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Effects of fertilization experiment by liquid of anaerobic fermentation from livestock field on soil properties and plant nutrition

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The liquid of anaerobic fermentation from Livestock (LAFL) can supply nutrients for plants. Therefore, it should be beneficial to the growth of crops. The experiment was carried out with a view to study the effect of irrigation based on LAFL and separately, chemical fertilizer (CK) for ten kinds of crops. The results showed that the organic matter in the LAFL were slightly higher than those in the CK. In the LAFL, phosphorus (P) and potassium (K) content in the soil were all similar to CK. The content of calcium (Ca) and magnesium (Mg) in the soil after 5 months varied according to different crops. In addition, the content of iron (Fe), manganese (Mn), copper (Cu) and zinc (Zn) in the soil of the LAFL were all lower. The sodium (Na) concentration in the soil of LAFL and CK before and after the test were all below 250 mg kg^{-1}, indicating that the fertilization of LAFL did not significantly increase soil Na content and caused no soil salinization.

Key words: Circular economy, friendly environment, soil properties, plant nutrition, salt damage.

INTRODUCTION

As many developing countries pay attention to global food security and face the cost of high fertilizer prices simultaneously, there are many researchers conducting the recycling studies of nutrient-rich wastewater as agricultural fertilizers (Wang et al., 2019; Pradhan et al., 2017; Munir et al., 2017; Huang et al., 2017). Nutrient components had been derived from many waste resources such as cow manure, poultry manure, pig manure, aquaculture wastewater, and slaughterhouse wastewater (Kataki et al., 2016a). It showed that agricultural waste is a valuable source of nutrient recycling. In the past 40 years, the total number of livestock worldwide has increased from 7.3 billion to 24.2 billion. It had increased about three times (FAO, 2016b). Therefore, a large amount of nutrient-rich agricultural wastewater should be reused. In fact, agricultural wastewater is rich in phosphorus (P) and ammonium (NH_4^+) and much nutrients that crops can absorb. Hence, it can be used as agricultural fertilizer. Studies have shown that more than 70% of the feed consumed by animals is excreted. The excrement (that is, urine and feces) is rich in organic matter, nitrogen (N), P, potassium (K) and essential minerals (Barnett, 1994). In pig, poultry, and dairy wastes, in addition to rich in N fertilizers, the

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average total of P content is about 39.0, 9.3, and 18.0 g kg^{-1}, respectively (Barnett, 1994; Shen and Shen, 2011). Many researches inferred that nutrient-rich agricultural wastewater can be appropriately used as fertilizer.

Anaerobic digestion is a known sustainable management technology that contributes to the integrated management of livestock wastewater in agriculture and farming management. In the process of anaerobic digestion, organic residues can be converted into biofuels (biogas), and the discharged water (digested substances) can be reused as fertilizers or soil amendments in agriculture (Ferrer et al., 2009). At present, many countries have thought the following benefits of anaerobic digestion of livestock manure treatments (Garfí et al., in press): (1) Provide clean biofuel to replace the traditional one used in rural areas, for example, firewood or air-dried cow dung; (2) Reduce the consumption of firewood for cooking and heating to improve the indoor environment; (3) Protect the environment and reduce deforestation through wastewater treatment and reduce Greenhouse effect; (4) Reduce workload of collecting firewood by women and children. In order to improve family living conditions, livestock wastewater treatment has been implemented in the Andes Plateau of Central and South America in the past years to produce biogas for domestic cooking. The raw material for biogas production is excreta from cattle and pigs (Ferrer et al., 2011; Garfí et al., 2011). According to the literature, there have been many studies on the physical and chemical properties of biogas slurry (slag) (Garfí et al., 2011; Lansing et al., 2010; Tambone et al., 2010; Tani et al., 2006; Thy et al., 2003), however, the researches for fertilizer application are still scarce.

In the anaerobic digestion process, the complex organic matter is hydrolyzed into simple molecules, and then the fermentation broth is finally converted into methane and organic acids. Through this anaerobic fermentation method, the organic nitrogen in the protein is hydrolyzed to release ammonia nitrogen, which is present in the biogas slurry.

