Effect of Soil Fertilizers on Growth and Yield of *Aloe vera*

Abstract

Purpose: To study the effect of vermicompost and nitrogen fertilizers on the growth and production of *Aloe vera*, a factorial was conducted based on Randomized Complete Block Design (RCBD).

Methods: Treatments included four levels of vermicompost (V0: Control, V1: 75, V2: 150 and V3: 200 g per pot) and four levels of nitrogen fertilizer (N0: control, N1: 500, N2: 1000, and N3: 1500 mg per pot). At the end of the plant growth stage, traits such as plant height, number of leaves, leaf diameter, number of suckers, number of leaf suckers, sucker weight, sucker height, and total biomass were measured.

Results: The results showed that application of 150 g of vermicompost and 1000 mg of nitrogen had the highest effect on growth traits, and application of 200 g of vermicompost and 1500 mg of nitrogen had the greatest effect on sucker characteristics, so that the highest number of suckers was obtained by using 200 g of vermicompost and 1000 and 1500 mg of nitrogen. However, simultaneous application of 150 g of vermicompost and 1000 mg of nitrogen had the greatest effect on plant height, number of leaves, and leaf diameter, and treatment with 200 g of vermicompost and 1500 mg of nitrogen had the greatest effect on the number of suckers, stem weight, number of leaves, sucker height, total biomass and Aloin content.

Conclusions: Therefore, simultaneous use of vermicompost and nitrogen fertilizer in *Aloe vera* cultivation plays an important role in the production and enhancement of sucker and plant yield.

Key words: Aloe; Sucker; Yield; Organic Fertilizer

Introduction

Vermicompost is derived from a semi-aerobic process resulting from organic matter degradation by soil worms (such as *Eisenia fetida*) and microorganisms (Atiye et al. 2000). By supplying these fertilizers, in addition to improving the nutritional aspects of the soil, the physical and microbial conditions of the soil are also improved (Robin et al., 2001; Renato et al. 2003). Studies have shown that vermicompost can be used in sustainable agriculture to support growing populations by increasing water holding capacity, nutrient supply, high porosity, adequate ventilation and drainage, and production of plant hormones that have beneficial effects on seed germination. In addition, vermicomposts are rich in the beneficial microorganisms (such as mycorrhizal fungi and bacteria and actinomycetes) that can provide nutrients such as nitrogen, phosphorus, and potassium in soil and improves the growth that consequently increased yield of crop plants (Arancon et al. 2004).

Nutrient management in *Aloe vera* can increase fertility and plant production. This plant need necessary nutrient such as nitrogen due to its high vegetative value. Nitrogen, water, and soil acidity are important factors in the production of *Aloe vera* (Reynolds 2004). Studies have shown that *Aloe vera* reacts very strongly to the application of nitrogen

fertilizer because of its succulence. In one study, the application of chemical fertilizers increased the yield and growth of *Aloe vera,* but high levels of chemical elements could have a negative effect on quality (Nejatzadeh Barandozi et al. 2011). In a study by Yavori et al. (2015) evaluating the antioxidant activity of *Aloe vera*, the effects of various levels of vermicompost and nano-potassium spray were investigated. Vermicompost fertilizer and nano-potassium spray application increased gel weight, gel moisture content, glucomannan, and anthocyanin in gel tissue. According to a report by Uyanoz et al. (2002), succulent plants require high levels of nitrogen and potassium, and the presence of potassium in the soil accelerates nitrogen uptake. Therefore, in *Aloe vera*, nitrogen and potassium fertilizers have positive effects on leaf length and yield.

