of the weedy for fifteen days after transplanting. Variation in the weedy period from fifteen days after transplanting (15DAT) to thirty days after transplanting (30DAT) resulted in 33.27% fresh stevia leaf yield reduction and 44.40% dry stevia leaf yield reduction. Weedy season treatment was used as a check and showed significantly lower stevia leaf yield which was also similar to the results of the weedy period for ninety days after transplanting (90DAT). On the other hand, the weedy period for fifteen days after transplanting (15DAT), the weed-free period for ninety days after transplanting (90DAT), and weed-free season treatments showed similar significantly lower weed density. An increase in the weedy period showed higher weed density and weed biomass results. Therefore, as weeds greatly affect stevia growth and yield, early weeding at 15DAT is important and recommended based on the present finding, however, for comprehensive results the experiment should be repeated over site and year.

Keywords: Stevia, weed-completion, weed-density.

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INTRODUCTION

Stevia (*Stevia rebaudiana* Bertoni) is a small perennial herb that belongs to the Asteraceae family of the genus *Stevia*. *Stevia* is known and grown largely in South and Central America and Asian countries as a natural sweetener (Hossain *et al.*, 2017). *Stevia* is grown best in semi-humid subtropical climatic conditions. Though its stem, seed, and flower are important parts, the main economic part of the stevia plant is the leaf. The leaves are the source of sweet glycosides and have industrial importance. *Stevia* is considered to be the *best alternative* source of sugar especially for diabetes patients (Antonie, 2000). Many medicinal benefits of stevia have been reported so far. For instance, Bhosle (2000) reported as stevia is used to regulate blood pressure induces the pancreas to produce more insulin, and also acts as a bactericidal agent. The main chemical component of stevia is stevioside which is used to improve body energy levels, strengthen the

immune system, stimulate mental activity, and help in withdrawing tobacco and alcohol addiction. *Stevia* growth and yield are governed by many abiotic and biotic factors. Soil type, weed, genotype, temperature, and water are some of the factors. Soil type, weed, genotype, temperature, and water are some of the factors. According to Zaman *et al.*, (2015) stevia yield can be influenced by variation in soil type. In addition, stevia has a poor capacity to compete with weeds during the initial growth period (Ramesh *et al.*, 2006), and weed control practices in stevia production are important to reduce the effects of the weeds that can also make complete yield loss. Taak *et al.*, (2020) stated about a 25% stevia yield penalty due to weed competition. Hence, an appropriate weed control technique is important in order to reduce yield loss and related increases in production costs. In Ethiopia, stevia is a medicinal plant registered in after varietal evaluation over locations and years. However, like

other medicinal plants, the cultivation of stevia is influenced by many factors and it is important to update the necessary production package of a crop plant for growers. Hence, the present study was conducted to determine the critical weed competition period for the stevia plants. According to Zaman *et al.*, (2015) stevia yield can be influenced by variation in soil type. In addition, stevia has a poor capacity to compete with weeds during the initial growth period (Ramesh *et al.*, 2006) and weed control practices in stevia production are important to reduce the effects of the weeds that can also make complete yield loss. Taak *et al.*, (2020) stated about a 25% stevia yield penalty due to weed competition. Hence, an appropriate weed control technique is important to reduce yield loss and related increases in production costs. In Ethiopia, stevia is a medicinal plant registered after varietal evaluation over locations and years. However, like other medicinal plants, the cultivation of stevia is influenced by many factors and it is important to update the necessary production package of a crop plant for growers. Hence, the present study was conducted to find the critical weed competition period for stevia plants cultivation.

MATERIALS AND METHODS

Site Description

The experiment was conducted during 2019/2020 at Wondogenet agricultural research center, Sidama, Ethiopia. It is located 14km from Shashamene town. Wondogenet area is known for bimodal rainfall and the nearby farmers grow mainly sugarcane

(*Saccharum officinarum*), chat (*Catha edulis*), avocado (*Persea americana*), enset (*Ensete ventricosum*), common bean (*Phaseolus vulgaris*), and maize (*Zea mays*) in multiple cropping as well as sole cropping systems.