The concentration of ammonia nitrogen gradually increases from inflow water to discharge water, because the effectiveness of ammonia nitrogen is much higher than that of organic matter, so the biogas slurry (residue) is more suitable as fertilizer for crops than ordinary livestock manure (Massé et al., 2007; Lansing et al., 2010; Thy et al., 2003). In addition, the content of P and K in the biogas slurry is considerable and the availability is high. Tani et al. (2006) used cow dung biogas slurry to apply to Pennisetum and found that its yield was higher than that of raw cow dung. However, Zaldivar et al. (2006) observed that the yield of lettuce produced by the application of biogas slurry (residue) from anaerobic digesters was lower than that of compost applications. The reason may be due to the high concentration of biogas slurry (residue) that caused the damage of vegetables leaves. Therefore, it was recommended to dilute the biogas slurry with water for application to avoid crop damage (Brechelt, 2004).

In addition to the diseases and pests which affect the plants growth, the imbalance of nutrients is also the cause of their poor growth, especially in some soils with poor properties or difficult nutrient preservation. The nutrients are not easily absorbed by the roots as an usually results of poor fertility in soils (Neina, 2019). Hence, the liquid material can be irrigated into the soil directly during the different growth periods of crops and supplied to the roots for absorption and utilization. The plants will be able to absorb balanced nutrients (Mesquita et al., 2018) not only saving fertilizer costs but also avoiding the loss of nutrients. It can improve the quality of fruit production. The liquid of anaerobic fermentation from Livestock (LAFL) is rich in organic matter, minerals, as well as amino acids necessary for plant growth. It can help plants grow when applied to crops as fertilizer (Richardson and Ternes, 2011). However, for the application of LAFL it still needs to evaluate whether the various nutrients are balanced and adequately supplied for crop growth (Kholmanskiy et al., 2019) or not. This experiment consisted to irrigation of 10 crops (lemon, banana, betel nut, guava, yellow coconut, pingpon, cocoa, dragon fruit, jujube, sweet potato) with a view to evaluate its effects on the soil properties, as a tool to provide reference for farmers, in order to implement the circular economy and appropriate fertilization.

MATERIALS AND METHODS

Experimental design

Ten important crops in Kaosiung and Pingtung counties, Taiwan including lemon, banana, betel nut, guava, yellow coconut, pingpong, cocoa, dragon fruit, jujube, sweet potato leaf, were chosen for this experiment. The experiment was located in Ligang, Jiuru, Neipu, Changzhi and other towns in Pingtung County. Every crop was divided into the irrigation area of fermented livestock liquid (LAFL) and the application area of chemical fertilizer (CK). There were done calculations for required amount of fertilizer and conversion of the nitrogen content into the required amount of the LAFL per hectare (Q1) per year. Irrigation amount Q1 (metric tons/ha/year) = annual nitrogen demand (kg/ha/ Year) ÷ the nitrogen content of the LAFL in this case (mg/L) × 1.2 (replenishment amount 20%) × 10^3, the irrigation amount Q2 (metric tons/year) = the irrigation amount Q1 (metric tons/ha/year) × Apply for irrigated farmland area (hectares). The finally, the irrigation has been done according to the recommended fertilization amount for each stage, the area of CK be fertilized and managed according to the fertilization amount and method of the crop fertilization manual. The experiment has been done from April to September in 2021. The soils and plants of ten crops in the area of LAFL and CK were sampled in the 15th of each month for analysis.

Soil sampling and analysis

The soils from the areas of LAFL irrigation and application of CK were sampled from the 10 crops, respectively. The pH value was measured by the glass electrode method with a water-soil ratio of

1:1 (Mclean, 1982). The organic matter content was determined by the Walkley-Black wet oxidation method (Nelson and Sommer, 1982). After being extracted by the Bray No.1 method, the phosphorus (P) was determined by the molybdenum blue method (Murphy and Riley, 1962). Exchangeable calcium (Ca), magnesium (Mg), iron (Fe) and manganese (Mn) were extracted from the soil with 1N neutral ammonium acetate (pH=7.0), and were measured by inductive coupling plasma spectrophotometer (ICP-MS) (Parker and Bertsch, 1992). The concentration of potassium (K) was measured with a flame photometer (Baker and Suhr, 1982; Kundsen et al., 1982; Lanyon and Heald, 1982).