Aloe vera L. belongs to the Xanthorrhoeaceae family (Cardemil et al. 2019). This perennial plant has a rosette and always green growth pattern reaching about 60 cm in height, with short stems of 5–10 cm in diameter and spiny leaves that are directly attached to the stem. This plant is native to Africa, the African islets, the Socotra Islands, and the southern coast of our country, which is home to over 400 species in the world. So far, no more than a few species of *Aloe vera* are cultivated in Iran. In the commercial market, the extracted gel of the *A. vera* has been widely sought after due to its important uses, especially in herbal medicines (Reynolds 2004). The most widely used ingredient in this plant is the sticky gel material of the anthraquinone derivatives called Aloe's. The main anthraquinone derivative of Aloe's latex is aloin. (Chen et al. 2012). *Aloe vera* gel contains 98% water and various polysaccharides, such as glucomannan, and galactone. It has many biological and physiological properties, including the ability to treat burns and skin lesions,

anti-wrinkle properties, anti-bacterial and anti-parasitic properties, inhibition of proliferation of cancer cells, and stimulation of the immune system due to the presence of anthraquinone compounds (Chen et al. 2012).

The purpose of this experiment is to evaluate the effect of different levels of vermicompost and nitrogen fertilizers on the growth and production of the *Aloe vera* plant.

Materials and Methods

This research was carried out as a factorial based on a randomized complete block design with four replications in a greenhouse at the Faculty of Agriculture at the Azad University of Khoy Branch in 2015–2016. Treatments included four levels of vermicompost (V0: Control, V1: 75, V2: 150 and V3: 200 g per pot) and four levels of nitrogen fertilizer (N0: control, N1: 500, N2: 1000, and N3: 1,500 mg per pot). Nitrogen fertilizer applications were split into three stages (at eight leaves, before suckering, and at the beginning of sucker formation). In June, uniform suckers with a size of 18–20 cm were randomly selected and transferred to the greenhouse to be planted in pots. Before planting, vermicompost treatments were added to the pots and completely mixed with the soil. The greenhouse temperature for the growth of the *Aloe vera* was 28 ° C during the day and 22 ° C at night. Plants were sprinkler irrigated based on water requirement. At the end of the plant growth period, traits such as plant height, number of leaves, leaf diameter, number of suckers, number of leaf suckers, sucker weight, sucker height, total biomass and Aloin content were measured. For measuring traits such as the number of leaves, their number was counted, height of plant was measured by a ruler from the crown to the pot rim (from base leaf to leaf tip), for measuring the leaf diameter, biggest leaf selected and a digital caliper was

used, to measure the traits suckers, suckers were separated from the mother plant and their number was counted and then the height, weights, number of suckers leaves, total biomass and aloin content in leaves were measured.

Analysis of aloin was undertaken by injecting 20 µl of concentrated juice into a CAMAG high performance thin layer chromatograph (HPTLC) scanner. Before carrying out the test, a sample of soil was selected and transferred to the soil laboratory, the results of which are given in Table 1. Also, the amount of nitrogen, phosphorus and potassium in the vermicompost was measured (Table 2). Analysis of variance was performed using SAS software and comparison of means by LSD test was done at the 5% probability level.

RESULTS

The results of analysis of variance showed that vermicompost and nitrogen fertilizer had significant effect ($P < 0.01$) on all of traits (Table 3). Also, interaction effect of vermicompost and nitrogen fertilizer was significantly affected on all traits ($P < 0.01$), number of leaves ($P < 0.05$) and leaf diameter was not significant affect (Table 3). Mean comparisons showed that there was a significant increase in all traits other than plant height with increase vermicompost content (Table 4). The lowest height was found in 75g of vermicompost treatment, which had a significant difference compared to control, and the other treatment levels were not statistically different. Also, vermicompost increased the diameter of leaf at a level of 150 g and total plant biomass at a level of 200 g, which showed a significant difference ($P < 0.01$) compared to control treatments (Table 4). The highest number of sucker, sucker weight, number leaves of sucker, sucker height, total biomass and Aloin content was obtained in 200 g of vermicompost, which was different

