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The vinasse and yellow trap as an alternative in the ecological control of radish (*Raphanus sativus* L.). A practical approach

La vinaza y trampa amarillo una alternativa en el control ecológico del rabanito (*Raphanus sativus* L.). Una aproximación practica

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Abstract: The objective was to determine the dose for whitefly control. The methodology is based on applied research, so the Completely Randomized Block Design was implemented, consisting of 3 blocks and 5 treatments which were: T_1 0, T_2 10, T_3 20, T_4 30 and T_5 with 40 mL of vinasse/1.6 m^2, these were applied from the first week to the fourth week with doses of 10 mL of vinasse/32 mL of water/week/1.6 m^2. The physical characteristics of the crop, the number of flies trapped in the trap and the percentage of damage to the radish crop were also evaluated and statistically evaluated using the analysis of variance and Duncan's statistical method. It was determined that the T_5 treatment with 40 mL/1.6m^2 excelled in the most optimal results, which were the following values: Crops affected:31.67 %, whiteflies per trap:7, crop size: 26.58 cm, plant weight:37.26 g, agricultural yield:7.008 t/ha and bulb diameter:3.15 cm. It is concluded that the application of vinasse is an agro ecological alternative for whitefly control, with the best results being observed with treatment T_5.

Keywords: Vinasse, yellow trap, white fly, radish, performance.

Resumen: El objetivo fue determinar la dosis para el control de mosca blanca. La metodología se basa en investigación aplicada, por lo que se implementó el Diseño de Bloques Completamente al Azar que constaron de 3 bloques y 5 tratamientos los cuales fueron: T_1 con 0, T_2 con 10, T_3 con 20, T_4 con 30 y T_5 con 40 mL de vinaza/1.6 m^2, estas se aplicaron desde la primera semana hasta la cuarta semana con dosis de 10 mL de vinaza/32 mL de agua/ semana/1.6 m^2. Asimismo, se evaluaron las características físicas del cultivo, cantidad de moscas atrapadas en trampa y porcentaje de daño al cultivo rabanito, con esta información se evaluó estadísticamente, utilizando el análisis de varianza y método estadístico de Duncan. Se determinó que el tratamiento T_5 con 40 mL/1.6m^2 sobresalió en los resultados más óptimos que fueron los valores siguientes: Cultivos afectados:31.67 %, moscas blancas por trampa:7, tamaño de cultivo: 26.58 cm, peso de planta:37.26 g, rendimiento agrícola:7.008 t/ha y diámetro de bulbo:3.15 cm. Se concluye que la aplicación de vinaza es una alternativa agroecológica para el control de la mosca blanca, observándose los mejores resultados con el tratamiento T5.

Palabras clave: Vinaza, trampa amarilla, mosca blanca, rabanito, rendimiento.

Introduction

For many years, sugarcane organic wastes such as bagasse, vinasse and other wastes have not been optimally treated or disposed of in the environment. As a result, this causes harm to public health and negative environmental impact. Research has shown that industrial activities generate emissions of particles such as soot and smoke due to the use of fuel oil and bagasse from the burning of sugar cane[1]. This situation affects health, as the Ministry of Health has shown that inadequate management of these residues has negative effects on health, ranging from simple laryngitis to more complex diseases such as cancer, neuropsychiatric disorders and vascular diseases worldwide[2].

Vinasse, an effluent derived from sugarcane residues (SR), obtained from large volumes of alcohol distillation, whose final disposal is not adequately treated, on average, 10 to 15 L of vinasse/L of alcohol produced are generated[3]. These fresh by-products of the sugar industry (cachaza, bagasse and vinasse) incorporated into the soil generate a negative impact on plants[4]. There is another assessment that explains that cachaza and vinasse, residues from the sugar agroindustry, have a negative impact when discharged into bodies of water and a positive impact when applied to the soil, the application of vinasse mainly benefits the chemical and biological properties of the soil, they conclude that vinasse benefits the soil by providing a large amount of K and organic matter (OM)[5]. Due to this problem, it is necessary to develop an alternative solution, which could be its use as a complement in the preparation of compost, or its application in pest control, due to its chemical and physical characteristics. It should also be mentioned that these effluents are characterized by high temperatures, acid pH, high COD (chemical organic demand) and total solids[6]