Plant sampling and analysis

Plant sampling was based on the most suitable sampling locations for fruit trees and short-term crops from the method of Agricultural Research and Extension Station. The mature leaves of each location were taken in a random method in the field. At least 25-30 leaves were processed for each treatment. After sampling, at the laboratory, samples were cleaned with distilled water and then put in an oven (65°C) for 24 h. At last, they were ground and stored. The leaf analysis was performed after the dried sample was decomposed with 36 N sulfuric acid. Nitrogen (N) was measured by the micro diffusion method. P was measured by the molybdenum yellow method as above description of soil analysis. The concentration of K Ca , Mg , Fe, Mn , copper (Cu), zinc (Zn) and sodium (Na) were measured by an ICP-MS method.

Statistical analysis

Statistical Analytical System (SAS) was used for the variable square analysis to calculate the difference between treatments.

RESULTS

Effects of LAFL irrigation on the soil properties of 10 garden crops

Except guava area, soil pH was slower decreased in the LAFL area than that in the conventional fertilization area in the other 9 garden crops for 5 months. It showed that the application of CK in the conventional fertilization area may cause changes of the speed of soil acidification which were faster. As for the LAFL irrigation area, because the LAFL was used as fertilizer, the acidification speed was slower without the application of CK The soil pH data of ten crops after the experiment are shown in Table 1. The CK area in jujube orchard increased by 1.14 from April to September. Although the LAFL irrigation area only increased by 0.81, the final pH of the LAFL area was about 0.04 higher than that of the CK area. The soil pH in CK area of lemon garden decreased by 0.69 from April to September, and the LAFL irrigation area only decreased by 0.39. The CK of banana area decreased by 1.07 from April to September, and the LALF irrigation area was only nearly 0.10 lower. The CK area of Pingpoyuan increased by 0.17 from April to September, and the LAFL irrigation area decreased by 0.27. The CK area of yellow palm Garden decreased by 1.07 and the LAFL area increased by 0.44. The CK area of sweet potato orchard decreased by 0.1, and the LAFL area increased by 1.29. The CK area of dragon fruit orchard decreased by 0.55, and the LAFL irrigation area only decreased by 0.36. The CK area of cocoa orchard decreased by 0.35 and the LAFL irrigation area decreased by 0.94. The CK area of betel nut decreased by 2.52, and the LAFL irrigation area only decreased by 0.71. The CK area of guava area decreased by 0.01 and the LAFL irrigation area increased by 1.2. Overall, the soil pH of CK are were higher than LAFL area at the lemon, pinpon and cocoa gardens. The soil pH of LAFL are were higher than CK area at the Jujube, banana, yellow palm, potato, dragon fruit, betel nut and guava gardens. However, the significantly increased soil pH of LAFL treatments than CK was only at the gardens of yellow palm, potato, betal nut and guava.

Table 2 showed that the soil electrical conductivity (EC) of 10 crops, no matter in the LAFL irrigation area or the CK area, is generally reduced after 5 months of treatment. However, the soil electrical conductivity of jujube, lemon, dragon fruit, cocoa and betel nut orchard, the degree of reduction was less than that in the CK area. The banana, Pingpo, yellow coconut, sweet potato, and guava orchards were more reduced than the CK area after being irrigated with LAFL. Except for the slight improvement in the treatment of several crops such as jujube orchards, most orchards have a decline regardless of the treatment. It may be most of the 10 gardens were irrigated with LAFL or chemical fertilizer and cause the amount of organic fertilizers is insufficient.

Table 3 showed that the reduction of soil organic matter in the LAFL irrigation area in the three gardens of jujube, lemon and guava were less than that in the CK area. Table 4 data shows that except the content of soil P in banana, pingpo and yellow coconut areas have been significantly reduced after 5 months of LAFL irrigation, it were slightly increased no matter in the area of LAFL irrigation or CK area. Table 5 shows that except that the soil K content in the CK area of jujube, pingpo, and guava areas decreased significantly, the other crops were slightly increased in the LAFL irrigation area or the CK area.