from control (Table 4). Analysis of variance showed that nitrogen fertilizer had a significant effect ($P < 0.01$) on all of traits (Table 3). Mean comparisons showed that the highest plant height was related to 1000 mg nitrogen and the lowest plant height was related to control treatment. The highest number of leaves belonged to 1500 mg nitrogen and the lowest number of leaves for the control treatment (Table 4). The highest diameter of leaf was related to 1000 mg nitrogen and the lowest leaf diameter belonged to control. However, traits such as number of leaves, sucker weight, number of sucker leaves, sucker height, total biomass and Aloin content increased with increasing application of nitrogen levels to 1500 mg (Table 4). The application of nitrogen on the number of suckers had a significant effect (Table 3). Based on the results in the comparison table, the highest number of suckers was observed in 1000 and 1500 mg nitrogen treatments (Table 4). The results of different treatments showed that with the simultaneous application of vermicompost with nitrogen, these traits increased. The lowest plant height was obtained in the treatment of 200 g of vermicompost without application of nitrogen and the maximum height was 200 g of vermicompost and 1000 mg nitrogen. At the same time, 150 g of vermicompost and 1000 mg nitrogen had the highest number of leaves, which was 22.37% higher than control (Table 4). With increasing the amount of vermicompost, the number of suckers was increased and the highest number of suckers were obtained in treatment of 200 g of vermicompost with 1000 and 1500 mg nitrogen, which was higher than control (100%). In this experiment, when nitrogen with no vermicompost was used, it did not affect the number of suckers, but when nitrogen was used with vermicompost, the weight of the suckers was increased and the maximum weight of the sucker was at a level of 200 g of vermicompost and 1500 mg nitrogen that was different from control (100%). The highest

number of leaves of sucker was obtained with a 75 g of vermicompost and 1500 mg nitrogen. Of course, when vermicompost and nitrogen were used together, they were increased to the height of the sucker and number of sucker but when applied solely, they did not affect the height. Based on the results of Table 4 and 5, Nitrogen and Vermicompost levels have significant interaction. However, they had not main effects, i.e. they had not an effect on total biomass, independently one from the other (Table 5). The results of correlation between traits showed that the number of leaves with all traits had a positive and significant correlation in each plant, the highest correlation was the leaf diameter with the number of sucker r = 0.77 and total biomass (r = 0.71). There was a positive and significant correlation between the number of sucker with sucker weights, number of sucker leaves, sucker height and total biomass; total biomass also had a positive and significant correlation with all traits. The diameter of leaf had a positive and significant correlation with leaf number, plant height and total biomass. Regarding the role of leaf in transferring food and water in plant, with increase leaf diameter, a better relationship was established between the sections of plants and as a result, plant height, number of leaves, number of suckers and number of leaves on the suckers increased. Therefore, the height of the sucker with the number of sucker, the weight of the sucker and the number of leaves of the suckers showed a positive and significant correlation. There was a positive and significant correlation between the sucker weight with the height of the sucker, the number of leaves and the total biomass, so that the highest correlation with the number of leaves was (r = 0.88) (Table 6).

The aloin content derived from aloe gel was found to be higher in 200 g of vermicompost and 1500 mg nitrogen (Figure 1). Maximum aloin content of 22.32% was in N3V3 and minimum aloin content of 14.61 % in control.

Discussion

The results showed that application of 150g of vermicompost and 1000mg of nitrogen had the most effect on growth traits and application of 200g of vermicompost and 1500mg of nitrogen had the most effect on the characteristics of sucker, so that by increasing the amount of vermicompost, number of sucker increased, and the highest number of sucker was obtained in 200 g of vermicompost and 1000 mg nitrogen application. However, simultaneous application of 150 g of vermicompost and 1500 mg of nitrogen had the highest effect on plant height, leaf number and leaf diameter, and treatment of 200 g of vermicompost and 1500 mg of nitrogen had the most effect on the number of sucker, sucker weight, number of leaves, height, total biomass and Aloin content. The results of this study indicate the positive effect of vermicompost and nitrogen on growth and production of suckers in *Aloe vera*. In this experiment, vermicompost reduced the height in low concentrations, due to the increase in sucker production and number of leaves of sucker (Nejatzadeh Barandozi et al. 2011). The results of this experiment were in agreement with the results of Daneshian et al. (2009) on the Basil plant. Improvement caused by the vermicompost treatment can be due to the increase of secondary metabolites under adverse environmental conditions and nutrient deficiencies, because organic fertilizer treatments with more water in the soil and providing nutrients provide a more suitable substrate for plant growth. (Jahan, Koocheki 2004). Moradi (2009) reported similar results in their study

