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Effect of Vinasse Application on Germination and Absorption of Some Macro Elements by Barley (*Hordeum vulgare*)

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ABSTRACT

BACKGROUND: Vinasse, the effluent of ethanol alcohol factories, is one of the water sources that can be used well in agriculture. The management of this resource rich in nutrients is very important and necessary to supply plants with nutrients.

OBJECTIVES: Current research investigated the effect of different levels of Vinasse on germination and absorption of nutrients nitrogen, phosphorus and calcium by barley.

METHODS: In the present study, an experiment was conducted at two levels of 10% and 25% Vinasse and a control in experimental plots with a randomized complete block design with four replications. Vinasse treatments with irrigation water included the first treatment without the use of Vinasse, the second treatment including 90% water and 10% Vinasse, and the third treatment including 75% irrigation water and 25% Vinasse.

RESULT: The results showed that the increase of Vinasse in the germination stage of the seeds was effective at the level of 1% and caused a decrease in the average daily germination and germination percentage. So that the highest daily germination with an average of 0.90 corresponds to the control treatment, i.e., 100% water, and the lowest daily germination with an average of 0.74 corresponds to the third treatment of 25% Vinasse. The highest and lowest germination percentages were obtained in the control treatment and the 25% Vinasse treatment, respectively 100% and 88%. The amount of absorbed food elements (nitrogen, phosphorus and potassium) in vegetative parts of barley plant was significant compared to the control. Adding Vinasse to the soil increased fodder yield, so that by adding 25% Vinasse, a significant difference was observed with the control, the amount of fodder increased from 5.87 in the control to 9.19 tons per hectare in the 25% Vinasse treatment.

CONCLUSION: Adding Vinasse to the soil caused a significant increase in the amount of nitrogen, phosphorus and potassium absorbed in the vegetative parts of the barley plant at the level of 1%. Adding Vinasse to the soil increased fodder yield and barley grain yield. The results showed that due to the abundance of Vinasse in food, adding it to the soil can be recommended as an alternative to chemical fertilizers in the cultivation of plants such as barley with proper management.

KEYWORDS: *Cereal, Forage, Nitrogen, Phosphorus, Potash, Yield.*

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1. BACKGROUND

One of the important crises that threaten humanity is the issue of water shortage crisis; the high share of water consumption in the agriculture sector is one of the biggest challenges of water shortage crisis. Iran is located in one of the driest areas in the world and lack of water is considered the most important bottleneck for agricultural development (Christofoletti *et al.*, 2013). One of the water resources that can be used well in agriculture is sewage (urban, agricultural and industrial). The use of wastewater as a permanent source of water in agriculture, in addition to providing part of the water needs, also saves and lasts the existing water resources. In addition, the presence of plant nutrients in wastewater reduces the use of chemical fertilizers and, of course, the environmental effects of their use (Marcińczyk *et al.*, 2022). One of the water resources that can be used well in agriculture is sewage (urban, agricultural and industrial). The use of wastewater as a permanent source of water in agriculture, in addition to providing part of the water needs, also saves and lasts the existing water resources. In addition, the presence of plant nutrients in wastewater reduces the consumption of chemical fertilizers and the environmental effects of their use. Sugarcane Vinasse is a liquid produced by fermentation of molasses to produce ethanol alcohol from the distillation process and it is used in animal feed and soil amendment (Christofoletti *et al*., 2013). Each liter of the produced an average of 10 to 15 L of Vinasse and is a waste liquid produced during the production of ethanol from sugarcane or sugar beet or cellulosic material (Sadeghi *et al.*, 2016). Vinasse is a low-cost alternative to fertilization because it replaces fertilizers and improves crop productivity through improving the soil structure (Pasqualin *et al.*, 2012). Vinasse increases soil fertility, soil quality and crop production (Elgharbawy, 2021). Research has shown that frequent irrigation with Vinasse at concentrations ≥50% increases EC, K^+, Na^+, Mg^{2+}, Ca^{2+} and available P in the soil (Sanchez-Lizarraga *et al.*, 2018). Amin (2018) showed that the amendment of calcareous sandy soil by biochar improves the availability of phosphorus and dry biomass of the atmosphere. In addition, it improved the efficiency of phosphorus uptake by barley plants. Pinto *et al.* (2022) found that the application of Vinasse for two years improves the biological and chemical properties of the soil and increases the yield of corn, soybeans and pastures. Chen *et al.* (2020) Showed that the biochar application increased soil water holding capacity (0.88–47.93%), pH (-0.03-1.61 units), cation exchange capacity (CEC) (0.1–3.4 cmol kg^{-1}), soil organic matter (2.35–229.31%), total nitrogen (4.88–86.84%), available phosphorus (0–171.74%), and potassium (0.25–14.47 times) on paddy soil. Meyer *et al.* (2022) found that the application of biochar fertilizer blends had a positive impact on soil fertility monitored within the first harvest year and the asparagus yield in the second harvest year under the observe field conditions.

