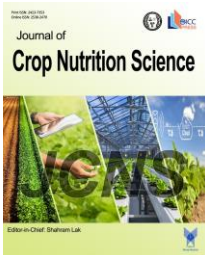

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Research Article

Research on the Effects of Vinasse and Humic Acid Along with Optimal Use of Chemical Fertilizers on Soil Nitrogen and Phosphorus Availability and Sugarcane Yield

Seyedeh Zahra Jafari Naeini[1,2], Alireza Jafarnejadi[*2,3], Kamran Mohsenifar[2], Timoor Babaienejad[2], Ali Gholami[4]

[1] *Department of Soil Science, Khuzestan Science and Research Branch, Islamic Azad University, Ahvaz, Iran*

[2] *Department of Soil Science, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran*

[3] *Soil and Water Research Department, Khuzestan Agricultural and Natural Resources Research and Education Center, AREEO, Ahvaz, Iran*

[4] *Water Studies Research Center, Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, Iran.*

***Corresponding author:** arjafarnejady@gmail.com

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Abstract

Background: Replacing chemical fertilizers with organic fertilizers can play an important role in crop management. Also, by using organic fertilizers, in addition to reducing the consumption of Nitrogenous chemical fertilizers and triple superphosphate, it is possible to reduce costs and environmental pollution, which is a move towards achieving sustainable agricultural goals.

Objectives: The aim of this study was to investigate the effect of Vinasse and Humic acid on soil Nitrogen and Phosphorus concentrations under Sugarcane cultivation conditions with chemical inputs.

Methods: Current research was done via split split plots experiment based on complete randomized block design with three replications. Vinasse at three level (0, 50, and 100 cubic meters per hectare) belonged to main plot, three levels of Humic acid (0, 2.5, and 5 kg.ha^{-1}) belonged to sub plot, and two levels of fertilizer treatment (Recommended advised to consume N, P, K and 50% of Recommended) belonged to sub sub plot.

Result: The result of analysis of variance revealed effect of effect of Vinasse, Humic acid, fertilizer and interaction effect of treatments on Nitrogen and Phosphorus concentration at both depth was significant. The highest increase in soil Nitrogen content compared to the control at a depth of (30-60) is 0.084 percent, and the highest average percentage increase in soil Nitrogen content compared to the control at a depth of 0-30 centimeters (0.081 percent) is with the use in treatments (100 m3. ha^{-1} Vinasse). The highest increase in soil Phosphorus compared to the control at a depth of (0-30 cm) and (30-60 cm) was 7.98 and 6.8 mg Phosphorus per kilogram of soil and with the in treatments (100 m3. ha^{-1} Vinasse). Consume 5 kg.ha^{-1} Humic acid achieve highest amount of Nitrogen, Phosphorus content and crop yield in both depths. So we can conclude that Vinasse, along with proper fertilizer management, can compensate for the lack and availability of some Nitrogen and Phosphorus in the soil and lead to a reduction in the consumption of chemical inputs and consequently reduce environmental pollution and by adding the highly nutritious elements Nitrogen, Phosphorus, and organic matter, it contributes significantly to soil fertility and plant growth.

Conclusion: Finally according result of current research consume 50 m3.ha^{-1} Vinasse and 5 kg.ha^{-1} with 50% recommended amount fertilizer led to produce economic yield and decrease use of conventional fertilizer based on sustainable agriculture and input management.

Keyword: Industrial crop, Nutrition, Organic matter, Soil depth, Sugarcane by products.