in fennel. Other research results showed that different levels of nitrogen, also combining nitrogen, organic, and mineral fertilizers, increased the percentage of essential oil of basil (Daneshian et al. 2009). The organic fertilizers, especially the vermicompost, with the desired effects mentioned above, increased the yield of the plant and produced an acceptable percentage of sucker, thus raising the yield to a favorable level. Darzi, Haj Seyed Hadi (2012) with application of different levels of vermicompost fertilizer (0, 4, 8 and 12 tons per hectare) reported that maximum yield of biomass and plant height were at 4 and 12 tons of vermicompost per hectare, respectively (Darzi, Haj Seyed Hadi 2012). Das et al. (2002) observed that the application of vermicompost increased the leaf area, dry matter accumulation and other growth parameters of the pea's plant. The variation in leaf area index under the influence of different levels of vermicompost fertilizer showed that with increase in vermicompost consumption, leaf area index increased, and in the treatment of 10 t ha^{-1}, had relative superiority to treatments of 5 t ha^{-1} and the lack of vermicompost (Das et al. 2002). The most valuable characteristic of vermicompost is the enzymes, microorganisms and various hormones. Vermicompost has enzymes such as protease, amylase, lipase, cellulase and ketinase, which plays an important role in the degradation of organic matter and thus the availability of essential nutrients for plants, and by providing a suitable growth medium, it can increase the growth rate (Ji-dong et al. 2006; Karmegam and Daniel 2000). In another greenhouse research on *Sesbania emerus*, it was found that application of different amounts of vermicompost in comparison to control treatment resulted in a significant superiority in the dry weight of the limbs (Gardezi et al. 2000). In this research, nitrogen fertilizer treatments increased plant height, number of leaves and leaf diameter, and with increasing of these traits, the total biomass increased, which is

consistent with the results of the study of Babatunde and Yongabi (2008). According to many scientists, the application of nitrogen increases the hormones, especially auxins and nucleic acids in the plant, and causes more growth and development, but decreasing these traits in high concentration of nitrogen fertilizer may be due to an antagonistic effect between nitrogen and phosphorus cause an imbalance in the uptake of elements in the soil (Khalighi et al. 2000). The application of nitrogen has a significant effect on the number of suckers, which is consistent with the results of Babatunde and Yongabi (2008) and Nejatzadeh- Barandozi et al. (2011). The results of researches have shown that with increasing nitrogen consumption, the number and surface area of leaves increase, which increases the photosynthetic capacity, resulting in higher growth rates and higher dry matter production (Gulser 2005). According to the results obtained from the interactions of the treatments, it can be concluded that the best yield, the highest number of sucker, is obtained in the simultaneous application of 200 g of vermicompost and 1000 and 1500 mg N, and increasing the number of leaves, leaf diameter, number of suckers, size and weight of sucker due to many internal and external factors.

Conclusions

Soil fertilizer management using organic amendments such as vermicompost can be very important in advancing the goal of achieving maximum yield and sustainable soil fertility. On the other hand, the application of chemical fertilizers and vermicompost in large quantities and in short term due to the gradual release of food elements that cannot fully support the need for *Aloe vera.* According to the results of this study, we can conclude that simultaneous use of vermicompost fertilizer with optimum levels of nitrogen fertilizer

by increasing the absorption of nutrients improves the growth and plant development stages, which ultimately increases the yield of *Aloe vera*. Therefore, simultaneous use of vermicompost and nitrogen fertilizer in *Aloe vera* cultivation plays an important role in yield and the production and enhancement of sucker.

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TABLE 1. The result of Physic-Chemical analysis of the soil.