2. OBJECTIVES

The purpose of this research is to investigate the effect of using Vinasse on the absorption of nitrogen, phosphorus and sulfur elements by the barley plant and plant performance.

3. MATERIALS AND METHODS

3.1. Field and Treatments Information

In this research, in order to investigate the effect of Vinasse application on the amount of nitrogen, phosphorus and sodium nutrient absorption and growth and germination characteristics of barley plants, an experiment was conducted at two levels of 10% and 25% Vinasse and a control in experimental plots with a randomized complete block design with four Repetition was designed. Vinasse treatments with irrigation water included the first treatment without the use of Vinasse, the second treatment including 90% water and 10% Vinasse, and the third treatment including 75% irrigation water and 25% Vinasse. After plowing, the land was divided into 12 plots of 1.5×1 meters. The Vinasse needed to conduct the experiment was obtained from the Vinasse in the evaporation ponds of this wastewater, which is located in the vicinity of the Razi alcohol production plant, located in the Daabl Khazai agricultural and industrial complex, 30 km from Ahvaz-Abadan Road. The experiment was conducted during a period of barley plant growth.

3.2. Measured Traits

Plant sampling was done at three times of fresh fodder, before heading and harvest time. To obtain the forage yield, two rows of forage were harvested and weighed. After the final harvest of the plants, the seeds were separated and weighed. Plant sampling was done to determine the concentration of nitrogen, potassium and potassium elements in straw leaves and barley seeds. To measure phosphorus and potassium from plant samples, one gram of dry plant sample was ground and weighed with a digital scale and transferred to 100 ml flasks, then digested with acid by heat and after filtering with filter paper, the resulting extract was collected (Gee and Bauder, 1986). In the resulting extract, phosphorus was used by spectrophotometric method and potassium by film photometry (Sumner and Miller, 1996). Electrical conductivity in saturated soil extract (Regional Salinity, 1954).

3.3. Statistical Analysis

Statistical analyzes were performed using SPSS software and graphs were drawn using Excel.

4. RESULT AND DISCUSSION

4.1. Soil and Vinasse properties

Some characteristics of soil and Vinasse in the studied area can be seen in Table 1. According to table 1, the electrical conductivity (EC) is 4.55 $dS.m^{-1}$ and the soil is salty, while the EC of Vinasse is very high and more than 6 times that of the soil, so the high EC of Vinasse indicates the presence of its high salts and if it is added to the soil, the salinity of the soil will increase. The pH of the soil is alkaline, but Vinasse is acidic, adding it to the soil can balance the soil conditions. The soil texture is