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1. Background

Successful production of agricultural products requires the suitable soil and sufficient amounts of plant-usable nutrients. Organic and chemical fertilizers are necessary for each other, and both types of fertilizers are needed to create suitable conditions for plant growth. Adding organic fertilizers led to increase soil nutrients and maintains them at appropriate level (Monjezi et al., 2015). Nitrogen is one of the most limiting nutrients and plays an important role in crop (Raei et al., 2020), so, it is widely used as a chemical fertilizer (Dou et al., 2017). The emergence of economic and environmental problems resulting from the waste of Nitrogenous chemical fertilizers as a result of processes such as ammonia sublimation, denitrification, and nitrate leaching has led to composts and biological Nitrogen-fixing systems replacing chemical fertilizers as part of sustainable agricultural programs (Raei et al., 2013). The use of organic fertilizer in sustainable agriculture, in addition to increasing the support and activity of beneficial soil microorganisms, acts to provide plants with nutrients such as soluble Nitrogen, Phosphorus, potassium, improves crop growth and yield (Talebizadeh and Marashi, 2019). Phosphorus, after Nitrogen, is the most important nutrient limiting agricultural production in many regions of the world (Holfold, 1997). Soils under Sugarcane cultivation in Khuzestan province are usually rich in lime and poor in organic matter, Phosphorus, and Nitrogen. The soil pH in this region about 8 to 8.5, and it is expected crop has low efficiency in Phosphorus uptake specially in soils with high pH and lime content (Alkaline and calcareous soils) (Behravan et al., 2020; Barahimi et al., 2009). Therefore, it is very important to pay attention to managing Phosphorus fertilizer consumption, increasing fertilizer efficiency, and utilizing Phosphorus reserves in the soil of sugarcane fields. The use of organic compounds to increase Phosphorus mobility in soils and consequently increase its absorption by plants has been considered in many studies (Qetrani et al., 2024; Behravan et al., 2020). Usually, the use of organic fertilizers reduces Phosphorus absorption, maximum buffering capacity, and binding energy, and increases Phosphorus concentration in the soil solution. Organic matter can act as a protective coating around fertilizer particles, or as a Phosphorus binder at anion exchange sites, or by reacting with Phosphorus to form organic Phosphorus compounds. In all cases, the availability of Phosphorus to the plant increases and Phosphorus is gradually released into the soil solution (Barahimi et al., 2009). So replacing chemical fertilizers with organic fertilizers can play an important role in crop management. Also, by using organic fertilizers, in addition to reducing the consumption of Nitrogenous chemical fertilizers and triple superphosphate, it is possible to reduce costs and environmental pollution, which is a move towards achieving sustainable agricultural goals (Talebizadeh and Marashi, 2019). Nowadays, due to environmental considerations, the desire to use the potential of humic compounds as soil improvers and plant growth stimulants has increased (Rousta and Enayati, 2019). Humic substances affect plant growth both directly and indirectly (Roudgarnejad et al., 2021). Indirect effects include improving soil properties (aeration, permeability, water holding capacity), increasing the availability of trace elements and some macronutrients such as N, Ca, Mg, P, and K, and the direct effects of Humic substances include the absorption and transfer of nutrients to plant tissues and, as a result, various biochemical effects such as protein synthesis, photosynthesis, and enzymatic activities in plant tissues (Taleh Farahi et al., 2019). Desalegn et al. (2023) by evaluation the sugarcane variety, optimal Nitrogen rate, and potential bio regulator for improved sugarcane production, juice quality, and sugar yield reported sugarcane variety D42/58 with 100 $kg.ha^{-1}$ Nitrogen and/or Agrostemin bioregulator could maximize sugarcane production, juice quality, and sugar yield. Mehdi et al (2024) reported to produce economic sugarcane yield consume 60-100 $kg.ha^{-1}$ Nitrogen fertilizer can be advised to farmers. Jafarinia et al (2023) by compare different level of Nitrogen fertilizer (200, 300, and 400 kg Urea per hectare) reported the highest sugarcane yield (99.89 tons per hectare) was obtained in the treatment of 400 kg urea per hectare and the in-furrow planting method resulted in a higher yield compared to the on-ridge planting method. Mahohi et al (2023) reported most of the soils of sugarcane fields in the Khuzestan province are calcareous and have little organic matter. The availability of nutrients such as Phosphorus and the efficiency of Phosphorus fertilizer application are low in these soils. In calcareous soils, a significant part of Phosphorus fertilizers, becomes insoluble after entering the soil and are out of reach of plants. Their results revealed that the use of Phosphorus fertilizer compared to the control, significantly improved sugarcane yield, so that the highest yield of millable cane was belonged to 20 $kg.ha^{-1}$ urea Phosphate treatment (61.3 $t.ha^{-1}$ with 18.2% increase). Also, applying of 40 kg.ha-1 of urea phosphate, only a 10.5% increase was observed compared to the control. Generally, negative effect of high Phosphorus concentrations on Nitrogen content in leaves was evident, especially in the early growth period. Makvandi et al. (2024) compared the averages and showed that the combined use of 50% Nitrogen + 50% compost with the use of bacteria increased the traits of duration and grain filling speed, grain protein percentage and wet gluten.