The K content in the soil of the LAFL irrigated area of most crops was higher than that in the CK area. Table 6 shows that with the exception of the yellow coconut in the LAFL irrigated area and the guava in the CK area, the Ca content in the soil was slightly reduced. Regardless of the treatments, the Ca content in the soil was increased for most crops. Table 7 shows that except for the significant reduction in soil Mg content in the LAFL irrigated area of banana garden, most of the other crops have increased. However, the decrease was not significant. Table 8 shows that except for the significant reduction in the CK area of jujube, the Fe content in the soil has increased regardless of whether the LAFL irrigated or CK area. Table 9 shows that the Mn content in the soil has significantly decreased in the LAFL

Table 1. Comparison of soil pH between the areas of LAFL irrigation and CK for ten crops.

pH analysis dates	Jujube		Lemon		Banana		Pingpo		Yellow coconut		Sweet potato		Dragon fruit		Cocoa		Betel nut		Guava	
	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL
2021.4.19	6.47^{b}	6.84^{b}	6.61^{a}	6.86^{ab}	7.90^{a}	7.45^{a}	5.73^{ab}	6.02^{a}	6.38^{a}	5.84^{ab}	5.38^{ab}	4.53^{b}	6.33^{b}	6.61^{ab}	6.68^{ab}	7.08^{a}	7.89^{a}	6.03^{b}	6.41^{ab}	4.58^{ab}
2021.5.17	7.43^{a}	6.97^{ab}	6.66^{a}	7.62^{a}	5.11^{c}	7.01^{c}	5.73^{ab}	5.74^{b}	5.66^{ab}	5.76^{ab}	6.54^{a}	5.29^{ab}	5.99^{b}	6.66^{ab}	6.6^{ab}	6.3^{b}	6.93^{b}	6.53^{a}	5.94^{a}	5.58^{ab}
2021.6.17	6.98^{ab}	7.06^{a}	4.77^{b}	6.54^{b}	6.31^{b}	7.17^{ab}	5.26^{c}	5.96^{a}	5.37^{b}	5.14^{c}	6.39^{a}	6.26^{a}	5.45^{c}	7.14^{a}	5.84^{c}	6.71^{ab}	5.21^{c}	6.21^{ab}	6.23^{c}	6.02^{a}
2021.7.16	6.60^{b}	7.11^{ab}	4.92^{b}	6.21^{b}	6.20^{b}	7.19^{ab}	5.60^{b}	5.77^{ab}	5.26^{b}	5.77^{ab}	5.75^{ab}	6.91^{a}	6.25^{b}	5.35^{c}	5.96^{b}	6.01^{c}	5.01^{d}	5.2^{ab}	6.37^{ab}	4.54^{c}
2021.8.16	7.15^{a}	7.46^{a}	6.10 ^{ab}	6.77^{ab}	6.59 ^{ab}	7.15^{ab}	6.34^{a}	6.15^{a}	6.30 ^{a}	6.27^{a}	5.45^{ab}	5.74^{ab}	7.06^{a}	7.09^{a}	7.35^{a}	6.67^{ab}	6.09^{bc}	6.73^{a}	6.94^{a}	6.05^{a}
2021.9.16	7.61^{a}	7.65^{a}	5.92 ^{ab}	6.47^{b}	6.83 ^{ab}	7.35^{a}	5.90 ^{ab}	5.75^{ab}	5.31^{b}	6.28^{a}	5.28^{b}	5.82^{ab}	5.78^{bc}	6.97^{a}	7.03^{a}	6.14^{c}	5.37^{c}	6.74^{a}	6.40^{ab}	5.78^{a}

LAFL= liquid of anaerobic fermentation from Livestock; CK= chemical fertilizer; the same letter in the same column of means no significant difference with 0.05 level according to Duncan's multiple range test.

irrigated areas of yellow coconut, sweet potato and guava. In addition, the Mn content in the soil of other crops had increased regardless of the treatments.

Table 10 shows that the Cu content in the soil was reduced in most treatment areas, but it was not significant in most treatment areas no matter it was increased or decreased. Table 11 shows that the content of Zn in the soil is not high in the soil of the 10 crop gardens tested. Except for a few crops in the treatment area where the soil Zn was slightly reduced, the other treatment areas have a slightly increase. Table 12 shows that the soil Na content in the LAFL irrigated area and the CK area of 10 crops has slightly increased after 5 months experiment.

In addition to the slightly increase in the dragon fruit and the guava orchard, the soil Na content has increased slightly.

The crops grown in the LAFL irrigated area only slightly increased compared to the CK area but the Na content in all the experimental areas before and after the experiment fell below 250 mg/kg. It indicated that the LAFL irrigation did not significantly increase the soil Na content that cause the injury of crops.