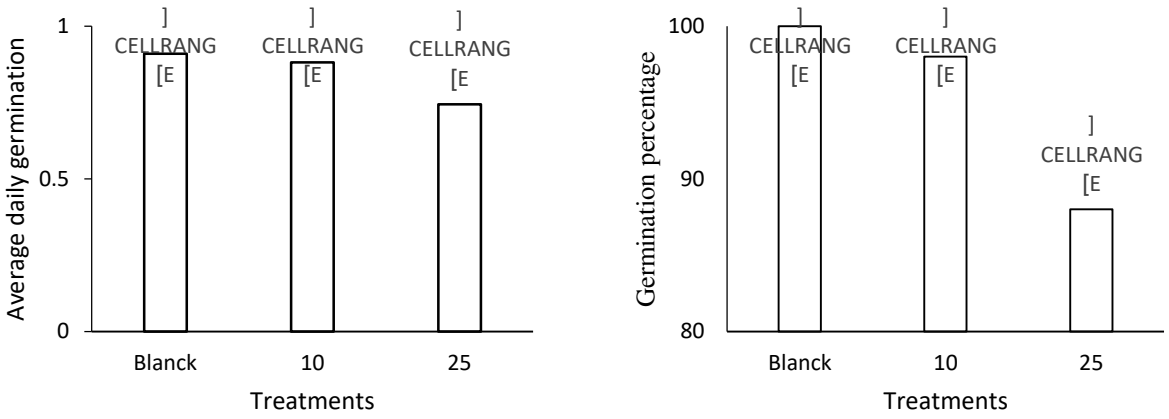
medium (CL) and soil nitrogen is low, adding Vinasse will increase soil nitrogen and increase soil fertility and reduce the consumption of nitrogen fertilizers (Table 1).

Table 1. Characteristics of soil and Vinasse

Property	Unit	Soil	Vinasse
EC	$dS.m^{-1}$	4.55	32.33
pH	-	7.85	6.0
N	%	0.08	8.1
P	$mg.kg^{-1}$	15.74	290
K	$mg.kg^{-1}$	335.0	1900
Sand	%	42	-
Silt	%	30	-
Clay	%	28	-
Texture	-	Clay Loam	-

4.2. Seed germination

Increasing the amount of Vinasse in the germination stage of seeds was effective at the level of 1% and decreased the average daily germination and germination percentage. According to Fig. 1, the highest daily germination with an average of 0.90 corresponds to the control treatment with 100% water, and the lowest daily germination with an average of 0.74 corresponds to the third treatment of 25% Vinasse. The highest germination percentage was obtained in the control treatment (100%) and the lowest percentage in the third treatment (88%). The decrease in plant germination with the increase of Vinasse is because the increase of Vinasse causes an increase in electrical conductivity, resulting in an increase in osmotic pressure and a decrease in water absorption by plant seeds (Sheldon *et al.*, 2017). The results are similar to Fakhari *et al.* (2013), which showed that the increase in electrical conductivity decreases the percentage of wheat germination.



Blanck: Without Vinasse 10: 10% Vinasse and 25: 25% Vinasse

Fig. 1. Average daily germination and germination percentage of barley in different

4.3. Vinasse effect on soil and plant

The application of Vinasse caused a significant increase in nitrogen, phosphorus and potassium at the level of 1% in the soil and barley plant (Table 2). Due to the abundance of Vinasse in nutrients, adding it to the soil increases nutrients in the soil and increases absorption by the plant. The results are similar to (Chen *et al.*, 2020), which showed that adding Vinasse increases macro elements in soil and plants.

Table 2. Variance analysis of Vinasse effect on soil and plant nutrients

S.O.V	df	Soil			Barley		
		N	P	K	N	P	K
Replication	3	0.0085**	3022.1**	35921.1**	1.05^{ns}	58.65**	12.193**
Treatment	2	0.014**	7455.8**	9954.41**	3.294**	594.88**	5.053*
Time	1	0.014**	2898.3**	1352.21**	363.18**	271.5**	280.09**
T*Time	2	0.007*	1873.9*	15.87^{ns}	2.13**	91.04*	6.576**
Error	30	0.0003	147.12	1599.53	0.558	17.6	4.228

^{ns}, * and **: no significant, significant at 5% and 1% of probability level, respectively.