Experimental Material, Design, and Treatments

Registered stevia (*Stevia rebaudiana* Bertoni) mother plant was used from Wondogenet agricultural research center's aromatic and medicinal plants maintenance site for seedling preparation using cuttings. Seedlings were prepared using a polyethylene tube of 10cm diameter. The seedlings were transplanted on the main field after two months of the field establishment. The experiment was arranged in an RCBD design with three replications. A plot was prepared to have 6 rows and 6 plants in each row and a total of 36 plants. Plant spacing of 50cm between rows and 40cm within plants was used during the experiment. The total experiment area was 819m² and one plot size was 2.4m*3m. Spacing of 1.5meter between the plot and 2meter between blocks were maintained. Fourteen treatments comprised of weed-free or weed interference sets and the other series consisted of allowing weed vegetation to grow for equivalent periods were used during the experiment (Table 1). Fifteen days interval was selected considering the slow growth capability and vegetation coverage of stevia (*Stevia rebaudiana* Bertoni) as compared to some of the fast-growing weeds in the study area.

Table 1: Treatment descriptions (DAT = represent days after transplanting)

Treatment	Description	Treatment	Description
1	Weed free for 15DAT	8	Weedy for 15DAT
2	Weed free for 30DAT	9	Weedy for 30DAT
3	Weed free for 45DAT	10	Weedy for 45DAT
4	Weed free for 60DAT	11	Weedy for 60DAT
5	Weed free for 75DAT	12	Weedy for 75DAT
6	Weed free for 90DAT	13	Weedy for 90DAT
7	weed-infested season long (no weed control)	14	Weed-free season long (no weed infestation);

Data Collection

Data for stevia (*Stevia rebaudiana* Bertoni) plant height (cm), branch number per plant (count), fresh and dry leaf yield per plot were collected and converted to per hectare (ton) for analysis to find the effects of the treatments. Net plot area was considered for weed data collection. Weed density (count/plant) was recorded for each weed species, and then, fresh

aboveground weed weight (g) was collected, recorded, and subjected to oven-dry at 70 °C until a constant weight was achieved (Prasad *et al.*, 2015) and the dry aboveground weight (g) recorded by using a digital balance (model YP20002). Weed density (count), fresh and dry aboveground data were converted to per m² for analysis.

Data Analysis

Data collected were subjected to analysis of variance (ANOVA) using SAS software version 9.3. Differences between means were assessed using the least significance difference (LSD) test at $P < 0.05$.

RESULTS AND DISCUSSION

Stevia (*Stevia rebaudiana* Bertoni) data

Plant height (cm)

Analysis of variance showed that stevia plant height was significantly affected by treatments (Table 2). As weedy (weed infestation period) increased from 45DAT to 60DAT, there was significantly increase in stevia plant height (Table 3) that might be due to competition for resource, such as, sun light as plants grow more in height under shade than open field conditions. It was also statistically similar with resulted obtained at weed infested season treatment.

Table 2: Analysis of variance for yield and yield components of stevia

Means					
Source	DF	PH(cm)	BN(count)	FLYPH(ton)	DLYPH(ton)
REP	2	1.88 ^{NS}	41.17 ^{NS}	1.53 ^{NS}	0.07 ^{NS}
TRT	13	53.00 ^{**}	114.91 ^{***}	6.31 ^{***}	0.31 ^{***}
Error	26	14.75	18.14	0.36	0.02
CV		7.46	22.22	22.29	25.36

NS=not significant; *, **, and *** significant at $P \leq 0.05$, $P \leq 0.01$ and $P \leq 0.001$ probability levels respectively; DF = degree of freedom; REP=replication; TRT=Treatment; CV=Coefficient of variance

Branch number (count/plant)

Analysis of variance showed that stevia branch number per plant was significantly affected by the treatment factor (Table 2). Weed-free period throughout the growing season as well as allowing weed growth only for 15 (fifteen) days after transplanting showed significantly higher branch numbers per plant which, were 33.33 and 30.67 respectively (Table 3). On the other hand, weed-infested season (no weeding, control) treatment showed the lower significant branch number (8.67). The present finding showed the importance of early weeding for the development of stevia plant branches.

Fresh and dry leaf yield per hectare (ton)

Analysis of variance revealed that both fresh and dry leaf yield per hectare was significantly affected

by treatments (Table 2). Both weedy for fifteen days after transplanting (15DAT) and weed-free season treatments showed a higher significant fresh and dry leaf yield per hectare (Table 3). Similar to the result for branch number per plant, weed-infested season resulted in lower significant fresh (1.18) and dry (0.26) leaf yield per hectare (Table 3). Moreover, the treatment weedy for thirty days after transplanting (30 DAT) showed the second significant higher both fresh and dry leaf yield per hectare compared to weedy for 45DAT, 60DAT, 75DAT, and 90DAT treatments for both fresh and dry leaf yield per hectare. Hence, allowing weeds growth for 15 days after transplanting and then removing weeds from the field throughout the growing period is recommended for stevia growers under similar agro-ecology with the present study.