DISCUSSION

LAFL contained higher N, K and P than the availability of pig manure compost. The soluble N, K and P produced by the hydrolysis of organic matter in the anaerobic digestion process are more easily absorbed by crops (Lansing et al., 2010; Thy et al., 2003; Tambone et al., 2010). Thy et al. (2003) and Massé et al. (2007) showed that due to solid precipitation in the anaerobic digester, the total Kjeldahl nitrogen concentration decreased from the inlet to the outlet of anaerobic digester, and at least 72% remained in the anaerobic digester. The NH_4^+-N concentration increased by 28% from the inlet to the outlet digester, indicating that more nitrogen fertilizers available for crop use are stored in the anaerobic digester.

Table 1 showed that 5 months after irrigated with LAFL, the soil pH in the LAFL irrigated area of 10 crops were generally higher in the CK area, that is, the soil acidification rate was slower than that in the CK area. Due to no application of chemical fertilizers in the LAFL area, it caused the soil acidification rate to be slower than that in the CK area.

Although the compost was all applied in the control area of 10 crops, the C/N ratio of compost containing cattle, sheep and poultry manure generally fell between 14 and 20.

As for the C/N of LAFL was much lower than that of solid compost (Pomares and Canet, 2001), therefore, the soil organic matter measured in the CK area was higher than that in the LAFL irrigation area after 5 months of testing for ten crops.

In the experiment of LAFL, Garfí et al. (2021) found that it is suitable for growing crops in the soil texture of sandy clay loam. After irrigation of LAFL, the organic matter content (3-4%) is as high as in the forest conditions. On the other hand, P and K content were much higher than the standard critical levels of 20 and 150 ppm, respectively.

Commonly, the nutrient concentration of N is high due to the solid retention in the digester, while the P_2O_5 and K_2O in the LAFL are relatively low (Tambone et al., 2010), so no matter in the soil or plant nutrients, the N content was higher than that of P and K in the LAFL irrigation area than CK area. As for the Ca and Mg content, the soil will have different levels of Ca and Mg according

Table 2. Comparison of soil electrical conductivity (EC) (μ o/cm) between the areas of LAFL irrigation and CK for ten crops.

The analysis dates	Jujube		Lemon		Banana		Pingpo		Yellow coconut		Sweet potato		Dragon fruit		Cocoa		Betel nut		Guava	
	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL
2021.4.19	1023^{a}	858^{b}	100^{b}	68^{ab}	38^{c}	94^{a}	250^{a}	96^{b}	84^{b}	354^{a}	89^{a}	394^{a}	261^{b}	396^{b}	415^{a}	113^{b}	64^{c}	71^{c}	40^{d}	330^{a}
2021.5.17	919^{a}	1199^{a}	244^{a}	90^{a}	57^{b}	51^{b}	85^{b}	252^{a}	131^{a}	94^{b}	77^{bc}	168^{b}	668^{a}	609^{a}	313^{ab}	603^{a}	118^{b}	63^{c}	274^{a}	131^{b}
2021.6.17	80.8^{b}	189^{c}	58^{bc}	55^{ab}	134^{a}	44^{bc}	32^{c}	23^{c}	36^{bc}	28^{c}	13^{c}	54^{cd}	102^{c}	92^{cd}	52^{c}	56^{c}	6	58^{cd}	84^{d}	74^{c}
2021.7.16	59.6^{bc}	64^{c}	228^{a}	49^{b}	28^{c}	34^{c}	42^{bc}	55^{bc}	29^{c}	26^{c}	48^{b}	46^{c}	71^{d}	128^{c}	55^{c}	46^{c}	206^{a}	444^{a}	151^{b}	78^{c}
2021.8.16	74.8^{b}	88.9^{cd}	144^{b}	57^{ab}	84^{ab}	57^{b}	33^{c}	44^{c}	41^{bc}	57^{bc}	68^{bc}	67^{c}	60^{d}	87^{d}	50^{c}	80^{bc}	94^{bc}	312^{ab}	105^{c}	143^{b}
2021.9.16	33.9^{c}	112^{c}	34.7^{c}	30^{c}	27^{c}	25^{c}	45^{bc}	47^{bc}	16^{d}	17^{c}	66^{bc}	50^{c}	175^{bc}	81^{d}	42^{c}	38^{c}	37^{c}	47^{d}	199^{ab}	24^{d}

LAFL= liquid of anaerobic fermentation from Livestock; CK = chemical fertilizer;The same letter in the same column of means no significant difference with 0.05 level according to Duncan's multiple range test.