Texture	pH	EC(ds m^{-1})	Available P	Available K	Total N (%)	Organic carbon (%)	Percent Saturated	Lime
Clay	8.66	1.57	8.43	314	0.25	2.57	60.98	30.74

TABLE 2. Physical and chemical properties of vermicompost used in the experiment.

pH	EC (ds m^{-1})	Organic carbon (%)	Neutralizing agents	Ash at 800	N	P	K	Ca	Mg	Cu	Zn	Mn	Fe	Na	Cl	Moisture	(CEC)	Water storage capacity
6.6	1.97	8	0.01	25	0.98	0.21	0.79	1.95	0.38	0.26	2.5	0.89	0.38	0.02	-	-	-	-

TABLE 3. Analysis of variance of vermicompost and nitrogen on studied traits in *Aloe vera* plant**.**

		Means of Squares							
Source of variations	DF	plant height	number of leaves	Leaf diameter	number of Sucker	sucker weight	number of leaf sucker	sucker height	Total biomass
Replication	3	46.12 ns	1.2	ns 14.61	1.27	41.476 ns	0.40 ns	4.40 ns	ns 0.030
Vermicompost	3	155.45**	32.70**	73.34**	108.81**	2489.43**	57.38**	1048.85**	8.45**
Nitrogen	3	618.7**	7.17**	28.61**	5.74**	2063.41**	45.76**	538.45**	20.49**
V× N	9	78.47**	1.16*	18.7 ns	11.97**	525.90**	13.86**	136.08**	0.48**
Error	32	18.34	0.46	9.26	0.82	43.76	0.28	4.8	0.0478
CV (%)	-	6.93	3.1	6.68	23.02	25.28	12.40	15.74	5.76

ns, * and **: Non-significant and significant at the 5 and 1% levels of probability, respectively

TABLE 4. Comparison of mean vermicompost and nitrogen treatments on the traits of *Aloe vera*

		Means of Squares							
Treatment	Level of treatment	plant height	number of leaves	Leaf diameter	number of Sucker	sucker weight	number of leaf sucker	sucker height	Total biomass
Nitrogen	0	52.76 c	20.58 c	41.93 b	3.30 b	10.48 c	2.39 c	7.07 c	2.29 d
	500	59.57 b	21.30 b	45.24 ab	3.56 b	27.50 b	4.26 b	14.60 b	3.70 c
	1 000	66.50 a	21.81 a	46.92 a	4.45 a	29.01 b	4.28 b	13.32 b	4.11 b
	1 500	65.60 a	22.13 a	46.46 a	4.45 a	36.62 a	6.53 a	21.20 a	5.09 a
Vermicompost	0	61.75 a	20.17 b	43.82 b	0..29 d	9.4 d	1.68 c	3.95 d	3.06 d
	75	57.30 b	20.28 b	43.73 b	4.08 c	24.79 c	4.39 b	11.92 c	3.34 c
	150	64.51 a	22.80 a	48.16 a	5.11 b	32 b	5.58 a	17.30 b	4.09 b
	200	63.06 a	20.59 a	46.34 a	6.32 a	38.42 a	6.80 a	22 a	4.62 a

In each column, the same letters indicate that there is no significant difference between the meanings (LSD test)

TABLE 5. Comparison of the mean of interaction between vermicompost and nitrogen on studied traits in *Aloe vera* plant

Treatment	number of leaves	Leaf diameter (mm)	sucker weight (gr)	number of leaf sucker	sucker height (cm)
N0V0(control)	17.84 h	40.16 e	0 g	0 g	0 h
N0V1	20 g	42.40 cd	0 g	0 g	0 h
N0 V2	22.23 bc	49.11 a	15.1 f	4.22 f	12.72 fg
N0 V3	22dc	43.18 bd	26.71 e	5.29 ce	15.51 ef
N1V0	20.23 fg	42.90 cd	0 g	0 g	0 h
N1V1	20.23 fg	44.13 bd	42.5 ab	4.4 ef	9.94 g
N1V2	22.23 bc	48.16 ab	33.6 ce	6.05 ac	14.4 f
N1V3	22.41 bc	45.68 ac	35.03 be	6.26 ab	33.22 a
N2V0	21.23 de	47.93 ab	0 g	0 g	0 h
N2V1	20.64 fg	45.26 ac	29.96 de	6 ac	15.43 f
N2V2	23.60 a	45.70 ac	43.50 ab	5.73 bd	19.1 cd
N2V3	23 ab	47.51 ab	42.55 ab	5.25 de	18.4 de
N3V0	21 ef	44.20 bd	37.4 bd	6.70 a	15.85 ef
N3V1	20.23 fg	43.05 cd	27.02 e	6.76 a	22.30 bc
N3V2	23 ab	49.4 a	36.2 bd	6.26 ab	22.68 b
N3V3	23 ab	48.93 a	49.26 a	6.30 ab	23.93 b