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Also, the highest grain yield (5864 kg.ha^{-1}) was obtained on the first planting date and the combined use of 50% Nitrogen + 50% compost and its lowest amount (1115 kg.ha^{-1}) was obtained on the third planting date and the control treatment. Behravan et al. (2020) studied the effect of Humic acid application on sugarcane and found that Humic acid application not only increased sugarcane yield but also improved Phosphorus fertilizer use efficiency. Based on the research of Rodrigues Reis and Hu (2017) conducted on 4 Sugarcane varieties for 3 consecutive harvest periods, it was shown that the values of K > N > Ca > Mg > S > P elements were found to have the highest values in sugarcane biomass, indicating the abundance of potassium in the Vinasse. Campiteli et al. (2018), reported Vinasse and filter cake improved soil microbiological conditions and fertility, although no changes were found in this study for sugarcane yield. Findings by Yin et al. (2018) in China on soils irrigated with Vinasse for 2 to 18 years showed that after long-term irrigation with Vinasse, soil acidification was observed and the amount of organic matter, Nitrogen and Potassium increased, but no significant change was observed in the increase in Phosphorus content. This research also showed that in soils irrigated with Vinasse for long periods, the accumulation of heavy metals was very small. Iran is one of the producers of sugarcane and its by-products in the Middle East, and its cultivated area has increased by almost 100% in the last 10 years. Khuzestan Province, with several sugarcane production units with a cultivated area of over 85,000 hectares, accounts for more than 99% of the country's sugarcane cultivation area. After harvesting, sugarcane is ground and sugar is extracted from its juice. One of the by-products of sugarcane is molasses, from which ethanol is produced. Vinasse is a raw material produced from the wastewater of alcohol. Vinasse, which is a type of organic matter, is 90% water (Pazoki et al., 2006). Currently, most of the Vinasse produced by sugar factories is not used and is stored in ponds to evaporate and concentrate. Since Vinasse is an important source of nutrients, needed by plants, adding it to the soil can increase fertility and improve soil properties, and consequently increase sugarcane yield. Considering the important physiological role of Nitrogen and Phosphorus and the high need of Sugarcane for these elements, the lower use of chemical fertilizers and the deficiency of these elements in the soils under the cultivation of this plant in Khuzestan province, as well as the use of wastes and their management in a way that causes the least damage to the environment

2. Objectives

Today, proper management of chemical fertilizer use and replacing or combining them with organic and biological fertilizers is of particular importance. Therefore, given the abundant and free amounts of Vinasse in sugarcane production centers, which is rich in Nitrogen and Phosphorus nutrients, its use together with Humic acid can moderate the high electrical conductivity of Vinasse. This study aimed to investigate the application of Vinasse and Humic acid to reduce the use of recommended amount of chemical fertilizers, soil Nitrogen and Phosphorus availability and sugarcane crop production.

3. Materials and methods

3.1. Field and Treatments Information

This research was carried out via Split split plot experiment based on randomized complete blocks design with three replications along 2019 year. The Main plot included Vinasse (a_1: 0, a_2: 50 and a_3: 100 m^3.ha^{-1}). The sub plot consisted Humic acid (b_1: 0, b_2: 2.5 and b_3: 5 kg.ka^{-1}) and sub sub plot included Macro elements (c_1: Conventional recommended NPK, c_2: 50% Conventional recommended NPK). Sugarcane cultivation with the CP 48-103 variety was carried out on a land dimension 1000 × 250 square meters after removing the field edges with a total of 108 plots, each plot dimension 4 × 6.3 meters with 6-meter intervals between plots (to ensure no leakage of Vinasse to adjacent plots). Place of research was located in Ahvaz city at longitude 48°35'E and latitude 31°08'N in De'bal Khazai Agro-industrial complex (Khuzestan province, Southwest of Iran). Based on the recent twenty-year statistical period of the synoptic station of the Sugarcane Research Institute, the average annual rainfall in the De'bal Khazai agro-industry was 158.7 mm and the average annual temperature was 24.7 degrees Celsius (Meteorological Organization, 2019). The soil moisture regime in this unit was Aridic and its thermal regime is Hyperthermic. The elevation of the area above sea level was 7 meters and the area had a low overall slope (0-2%) and no valleys or elevations. This area mainly has clay loam soil, which is poor in organic matter and nutrients due to continuous and excessive exploitation by sugarcane cultivation.