4.3. Plant nitrogen

According to table 2, the amount of nitrogen absorbed in the vegetative parts of the plant is significant compared to the control. In the 10% Vinasse treatment at the 5% level and the 25% Vinasse treatment at the 1% level, there was a significant difference with the control. In general, adding Vinasse to the soil caused a decrease in nitrogen and then an increase in the concentration of nitrogen in the vegetative parts of the plant. Because the amount of nitrogen in the soil is high in the first stage, the plant has absorbed a large amount of nitrogen, and the remaining nitrogen has been removed from the root absorption zone for various reasons, including washing and absorption by microorganisms (Premi and Cornfield, 1969). In the third stage, most of the nitrogen is absorbed by the grain and its concentration in the straw is low. The results showed that the amount of nitrogen absorbed by barley seed compared to the control is significant at the level of 1% (Table 3). The comparison of averages was carried out by Duncan's test of nitrogen concentration in the vegetative parts separately (Table 4). In the fodder stage, the amount of nitrogen increased from 3.11 to 4.17% with increasing the amounts of Vinasse compared to the control, which is a significant difference. It also increased from 1.94 to 2.33 percent in plant seeds. Only in the stem, despite the increase of Vinasse, nitrogen increased, but it was not statistically significant (Table 4).

4.4.*Plant phosphorus*

The amount of phosphorus absorbed in the vegetative parts of the plant compared to the control has a significant difference at the level of 1% (Table 2), but the difference between the treatments was not significant.

Table 3. Variance analysis effect of different treatments on element absorption by barley seeds

S.O.V	df	N	P	K
Replication	3	0.95**	3.94^{ns}	0.665**
Treatment	2	0.83**	22.65**	0.072^{ns}
Error	30	0.078	3.68	0.055

Table 4. Amounts of elements in different parts of barley plant

Barley parts	Treatments	N %	P %	K %
Seed	Blank	1.94[b]	1.28[b]	0.166[a]
	10%	2.45[a]	1.35[b]	0.166[a]
	25%	2.33[a]	1.56[a]	0.177[a]
Straw	Blank	0.58[b]	0.094[a]	0.333[a]
	10%	0.69[a]	0.104[a]	0.343[a]
	25%	0.65[a]	0.114[a]	0.348[a]
Leaf	Blank	2.22[b]	0.842[b]	0.541[b]
	10%	3.11[a]	0.884[b]	0.603[a]
	25%	2.81[a]	0.967[a]	0.624[a]
Stem	Blank	1.94[a]	0.416[b]	0.510[b]
	10%	2.45[a]	0.614[a]	0.515[b]
	25%	2.33[a]	0.624[a]	0.572[a]
Forage	Blank	3.11[c]	0.863[b]	0.697[b]
	10%	3.77[b]	0.915[ab]	0.728[b]
	25%	4.166[a]	0.946[a]	0.770[a]

According to table 3, phosphorus absorbed by barley grain is significant at the level of 1% compared to the control. Probably, with the passage of time, the phosphorus in phosphate compounds has been released in an accessible form in organic and inorganic form. With the increase of Vinasse, the amount of phosphorus in the fodder increased to 10%, but it is not statistically significant, but with the addition of 25% of Vinasse, the amount of phosphorus in the fodder increased to 0.95%, which is statistically significant compared to the control. With the increase of Vinasse, the amount of phosphorus in the fodder increased to 10%, but it is not statistically significant, but with the addition of 25% of Vinasse, the amount of phosphorus in the fodder increased to 0.95%, which is statistically significant compared to the control. In the case of the stem, by adding 25% of Vinasse, the amount of phosphorus increased from 0.42 to 0.62%. In the leaves, it increased from 0.84 to 0.97% in the 25% Vinasse treatment, but there was no significant difference in the 10% Vinasse treatment. In plant seeds, by adding 25% of Vinasse, phosphorus increased to 1.56% (Table 4).