In each column, the same letters indicate that there is no significant difference between the meanings (LSD test)

TABLE 6. Simple correlation coefficients of the traits studied in the *Aloe vera* plant

Trait studied	Plant height	Number of leaves	Leaf diameter	Number of Sucker	Sucker weight	Number of leaf sucker	Sucker height	Total biomass
Plant height	1							
Number of leaves	0.677**	1						
Leaf diameter	0.677**	0.722**	1					
Number of Sucker	ns 0.182	0.621**	0.480 ns	1				
Sucker weight	ns 0.377	0.652**	0.431 ns	0.711**	1			
Number of leaf sucker	ns 0.257	0.587*	0.408 ns	0.777**	0.884**	1		
Sucker height	ns 0.312	0.658*	0.424 ns	0.757*	0.806**	0.888**	1	
Total biomass	0.624**	0.718**	0.571*	0.572**	0.810**	0.800**	0.841**	1

ns, * and **: Non-significant and significant at the 5 and 1% levels of probability, respectively

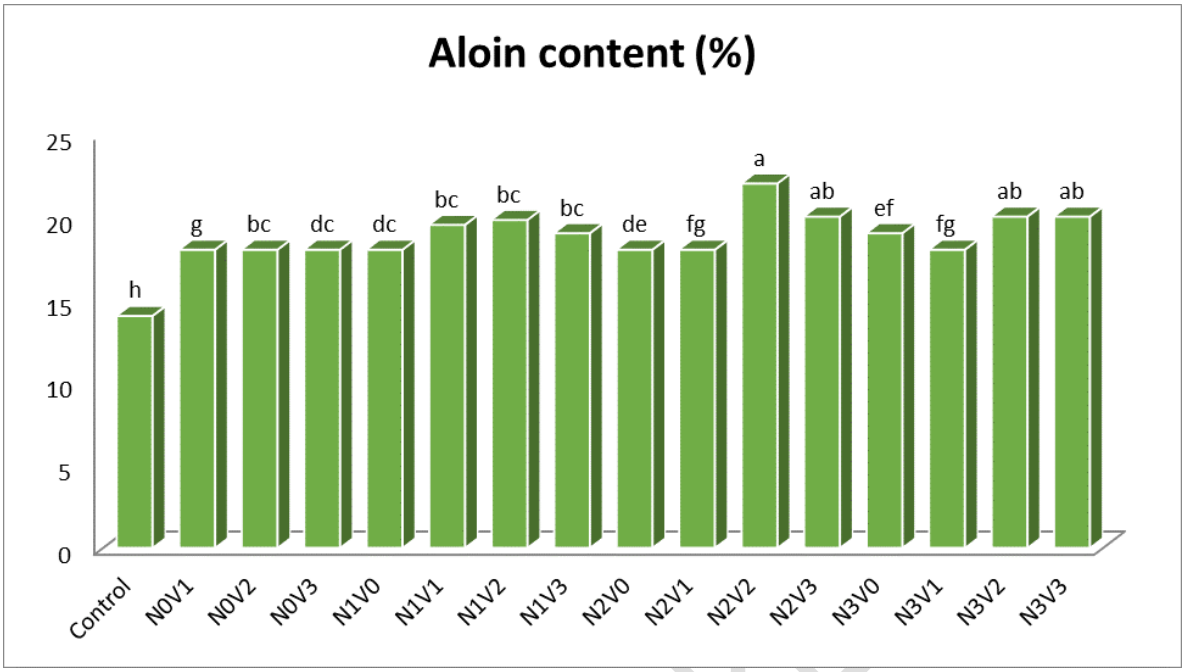

Fig. 1. Aloin content of *Aloe vera* under different vermicompost and nitrogen treatments at 120 days after sowing.