3.2. Farm Management

This area mainly has clay loam soil, which is poor in organic matter and nutrients due to continuous and excessive exploitation by sugarcane cultivation. To conduct this experiment, a field with dimensions of (1000×250) meters was selected. So that two meters from the beginning and end of the land were not considered. The distance between each plot was 6 meters. Each 2 furrows included 9 plots (approximately 4×3.6 meters), including the distance for adding Vinasse, loading the Vinasse solution from the Vinasse discharge pond number

1 of the Razi Alcohol Factory located in the De'bal Khazai Agricultural and Industrial Company was carried out by a 15000-liter tanker. After transferring the Vinasse solution to the experimental field, the operation of adding it to the determined treatments and the considered ratios was carried out. After adding Vinasse to the field, the operation of the field including irrigation and fertilization was carried out as usual in other fields. Irrigation was carried out by surface method using Hydroflum pipes and during the period from planting to harvest, an average of 27 thousand cubic meters of water per hectare was irrigated in 22 times.

3.3. Measured Traits

To determine the physical and chemical properties of the consumed Vinasse, a sample was transferred to the laboratory of Jundishapur University of Ahvaz for initial analysis, Also the physical and chemical properties of the soil are mentioned in table 1. Before the start of the experiment and at the end of the research, samples were collected from the field soil at depths of 0-30 and 30-60 cm. Soil samples were air-dried and crushed and passed through a 2 mm sieve. The physical and chemical properties of the soil samples after transfer to the laboratory, including soil electrical conductivity (EC) in saturated extract using a conductivity meter (Richards, 1954), soil reaction in saturated mud using a pH meter (Gee and Bauder, 1986), organic carbon (OC) content by Walkley and Black (1934) method, and soil texture by using the hydrometric method (Bouyoucos, 1962), were determined. Potassium concentration in the soil by flame photometer (Knudsen et al., 1982), calcium carbonate content by acid titration (Gee and Bauder, 1986), Nitrogen Content measured by Kejeldal method (Zarcinas et al., 1987) and available Phosphorus by extraction with 0.5 N sodium bicarbonate by spectrophotometer was measured (Sumner and Miller, 1996). At the end of cultivation, after removing the edges of plots, the cane straw was harvested and weighed to determine crop yield.

3.4. Statistical Analysis

Analysis of variance was done via SAS (Ver.9) software. Mean comparison was done with LSD test at 1% probability level.

4. Results and discussion

The soil characteristics of the studied area are approximately alkaline in acidity and high in calcium carbonate. Also, the amount of Nitrogen and Phosphorus that can be absorbed in the soil had low ability. The nutrients in Vinasse, such as Potassium, Nitrogen, Calcium, and Magnesium, are higher than in soil (Table 1).

Table 1. Physical and chemical properties of the studied soil and the Vinasse

Variable	Organic carbon	EC	pH	Na	$CaCO_3$	Mg	K^{Ab}	SO_4^{-2}	CO_3^{-2}	K Solution	P	N	Texture
	%	$ds.m^{-1}$		$Meq.Lit^{-1}$						ppm		%	
Soil	0.83	3.25	8.2	30	39.4	18.2	110	39.3	3.1	5.1	2.2	0.04	Loamy clay
Vinasse	0.2	90	4.6	4200	211	478	-	32.5	7.7	22400	0.9	0.33	