Hence, the incorporation of SR such as cachaza, bagasse, vinasse, has favored agriculture, whether in the preparation of compost, due to its concentration of nutrients, such as nitrogen and microelements, which supplement their availability in the soil, reducing environmental pollution and fertilizer costs. The applications of pure vinasse as an organic amendment, produce marked residual effects, positively influencing chemical properties, increasing assimilable OM, phosphorus and potassium contents, which made it possible to dispense with mineral fertilization and maintain high agricultural yields[7]. Likewise, the disposal of composted and/or biodigested vinasse in soils is a way of reducing the costs of distribution and application of these and at the same time adding a certain value, in carrying out various treatments prior to their application[8].

It has been mentioned that there is an important need to carry out research on the biocidal effect of agroindustrial and livestock by-products as a basis or complement for the registration of a series of biopesticides, which would be very useful in agriculture[9]. It should be noted that vinasse, due to its properties, can be used as a sustainable ecological alternative for pest control in vegetables, either because of its expandable odor, acid pH, as a repellent for some insects, which are attracted by the yellow color and get trapped in traps installed for this purpose, thus reducing the cost of production, obtaining ecological fruit

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and at the same time reducing environmental pollution. Currently, the biocidal effect of agro-industrial and livestock by products will make it possible to comply with international environmental and health commitments. The use of vinasse in aerobic fermentation processes is feasible because it is rich in carbon and some salts such as potassium and calcium, making it an important source of microbial growth[10]. Its use for the ecological control of pests, as a substrate for the propagation of microorganisms such as *Trichoderma* spp. can have effects on some diseases or nematodes, reducing damage to the crop and increasing its yield[11]. The study of its physicochemical properties, its importance if biological treatments are to be used[12]. Therefore, the dose of vinasse can reduce the damage of the white fly (*Trialeurodes vaporariorum*), a pest of economic importance in vegetables, compared to synthetic insecticides that have generated resistance with adverse effects for the environment. The high sugars and organic matter of the SR (vinasse), could be used as substrates to favor the multiplication of beneficial microorganisms such as *Trichoderma* spp.[13].

Therefore, this research was carried out on the use of vinasse as an ecological alternative for pest control and to reduce the damage caused by the white fly in vegetables in the area.

Materials and methods

Location of the experiment. The research was carried out in the district of Barranca, province of Barranca, located in the Lima region, temperature 23 to 25° C, relative humidity 85 to 88 %, sandy loam soil type[14].

TABLE 1
Treatment of vinasse doses

Treatments	Doses	TA	Application timing (mL/L of water/ha/week)				TH
			Week 1	Week 2	Week 3	Week 4	
T_1	0	0	0	0	0	0	0.00
T_2	10	10	62.5/200	0	0	0	62.5
T_3	10	20	62.5/200	62.5/200	0	0	125.0
T_4	10	30	62.5/200	62.5/200	62.5/200	0	187.5
T_5	10	40	62.5/200	62.5/200	62.5/200	62.5/200	250.0

Dose: mL/32 mL water/week, TA Total: mL/1.6 m^2, TH Total application: L./ha
The water used to dilute the vinasse was groundwater.

A Completely Randomized Block Design (CRBD) was used, consisting of 3 blocks and 5 treatments which were: T_1 with 0, T_2 with 10, T_3 with 20, T_4 with 30 and T_5 with 40 mL of vinasse/1.6 m^2, taking into account a control treatment and the vinasse was dosed at a rate of 10 mL/32 mL of water/week (Table 1), applied with doses of 8 mL/24 mL of water /1.6m^2 /week[15], to reduce or eliminate the action of the earthworm, the dose used was proportional to that used[16].

Radish seed was sown at distances of 0.10 m between plants and 0.50 m between rows, and yellow traps were placed in all the demonstration plots, smeared with glue for traps. Data were recorded from sowing to harvesting of the radish crop in each plot and the number of whiteflies stuck in the yellow traps.