Table 3: Mean performance of stevia yield and yield components

Treatment	PH (cm)	BN (count/plant)	FLYPH(ton)	DLYPH(ton)
1. Weed free for 15DAT	51.00 ^{bcd}	15.33 ^{bc}	1.40 ^{de}	0.32 ^{de}
2. Weed free for 30DAT	54.00 ^{abc}	16.33 ^b	1.33 ^{de}	0.34 ^{de}
3. Weed free for 45DAT	54.00 ^{abc}	17.33 ^b	1.50 ^{de}	0.34 ^{de}
4. Weed free for 60DAT	51.33 ^{bcd}	17.33 ^b	1.17 ^{cde}	0.37 ^{cde}
5. Weed free for 75DAT	48.33 ^{cd}	18.67 ^b	2.3 ^{cd}	0.51 ^{cd}
6. Weed free for 90DAT	45.00 ^d	20.00 ^b	2.57 ^c	0.59 ^c
7. Weed-infested season	55.33 ^{ab}	8.67 ^c	1.12 ^e	0.26 ^e
8. Weedy for 15DAT	47.67 ^{cd}	30.67 ^a	5.65 ^a	1.20 ^a
9. Weedy for 30DAT	49.67 ^{bcd}	21.33 ^b	3.77 ^b	0.83 ^b
10. Weedy for 45DAT	47.33 ^d	19.33 ^b	1.75 ^{cde}	0.43 ^{cde}
11. Weedy for 60DAT	59.00 ^a	16.67 ^b	1.58 ^{de}	0.35 ^{de}
12. Weedy for 75DAT	56.00 ^{ab}	17.33 ^b	1.3 ^{de}	0.29 ^{de}
13. Weedy for 90DAT	55.33 ^{ab}	16.00 ^b	1.23 ^e	0.27 ^e
14. Weed-free season	46.68 ^d	33.33 ^a	6.10 ^a	1.21 ^a
LSD	6.45	7.15	1.00	0.22
CV	7.46	22.22	22.29	25.36

Column followed by the same letter is not significantly different at $P \leq 5\%$ level of significance.

Weed data

Weed density (plant/m²) was recorded during the experimental period by counting plants of each weed species observed in the net area of each plot and by converting the observed total number of weeds per

net area of each plot to m² for analysis. Eleven weed species were identified, among which broadleaf weeds were dominated (72.72%) followed by grass leaf weeds (18.18%) and sedges (9.09) (Figure 1).

Table 4: Analyses of variance for weed density and above ground weed biomass

Mean Values				
Source	DF	Weed Density (Plant/M ²)	Fresh weed Biomass per M ² (g)	Dry Weed Biomass per M ² (g)
REP	2	10.38 ^{NS}	5511.19 [*]	344.45 [*]
TRT	13	28.04 [*]	15058.33 ^{***}	941.14 ^{***}
Error	26	11.64	1128.40	70.52
CV		44.77	19.53	26.12

NS=not significant; *, **, and *** significant at P<0.05, P<0.01 and P<0.001 probability levels respectively; DF = degree of freedom; REP=replication; TRT=Treatment; CV=Coefficient of variance

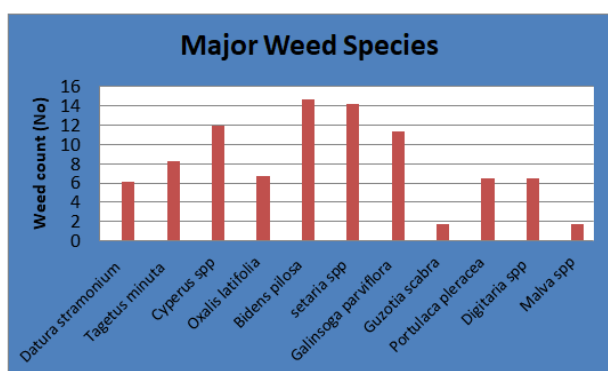


Figure 1: Weed species identified during the experimental period

ANOVA (analysis of variance) showed that treatments significantly affected weed density (Table 4). While the lower significant weed density (4.00)