Table 2. Results of analysis of variance of measured traits

S.O.V	df	Nitrogen 0-30 cm	Nitrogen 30-60 cm	Phosphorus 0-30 cm	Phosphorus 30-60 cm	Yield
Repetition (R)	2	0.000486^{ns}	0.000651^{ns}	11.445^{ns}	3.306^{ns}	1.6713^{ns}
Vinasse (V)	2	0.000315^{**}	0.000202^{**}	37.715^{**}	29.135^{*}	5011.815^{**}
R × V	4	0.000974	0.00063	4.364	2.784	2.4160
Humic acid (H)	2	0.000388^{*}	0.000417^{*}	2.880^{*}	1.680^{*}	298.095^{**}
V × H	4	0.000214^{*}	0.000327^{*}	3.691^{*}	7.733^{*}	103.734^{**}
R × H	4	0.000342	0.000511	4.562	8.287	21.51
Fertilizer treatment (F)	1	0.000423^{**}	0.000214^{**}	23.178^{*}	19.680^{**}	1320.167^{**}
F × V	2	0.000759^{**}	0.000363^{**}	18.825^{**}	45.192^{**}	413.954^{**}
F × H	2	0.000699^{*}	0.000122^{**}	0.4140^{*}	0.778^{*}	25.024^{**}
F × H × V	4	0.000290^{*}	0.000280^{**}	26.621^{**}	18.194^{**}	32.176^{**}
Error	18	0.000098	0.000059	6.038	4.137	5.76233
CV (%)		5.53	5.08	7.71	6.2	4.03

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

4.1. The effect of treatments on soil Nitrogen concentration

The results of analysis of variance showed the effect of Vinasse, Humic acid, fertilizer treatment and interaction effect of treatments on Nitrogen concentration of soil at both depth was significant (Table 2). Humic acid, had significant effect on the percentage of Nitrogen at a both studied soil depth (0-30, 30-60 cm) it increased this element in the soil. The results of comparing the averages showed that all levels of applied Vinasse and also the amount of fertilizer recommended by the sugarcane company showed a significant increase in the percentage of Nitrogen in the soil compared to the control. The highest increase in soil Nitrogen content compared to the control was recorded at a depth of (30-60) equal to 0.084 percent and with the use of 100 cubic meters of Vinasse (Table 3).

Also, the highest percentage increase in the average soil Nitrogen content compared to the control was recorded at a depth of 0-30 centimeters (equivalent to 0.0812 percent and with the use of 100 cubic meters of Vinasse (Table 3). Comparing the measured properties at two depths of 60-30 and 0-30, it shows that the amount of soil Nitrogen is higher at the depth of 60-30, indicating leaching in the soils under Sugarcane cultivation due to excessive irrigation and high water requirements of sugarcane and proper drainage of the lands under sugarcane cultivation. Looking at the escape of Nitrogen from the soil in the form of greenhouse gases and also its leaching and also burnt harvesting, which is an outdated but permanent method in Sugarcane cultivation and industries in Khuzestan, and the continuous and continuous use of low-quality inputs in these cultivations and industries, the amount of soil Nitrogen in these lands is still at critical levels (Table 3). From the results of table (3) it can be concluded that Vinasse, along with proper fertilizer management, can compensate for some soil Nitrogen deficiency and lead to a reduction in the consumption of chemical inputs, thereby reducing environmental pollution, and by adding highly consumed nutrients, especially Nitrogen, Phosphorus, and organic matter, it can significantly contribute to soil fertility and plant growth. This result was similar with the findings of Soroush et al. (2011) who stated that increasing fertilizer increases Nitrogen and soil nitrate concentration, with the highest increase in the fertilizer treatment of 300 $kg.ha^{-1}$ of Nitrogen, but it contradicts part of their study that stated that the heaviness of soil texture, high apparent specific gravity, and irrigation limited the movement of Nitrogen to the lower layers and that the highest concentration was in the 0-30 soil layer, because in this study we observed the highest amount of Nitrogen in the 30-60 cm layer and due to leaching. Evaluation mean comparison of different level of Humic acid indicated the maximum amount of Nitrogen content (0.069% in 0-30 cm and 0.058% in 30-60 cm) in both depth was noted for 5 $kg.ha^{-1}$ and minimum of those belonged to control treatment (Table 3). Assessment mean comparison result of interaction effect of treatments showed maximum soil Nitrogen content (0.081% in 0-30cm, 0.087% in 30-60cm) was noted for 100 $m^3.ha^{-1}$ Vinasse and 5 $kg.ha^{-1}$ Humic acid with recommended amount of fertilizer and lowest one (0.040% in 0-30cm, 0.039% in 30-60cm) belonged to nonuse of Vinasse and Humic acid with 50% recommended amount of fertilizer (Table 4). So it does conclude increasing use of Vinasse led to increase soil Nitrogen content and it's better to limit consume Vinasse to 50 $m^3.ha^{-1}$.