4.5. Plant potassium

According to Table 2, the concentration of absorbable potassium in the vegetative parts of the barley plant is significant at the level of 5% compared to the control, if the difference between the treatments was not significant. The effect of time on the absorbable amount of potassium in the vegetative organs of the plant was also significant at the level of 1% and with the passage of time, the amount of potassium in the vegetative organs decreased. The interaction effect of time and treatment on potassium concentration absorbed by vegetative organs of barley plant was also significant at the level of 1%. With the passage of time in the control and two Vinasse treatments, the amount of potassium absorbed by the plant de-

creased, which could be due to its stabilization among soil minerals and its removal from the reach of the plant (JafariNaini *et al.*, 2022). The increase of Vinasse increased the amount of potassium in plant seeds (0.18%), but it was not statistically significant (Table 4). When harvesting fodder, the highest concentration of potassium was obtained with 25% of Vinasse to the amount of 0.77%. Similar results JafariNaini *et al*. (2022) showed that the use of Vinasse increases the amount of potassium in the soil and sugarcane.

4.6. *Seed and forage yield of the plant*

Adding Vinasse to the soil increased fodder yield, so that by adding 25% Vinasse, a significant difference was observed with the control (Fig. 2). Also, the application of Vinasse with a probability of 1% was effective on barley grain yield and increased grain yield from 5.86 to 7.36 tons per hectare. Similar results (Alinejadian Bidabadi *et al.*, 2021) showed that the dry matter function of the aerial organ and root increases with the use of Vinasse.

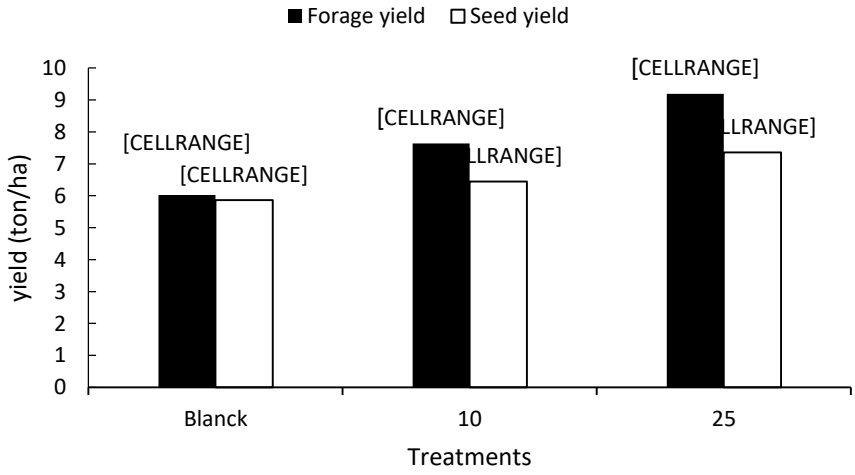


Fig. 2. Forage and seed yield in Vinasse treatments

5. CONCLUSION

The results showed that the pH of the studied soil is alkaline and the consumption of Vinasse can balance the soil conditions due to its acidity. The EC of Vinasse is high and it is full of all kinds of nutrients, the addition of Vinasse increased soil nutrients, especially nitrogen, phosphorus and potassium at the level of 1% in soil and barley plants. The increase of Vinasse in the germination stage of barley plant seeds is effective at the level of 1% and caused a decrease in the average daily germination and germination percentage. The results showed that adding Vinasse to the soil caused a significant increase in the amount of nitrogen, phosphorus and potassium absorbed in the vegetative parts of the barley plant. Adding Vinasse to the soil increased fodder yield and barley grain yield. The results showed that due to the abundance of Vinasse in food, its addition to the soil

can be recommended as an alternative to chemical fertilizers in the cultivation of plants such as barley with proper management.

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FOOTNOTES

AUTHORS' CONTRIBUTION: All authors are equally involved.

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