The application of the vinasse doses of 10 mL of vinasse/32 mL of water/1.6 m^2 from the first week to the fourth week, according to Table 1. Experiment procedures. Field preparation was carried out in a conventional manner, i.e., the way it is done by farmers in the area. Soil samples were taken from the experimental area in a staggered manner and only 1 kg was taken to the National Institute for Agrarian Innovation (INIA) for evaluation[17]. The physical characteristics of the radish crop were then evaluated, such as: plant size (TS), plant weight (PW), commercial yield (CY) and equatorial bulb diameter (EBD), and the data were processed using analysis of variance and Duncan's test at 5 % error. Finally, yellow traps were placed in each plot to attract and trap the insects; the trap measures 40 cm long by 20 cm wide. Five days after planting and at harvest time, the insects stuck in each trap were counted. Once the data were obtained, they were processed by statistical analysis. Analysis of variance. The experimental information was processed with the analysis of variance, which allowed determining if there was an effect of the vinasse dose on the physical characteristics and on the ecological control of this pest.

Duncan's test. This statistical operation was performed when it was determined that there was statistical significance in the physical characteristics of the crop.

Results

Soil analysis: neutral pH (6.8 - 7.3), low MO concentration (2-4 %), nitrogen (0.1-0.2 %), phosphorus (12-36 ppm), potassium (12-250 ppm), calcium carbonate medium concentration and no danger of salts (Table 2).

TABLE 2

Basic soil fertility analysis for radish crop[18]

E.C. mS/cm 1:2.5	pH (1:2.5)	O.M. (%)	N (%)	P (ppm)	K (ppm)	$CaCo_3$ (%)	Cation exchange (mEq/100 g soil)				CIC-E
							Ca	Mg	Na	K	
1.19	6.88	1.37	0.07	12	212	1.76	16.99	0.68	0.29	0.54	18.50

EC: electrical conductivity, OM: organic matter, mEq: milliequivalent, CEC-E: cation exchange capacity, ppm: parts per million.

The concentration of microelements, low values of copper and boron, normal iron, zinc in excess, so it was necessary to apply organic matter to supply these elements (Table 3).

TABLE 3

Trace element concentrations in the area of the experiment[19]

Microelements			
Fe (ppm)	Cu (ppm)	Zn (ppm)	Bo (ppm)
103.90	7.62	11.04	1.56
Normal	Low	Excess	Low

Characteristics of the vinasse. Percentage of total solids 8.2 %, total ashes 3.99 % and others. In nutrients, a concentration of 2.35 mg of nitrogen was obtained. Also in the physical characteristics a pH of 4.92 was obtained, electrical conductivity a value of 365.7 mS/cm. (Table 4).

TABLE 4

Physical and chemical characteristics of vinasse[15]

Parameters	Value
Total solids (%)	8.2
Total ash (%)	3.99
Crude fat (%)	1.33
Total nitrogen (mg L^{-1}.)	2.35
Crude fibre (%)	1.97
pH	4.92
Electrical conductivity (mS cm^{-1})	36.7
Brix degrees (°Bx)	10.0

Percentage of plants affected. Affected by whitefly per week, is shown in Table 5, T_5 with 31.67 %.

TABLE 5
Percentage of Plants Affected by Whiteflies

Treatments	TA	Percentage of damaged plants				Average (%)
		Week 1	Week 2	Week 3	Week 4	
T_1	0	33.33	40.00	53.33	66.67	48.33
T_2	10	30.00	36.67	46.67	60.00	43.33
T_3	20	26.67	33.33	43.33	53.33	39.17
T_4	30	20.00	30.00	40.00	56.67	36.67
T_5	40	16.67	23.33	36.67	50.00	31.67

TA Total, of vinasse application (mL/1.6 m^2)

Statistical analysis of the number of whiteflies per yellow trap. Table 6, there was no significance. Treatment T_5 with 7 whiteflies attached to the trap stood out in relation to the other treatments.