4.2. The effect of treatments on soil Phosphorus concentration

The results of analysis of variance showed the effect of Vinasse, Humic acid, fertilizer treatment and interaction effect of treatments on Phosphorus concentration of soil at both depth was significant (Table 2). The results of mean comparison of effect of treatments on Phosphorus concentration showed that all treatment levels showed a significant increase in soil Phosphorus content compared to the control. The highest increase in soil Phosphorus content compared to the control (unlike Nitrogen, which was the highest in deep soil depths) at a depth of (0-30) was equivalent to 7.98 mg Phosphorus per kg of soil and with the use of 100 cubic meters of Vinasse (Table 3), and the highest increase in the average soil Phosphorus content compared to the control at a depth of 30-60 cm was equivalent to 6.8 mg Phosphorus per kg of soil and with the use of 100 cubic meters of Vinasse (Table 3). This result was similar with the findings of Golchin et al. (2016) who investigated the effect of using Vinasse and Nitrogen and Phosphorus additives on the growth and yield of tomato plants and stated that by adding Phosphorus to Vinasse, the yield and height of the plant increase, which indicates an increase in Phosphorus in the soil. Oliveira et al. (2014) who reported that Vinasse organic fertilizer has a good potential to replace mineral fertilizers due to its high concentration of nutrients, including Phosphorus. On the other hand, it is in complete agreement with the findings of a number of researchers who introduced Vinasse as an organic fertilizer due to its high content of nutrients such as Nitrogen, Phosphorus, Potassium, Calcium, and Magnesium (Tejada and Gonzalez, 2005; Alavi et al., 2017; Garcia et al., 2017; Kusumaningtyas et al., 2018). The results of the mean comparison showed the highest Phosphorus level was at level 3 humic acid (5 $kg.ha^{-1}$) equivalent to 6.55 mg Phosphorus per kg of soil in the 0-30 cm layer of soil (Table 3). Most Phosphorus fertilizers have low mobility in the soil and most of their Phosphorus is fixed in the form of insoluble compounds in the soil after entering the soil, so that in calcareous soils it is converted into insoluble calcium compounds and in acidic soils it is converted into iron and aluminum phosphates and is unavailable to plants and their use efficiency is reduced (Mahidi et al., 2011; Mahohi et al., 2023). An addition, with the excessive use of chemical fertilizers, most agricultural soils often have large amounts of insoluble Phosphorus reserves (Hussain et al., 2017). Reducing soil pH improves the solubility of nutrients, including Phosphorus, in the soil and plays a key role in improving Phosphorus uptake by plants in calcareous soils. (Mahohi et al., 2023). Therefore, using organic fertilizers that both contain high levels of nutrients and, like Vinasse and Humic acid, reduce soil pH and increase the availability of some elements, especially Phosphorus, can be a partial replacement for chemical fertilizers.

Assessment mean comparison result of interaction effect of treatments showed maximum soil Phosphorus content (10.5ppm in 0-30cm, 9.3ppm in 30-60cm) was noted for 100 $m^3.ha^{-1}$ Vinasse and 5 $kg.ha^{-1}$ Humic acid with recommended amount of fertilizer and lowest one (0.040% in 0-30cm, 0.039% in 30-60cm) belonged to nonuse of Vinasse and Humic acid with 50% recommended amount of fertilizer (Table 4).