Table 3. Comparison of soil organic matter (OM)(%)) between the areas of LAFL irrigation and CK for ten crops.

Analysis dates	Jujube		Lemon		Banana		Pingpo		Yellow coconut		Sweet potato		Dragon fruit		Cocoa		betel nut		guava	
	CK	[1]LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL
2021.4.19	5.39 ^{ab}	4.94^{bc}	4.79^{a}	3.86^{a}	1.22^{c}	3.29^{a}	4.02^{bc}	6.07^{ab}	1.53^{b}	2.74^{a}	1.86^{c}	3.14^{ab}	2.20d	4.13^{bc}	2.98^{ab}	2.39^{a}	4.41^{bc}	4.41^{bc}	9.54^{a}	6.42^{c}
2021.5.17	6.21 ^{a2}	5.29^{ab}	2.43^{b}	4.36^{a}	2.22^{bc}	2.15^{b}	2.70^{b}	7.26^{a}	1.17^{c}	1.76^{bc}	4.46^{a}	3.91^{a}	5.06^{a}	5.01^{a}	2.06^{c}	2.02^{b}	3.25^{c}	3.23^{c}	9.54^{a}	8.78^{a}
2021.6.17	4.22^{b}	6.03^{a}	2.94^{b}	4.57^{a}	6.84^{a}	2.69^{ab}	5.41^{a}	5.14^{bc}	2.36^{a}	1.87^{ab}	3.30^{b}	2.10^{c}	4.27^{b}	3.92^{b}	3.60^{a}	2.47^{a}	4.72^{bc}	5.49^{a}	9.99^{a}	8.80^{a}
2021.7.16	3.98^{bc}	2.88d	1.87^{c}	2.57^{b}	1.40 ^{c}	1.26^{c}	2.36^{b}	3.10^{c}	1.28^{b}	1.23d	2.51^{c}	2.66^{bc}	2.97^{c}	3.35d	2.79^{bc}	2.65^{a}	5.84^{a}	3.95^{bc}	5.87^{bc}	5.02
2021.8.16	4.12^{b}	3.41^{bc}	2.27^{bc}	2.40^{b}	3.08^{b}	2.57^{ab}	3.70^{bc}	4.38^{b}	2.08^{a}	1.40^{c}	3.74^{ab}	2.59^{bc}	3.66^{bc}	4.02^{c}	3.09^{ab}	2.72^{a}	5.26^{a}	5.10^{a}	6.32^{b}	7.01^{bc}
2021.9.16	3.29^{c}	3.14^{c}	1.93^{c}	2.49^{b}	3.48^{b}	3.56^{a}	3.20^{b}	4.83^{b}	1.92^{ab}	1.31^{c}	2.01d	3.27^{ab}	1.97d	4.54^{bc}	2.67^{bc}	2.00^{b}	5.41^{a}	4.20^{bc}	5.01^{c}	7.25^{bc}

[1]LAFL: liquid of anaerobic fermentation from Livestock.[2]The same letter in the same column of means no significant difference with 0.05 level according to Duncan's multiple range test.

Table 4. Comparison of soil P (mg kg^{-1})between the areas of LAFL irrigation and CK for ten crops.