TABLE 6
Statistical analysis of number of whiteflies per yellow trap

Treatments	TA	Q
T_5	40	7.00 a
T_4	30	6.33 a
T_3	20	5.00 a
T_2	10	4.00 a
T_1	0	3.00 a
Significance	**	
Coefficient of variation %	43.31	

TA Total, of vinasse application (mL/1.6 m^2), Q Quantity (N whiteflies/trap Yellow fly/1.6 m^2

Plant size. The TP is detailed in Table 7, it indicates that there were no statistical differences, its coefficient of variation was 12.21 %, T_5 with 25.68 cm stood out in relation to the other treatments.

Plant weight. The PP shown in Table 7 shows that there was no significance in the treatments and it is observed that T_5 with 37.26 g obtained higher weight in relation to the others.

Commercial yield. Table 7 shows that there were no statistical differences, however, T_5 with 7.008 t/ha obtained the highest yield. *Equatorial diameter*. As shown in Table 7, there was no effect of dose in the treatments, T_5 with 3.15 cm differed from the others.

TABLE 7
Physical characteristics of the radish crop

Treatments	Total	PS	PW	CY	BED
T_5	40	26.58 a	37.26 a	7.008 a	3.15 a
T_4	30	25.79 a	34.10 ab	6.137 a	3.02 ab
T_3	20	25.36 a	32.18 ab	5.403 a	2.64 ab
T_2	10	24.69 a	28.01 ab	4.667 a	2.40 ab
T_1	00	22.67 a	26.33 b	4.240 a	2.34 b
Significance		**	**	**	**
Coefficient of variation		12.21	14.90	38.41	14.52

Total, of vinasse application (mL/1.6 m^2), CY commercial yield (t/ha),
TP Plant size (cm), PP Plant weight (g), DE Bulb equatorial diameter (cm)