resulted from both weedy for 15DAT and weed-free season, the higher significant weed density (14.00) was obtained from the weed-infested season (Table 5). Likewise, fresh and dry weed biomasses were significantly influenced by treatments (Table 4). The lower significant fresh (69.35g) and dry weed biomasses (11.20g) were obtained from weed-free season treatment while the higher significant fresh (255.28g) and dry (61.65g) weed biomasses were obtained from weed-infested season (no weed control) treatment (Table 5). Though statistically similar among each other the present study showed as treatments such as weed-free for 75DAT, 90DAT as well as weedy for 45DAT, 30DAT, and 15DAT had resulted in lower weed dry biomass next to the weed-free season treatment. The present result is similar to the result of (Alaoui *et al.*, 2003).

Table 5: Mean performance of weed density, fresh and dry weed above ground biomass

Treatment	Weed density (count/m ²)	Fresh weed biomass (g)	Dry weed biomass (g)
1. Weed free for 15DAT	7.67 ^{bc}	246.11 ^a	58.53 ^a
2. Weed free for 30DAT	6.33 ^{bc}	235.28 ^a	49.82 ^a
3. Weed free for 45DAT	9.00 ^{abc}	203.01 ^a	58.84 ^a
4. Weed free for 60DAT	6.00 ^{bc}	209.49 ^a	52.37 ^a
5. Weed free for 75DAT	5.00 ^c	93.15 ^b	25.25 ^b
6. Weed free for 90DAT	4.12 ^c	113.94 ^b	28.48 ^b
7. Weed-infested season	14.00 ^d	255.28 ^a	61.65 ^a
8. Weedy for 15DAT	4.00 ^c	79.58 ^b	19.90 ^{bc}
9. Weedy for 30DAT	6.00 ^{bc}	96.39 ^b	21.10 ^{bc}
10. Weedy for 45DAT	9.00 ^{abc}	121.99 ^b	30.50 ^b
11. Weedy for 60DAT	7.67 ^{bc}	220.09 ^a	51.82 ^a
12. Weedy for 75DAT	11.67 ^{ab}	237.41 ^a	48.35 ^a
13. Weedy for 90DAT	11.33 ^{ab}	226.57 ^a	60.24 ^a
14. Weed-free season	4.00 ^c	69.35 ^b	11.20 ^c
LSD	5.72	56.38	14.00
CV	44.77	19.53	26.12

Column followed by the same letter is not significantly different at P<5% level of significance.

SUMMARY AND CONCLUSION

Stevia is one of the important medicinal plants known globally. In Ethiopia, there registered stevia plant variety so far and there are suitable environmental

conditions for the production of the plant in the country. Besides, now proper stevia varieties together with proper management practices are being demanded. Wondogenet agricultural research center is the

nationally mandated center for medicinal plants research and the current work is part of production package fulfillment work for stevia as production packages were being developed and improved. Weed management practices are very important practices for quantity and quality. Therefore, the present study was conducted to find critical weed competition period for stevia growth at Wondogenet agricultural research center during the 2019/2020 cropping season. The experiment was arranged in an RCBD design with three replications having 14 treatments. Stevia plant height, branch number as well as fresh and dry leaf yield were evaluated. All of the evaluated growth and yield parameters were much influenced by the treatments. The longer weed-free period treatments showed significantly shorter stevia plant height and an increase in weed infestation period caused an increase in plant height. This might be due to competition for resources, such as sunlight. Stevia branch number per plant was also influenced by weed interferences for more than 15 days after transplanting. Similar to that of branch number per plant, weed-infested season resulted in lower significant fresh and dry leaf yield per hectare. The present work verified that weeds greatly influenced stevia growth and yield so that identification and use of proper weed management strategy is critical. Besides, weed density and above-ground weed biomass were also evaluated during the experiment. Treatments such as weed-free for seventy-five days after transplanting (75DAT), ninety days after transplanting (90DAT) as well as weedy for forty-five days after transplanting (45DAT), thirty days after transplanting (30DAT), and fifteen days after transplanting (15DAT) had resulted in lower weed dry biomass next to the weed-free season treatment. Therefore, as weeds greatly affect stevia growth and yield, early weeding at 15DAT is important and recommended based on the present finding, however, for comprehensive results the experiment should be repeated over site and year.

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