4.3. Sugarcane yield

According results of analysis of variance the effect of Vinasse, Humic acid, fertilizer treatment and interaction effect of treatments on Sugarcane yield was significant at 1% probability level (Table 2). The mean comparison different level of Vinasse revealed the highest yield (61.6 $t.ha^{-1}$) was obtained for 50 $m^3.ha^{-1}$ Vinasse and the lowest one (28.2 $t.ha^{-1}$) belonged to 100 $m^3.ha^{-1}$ Vinasse (Table 3). Also by increasing Vinasse to the soil in amount of 100 $m^3.ha^{-1}$, we see a more than twofold decrease in sugarcane yield to 28.2 tons per hectare. Although this amount of Vinasse increases soil nutrients, it exceeds the tolerance threshold of sugarcane due to a sudden and high increase in soil salinity, causing an adverse effect on plant growth and a severe decrease in sugarcane yield compared to the control treatment and even the combination of Humic acid with Vinasse failed to reduce the stress caused by salinity and yield loss, and this issue is one of the limiting factors for the use of high amounts of Vinasse (Paksoy et al., 2010). It seems highest amounts of Vinasse is higher than the tolerance threshold of sugarcane in this study, and to prevent increased soil salinity and yield loss, an amounts of 50 cubic meters per hectare was recommended in studied area, in other hand add Vinasse in the soil, with the chemical fertilizers, led to increase Nitrogen, Phosphorus and potassium in the soil, are considered as a limiting factor for crop growth due to the increase in soil EC. These results are consistent with the research of Prado et al. (2013), who stated that appropriate guidelines should be followed for the amounts of Vinasse and fertilizer used in agriculture, which vary depending on the soil characteristics of the region, and to prevent excessive use and as a result of inactivation of minerals, for example, Nitrate and Potassium, and groundwater pollution and yield loss, specific recommendations should be followed for each region. Li et al. (2019) reported limit use of Vinasse consumption, with lowest amount of chemical fertilizers led to reduce crop damage and yield loss so that the best and highest efficiency and yield can be achieved from using Vinasse along with other fertilizers. By comparing the sugarcane yields to the control treatment, it is observed that Vinasse can act well as a substitute for chemical fertilizers and, in particular, reduce the use of Nitrogenous chemical fertilizers in agriculture, in addition to increasing soil potassium, to benefit from other benefits of this valuable organic fertilizer, and this is consistent with the research of Campiteli et al. (2018); Da Silva et al. (2018). The mean comparison different level of Humic acid indicated the highest yield (47.7 $t.ha^{-1}$) was obtained for 5 $kg.ha^{-1}$ Vinasse and the lowest one (39.8 $t.ha^{-1}$) belonged to control (Table 3). Assessment mean comparison result of interaction effect of treatments showed maximum yield (75.2 $t.ha^{-1}$) was noted for 50 $m^3.ha^{-1}$ Vinasse and 5 $kg.ha^{-1}$ Humic acid with recommended amount of fertilizer and lowest one (420.6 $gr.m^{-2}$) belonged to 100 $m^3.ha^{-1}$ Vinasse and nonuse of Humic acid with recommended amount of fertilizer (Table 4). But to decrease consume of conventional fertilizer (N,P,K) use of for 50 $m^3.ha^{-1}$ Vinasse and 5 $kg.ha^{-1}$ Humic acid with 50% recommended amount of fertilizer is better solution to produce economic yield based on sustainable agriculture and input management.

5. Conclusion

The results show that Vinasse can act well as a substitute for chemical fertilizers and especially reduce the use of chemical fertilizers containing Nitrogen and Phosphorus in agriculture. In general, by replacing Vinasse and Humic acid instead of chemical fertilizers, further soil degradation can be prevented. Although Vinasse, with its high amounts of elements, can cause soil and groundwater pollution, using proper management and the right and optimal amounts of Vinasse not only prevents soil and water pollution, but also protects the soil, increases nutrients and prevents its release into nature and the environment. Also, using Vinasse in crop nutrition program with the aim of producing agricultural products is an excellent and sustainable form of meeting the nutritional demands of the soil and crop ecosystem. Finally according result of current research consume 50 m^3.ha^{-1} Vinasse and 5 kg.ha^{-1} with 50% recommended amount fertilizer led to produce economic yield and decrease use of conventional fertilizer based on sustainable agriculture and input management.