Discussion

According to the results, the percentage of affected plants shown in Table 5, it can be seen that the T_5 treatment with the lowest level of affectation that registered a value of 31.67 %, compared to the rest of the treatments. Therefore, at this dose of vinasse, a control effect on the propagation of this insect was verified, showing a lower level of damage (deterioration of the plant, reflected mainly in the leaves and in the agricultural yield, due to the action of the whitefly). This is due to the fact that the dose of higher concentration of vinasse and consequently also higher volatilization of its components, causes an intense odor that makes a hostile effect to the white fly to the radish crop, causing less damage to the plant and increasing the agricultural yield, in this regard Senatore et al.[20], indicate, with the purpose of reducing the resistance of this insect, by the excessive use of synthetic insecticides, environmental pollution and the cost of production, the application of vinasse and its different effects on the microbiota of the soil is important. It is important to mention that vinasse is the main by-product resulting from the production of bioethanol, it is a dark brown effluent with a strong odor and acid pH. This is due to its high contamination power, which is favored by substances such as: phytotoxins, antibacterials and recalcitrant compounds such as phenols, polyphenols and heavy metals, which have negative effects on microorganisms and plants[21]. The vinasse is composed of organic materials and mineral nutrients, which are part of plant compounds and constituents such as amino acids, proteins, lipids, various acids, enzymes, sugars and hormones[22]. With respect to the number of whiteflies per yellow trap, which is detailed in Table 6, it can be seen that there was no significance, i.e. the applications of vinasse did not have a statistical influence on the control of this insect, however, the highest dose, which is treatment T_5 with 7 whiteflies trapped, stood out in relation to the other treatments. It is an acid liquid (pH 3.7 to 5), with a characteristic odor, whose coloration varies from amber yellow to dark brown and which presents high temperature when produced[23].The vinasse dose of 250 m^3 ha^{-1} increased the K content in the cachaza compost and increased the P content[24]. However, a problem that persists is that the possible agronomic application of vinasse (both in the field and in experimental conditions) is its intense and persistent odor due to the presence of melanoidins[25]. In the evaluations of the physical characteristics of the radish crop such as PS, Table 7, the applications of vinasse did not influence, however, T_5 with 26.58 cm stood out in comparison to the others. At this dose of vinasse, greater availability of nutrients such as nitrogen, potassium and other micronutrients was obtained, and its physical characteristics mentioned influenced in repelling insects, which affected the development of PH, presenting good architecture. The application of vinasse in soil and its possible agricultural use in coriander (*Coriandrum sativum*), in the length of stems treated with 20 % v/v vinasse are greater than those obtained in T_0. The treatments with 5.152 and 7.879 L/ha had the greatest height[26]. The application of fortified vinasse (T_3) showed the best vegetative growth 30 days after sowing, surpassing by 25 cm in height on average all the treatments in corn crops[27]. It was investigated that Spirulina and vinasse have properties that favor the growth and development of crops, thus improving their nutritional quality[28]. The PW, Table 7, did not show statistical significance, it was also observed that the T_5 treatment with 37.26 g stood out in comparison to the other treatments. Therefore, it can be interpreted that there was an effect of the dose of vinasse on the PW, the dose of vinasse influenced the higher PW, at this dose, concentrations of nitrogen, phosphorus, potassium and microelements were added to the soil, and the greater availability of these elements promoted the absorption of other nutrients that influenced the development of the plant and therefore its weight. It should be noted that the contents of assimilable phosphorus and potassium in the soil benefited from the application of 60 m^3 ha^{-1} of vinasse; the pH was not influenced by the application of this product. Likewise, the results obtained allow us to identify the potential of vinasse as an alternative for fertilization[29]. In relation to the application of vinasse for fertilizer purposes, some authors maintain that there was a positive effect observed during the application of vinasse, increasing total organic carbon and inorganic nitrogen, which was used by corn plants[30]. The CY, Table 7, indicates that there was no significance, in other words, there was no effect of vinasse application, but it should be noted that T_5 with 7.008 t/ha obtained the highest yield compared to the other treatments. This result indicates that at this dose of vinasse, nutrients such as nitrogen, phosphorus, potassium and other nutrients were incorporated into the soil, which increased the availability and greater absorption of these elements that influenced the development of the plant and therefore the yield. In relation to the favorable effects of the application of vinasse in agriculture, there is information that the composting of vinasse effluent in organic residues of sugarcane bagasse, in order to increase the nitrogen in the final composition of this fertilizer, guano from guinea pigs was incorporated into this mixture, also taking into account the basic analysis of soil fertility, for the radish crop (*R. Sativus*, L)[31]. Another study treated SR, with the objective of using it as a fertilizer to minimize the use of synthetic fertilizers. To obtain this fertilizer, compost was made with 16.5 kg of stubble, 16.5 kg of guano from guinea pigs, 11 kg of bagasse and 11 liters of vinasse, the statistical analysis applied was analysis of variance and Duncan, it was determined that T_4 excelled in yield with 15.39 tn/ha, PW 44.66 g, PL 25.16 cm, DE 3.60 cm, polar diameter with 4.80 cm, RL 10.35 cm[32]. In ED Table 7, it was determined that there was no dose effect of vinasse applications in the treatments. However, T_5 with 3.15 cm stood out compared to the other treatments. This result analyzes that this dose of vinasse influenced the bulb thickness, hence with this dose of vinasse nutrients such as nitrogen, phosphorus, potassium and other micronutrients were incorporated into the soil, which increased the availability and greater efficiency of absorption of these elements that influenced the development of the plant and therefore the thickness of the fruit. It is worth mentioning that many studies have concluded that the use of vinasse is an organic alternative to reduce inorganic (chemical) fertilization, mainly due to its high nutritional content at low cost and soil chemical conditions[33]. The vinasse used rationally fully satisfies the needs of N, K and S, reducing fertilizer costs[34]. It is concluded that the current application of vinasse contributes to improve productivity by increasing crop biomass.

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Ethical considerations: For the development of this research, the established norms regarding ethics and morality were followed.

Research limitations: Financial difficulties and restrictions were encountered in finding similar research to ascertain the state of knowledge of our research.

Authors' contribution:*José Antonio Legua Cárdenas*, statistical processing and data analysis and interpretation. *Dante Daniel Cruz Nieto*, collaborated in the field data collection and conduct of all the technical aspects of the research. *Jose Vicente Nunja García*, participated in the critical interpretation of the information from the physical-chemical analysis and *Félix Gil Caro Soto*, in the revision of style and writing of the scientific article.

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