Table 3. Mean comparison effect of different level of Vinasse, Humic acid and Fertilizer on studied traits

Treatments		Nitrogen (%) 0-30 cm	Nitrogen (%) 30-60 cm	Phosphorus (ppm) 0-30 cm	Phosphorus (ppm) 30-60 cm	Yield (t.ha^{-1})
Vinasse (m^3.ha^{-1})	0	0.044^{c*}	0.048^{c}	3.7^{c}	4.2^{b}	43.3^{b}
	50	0.0593^{b}	0.062^{b}	6.2^{b}	6.0^{ab}	61.6^{a}
	100	0.0812^{a}	0.084^{a}	7.98^{a}	6.8^{a}	28.2^{c}
Humic acid (kg.ha^{-1})	0	0.047^{b}	0.040^{b}	4.7^{b}	4.9^{b}	39.8^{c}
	2.5	0.058^{ab}	0.047^{ab}	5.9^{ab}	5.5^{a}	45.5^{b}
	5	0.069^{a}	0.058^{a}	6.5^{a}	5.7^{a}	47.7^{a}
Fertilizer treatment (N, P, K)	Recommended	0.069^{a}	0.061^{a}	6.4^{a}	4.8^{b}	49.3^{a}
	50% Recommended	0.038^{b}	0.040^{b}	4.9^{b}	6.8^{a}	39.3^{b}

*Similar letters in each column show non-significant difference at 5% probability level via LSD test.

Table 4. Mean comparison interaction effect of treatments on measured traits

Vinasse (m^3.ha^{-1})	Humic acid (kg.ha^{-1})	Fertilizer treatment (N, P, K)	Nitrogen (%) 0-30 cm	Nitrogen (%) 30-60 cm	Phosphorus (ppm) 0-30 cm	Phosphorus (ppm) 30-60 cm	Yield (t.ha^{-1})
0	0	Recommended	0.047^{f}	0.047^{f}	3.3^{d}	2.9^{e*}	66.8^{b}
		50% Recommended	0.041^{g}	0.039^{h}	2.6^{e}	2.5^{f}	35.3^{e}
	2.5	Recommended	0.046^{f}	0.044^{g}	3.03^{e}	3.4^{e}	64.9^{b}
		50% Recommended	0.041^{g}	0.040^{g}	2.9^{e}	2.9^{e}	42.7^{d}
	5	Recommended	0.047^{f}	0.048^{f}	3.8^{d}	3.6^{e}	58.6^{c}
		50% Recommended	0.043^{g}	0.047^{f}	2.8^{e}	2.7^{f}	40.2^{d}
50	0	Recommended	0.055^{d}	0.065^{c}	4.4^{d}	5.9^{cd}	62.2^{b}
		50% Recommended	0.049^{e}	0.047^{f}	3.6^{d}	5.5^{d}	46.2^{d}
	2.5	Recommended	0.057^{d}	0.065^{c}	5.6^{c}	6.7^{c}	65.4^{b}
		50% Recommended	0.051^{e}	0.050^{f}	4.2^{d}	5.5^{d}	45.5^{d}
	5	Recommended	0.056^{d}	0.067^{c}	5.6^{c}	6.9^{c}	75.2^{a}
		50% Recommended	0.051^{e}	0.056^{e}	4.9^{d}	5.7^{d}	40.6^{d}
100	0	Recommended	0.065^{b}	0.064^{cd}	8.6^{b}	7.6^{b}	27.8^{f}
		50% Recommended	0.057^{d}	0.060^{d}	7.8^{bc}	6.6^{c}	33.6^{e}
	2.5	Recommended	0.067^{b}	0.077^{b}	9.4^{a}	10.1^{a}	31.7^{f}
		50% Recommended	0.060^{c}	0.069^{c}	7.1^{bc}	8.3^{b}	44.3^{d}
	5	Recommended	0.081^{a}	0.087^{a}	10.5^{a}	9.3^{a}	30.1^{f}
		50% Recommended	0.061^{c}	0.077^{b}	6.9^{c}	6.7^{c}	25.9^{j}

*Similar letters in each column show non-significant difference at 5% probability level via LSD test.

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