Analysis dates	Jujube		Lemon		Banana		Pingpo		Yellow coconut		Sweet potato		Dragon fruit		Cocoa		Betel nut		Guava	
	CK	[1]LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL
2021.4.19	9.6 ^{c2}	12.1^{ab}	8.2^{bc}	14.0^{a}	2.7^{a}	6.8^{a}	1.8^{a}	4.8^{ab}	6.9^{b}	19.0^{a}	18.1^{a}	17.8^{a}	13.1^{b}	16.9^{bc}	12.7^{b}	12.0^{b}	14.7^{b}	15.9^{bc}	18.4^{ab}	16.3^{ab}
2021.5.17	11.0^{a}	14.3^{ab}	12.6^{a}	13.5^{a}	7.0^{a}	4.3^{ab}	1.5^{a}	5.9^{a}	12.7^{a}	14.2^{ab}	15.7^{ab}	18.4^{a}	11.7^{b}	14.7^{c}	10.9^{c}	12.8^{b}	15.2^{b}	16.1^{ab}	16.3^{ab}	16.1^{ab}
2021.6.17	5.7^{c}	9.7^{c}	7.4^{c}	7.8^{c}	5.6^{a}	2.2^{b}	1.9^{a}	2.2^{b}	10.0^{ab}	8.0^{c}	9.2^{c}	16.5^{b}	15.9^{ab}	17.3^{bc}	14.9^{b}	14.1^{b}	17.7^{ab}	16.1^{ab}	16.0 ^{ab}	15.9^{ab}
2021.7.16	17.3^{a}	19.5^{a}	17.5^{a}	16.9^{a}	5.7^{a}	2.5^{b}	1.3^{b}	3.6^{b}	12.1^{a}	12.2^{ab}	19.4^{a}	20.9^{a}	20.0^{a}	28.7^{a}	22.2^{a}	19.1^{a}	27.6^{a}	28.5^{a}	22.7^{a}	24.2^{a}
2021.8.16	14.1^{ab}	17.7^{a}	8.3^{bc}	11.0^{bc}	8.9^{a}	2.4^{b}	2.0^{a}	3.3^{b}	11.7^{ab}	10.7^{b}	10.4^{b}	17.2^{a}	13.2^{b}	15.5^{c}	12.3^{bc}	13.6^{b}	16.4^{ab}	15.4^{c}	13.2^{c}	11.7^{b}
2021.9.16	10.7 ^{b}	18.2^{a}	12.8^{a}	14.2^{a}	5.9^{a}	2.0^{b}	1.7^{a}	3.7^{b}	12.7^{a}	11.8^{b}	12.3^{b}	18.6^{a}	16.3^{ab}	18.5^{b}	20.4^{a}	17.4^{a}	22.1^{a}	24.4^{a}	20.2^{a}	19.7^{a}

[1]LAFL: liquid of anaerobic fermentation from Livestock.[2] The same letter in the same column of means no significant difference with 0.05 level according to Duncan's multiple range test.

Table 5. Comparison of soil K (mg kg^{-1}) between the areas of LAFL irrigation and CK for ten crops.

Analysis dates	Jujube		Lemon		Banana		Pingpo		Yellow coconut		Sweet potato		Dragon fruit		Cocoa		Betel nut		Guava	
	CK	[1]LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL
2021.4.19	426.9^{a2}	319.0^{a}	44.1^{c}	57.7^{c}	49.4d	15.5^{c}	170.6^{a}	157.6^{b}	46.8^{c}	191.5^{ab}	129.9^{bc}	194.9^{a}	131.3^{b}	488.5^{b}	73.6^{b}	79.2^{c}	60.6^{c}	50.7^{b}	971.7^{a}	173.8^{b}
2021.5.17	113.1^{c}	117.8^{b}	32.9^{c}	45.5^{c}	128.7^{c}	180.9^{a}	91.1^{c}	189.1^{a}	105.8^{b}	89.7^{c}	112.0^{c}	110.3^{c}	270.9^{a}	749.8^{a}	85.4^{b}	89.8^{c}	25.7^{c}	64.0^{b}	111.7d	181.1^{ab}
2021.6.17	222.7^{ab}	199.3^{ab}	135.2^{b}	153.4^{b}	269.5^{a}	163.6	124.9^{bc}	175.8^{a}	256.0^{a}	104.2^{b}	117.1^{c}	112.0^{c}	240.7^{ab}	490.8^{bc}	152.2^{ab}	123.7^{b}	184.5^{a}	151.6^{a}	695.2^{ab}	176.4^{ab}
2021.7.16	122.1	307.1^{a}	134.9^{b}	154.0^{b}	180.8^{bc}	164.0^{bc}	123.9^{bc}	179.8^{a}	182.7^{ab}	180.9^{ab}	127.4^{bc}	161.4^{bc}	242.2^{ab}	627.6^{a}	175.4^{a}	180.1^{ab}	110.4^{bc}	51.2^{b}	425.5^{bc}	180.5^{ab}
2021.8.16	414.3^{a}	226.5^{ab}	159.5^{ab}	254.0^{a}	278.8^{a}	184.5^{a}	168.5^{a}	186.8^{a}	262.4^{a}	174.5^{ab}	129.4^{bc}	154.2^{bc}	260.5^{a}	499.7^{bc}	154.0^{ab}	147.1^{ab}	185.2^{a}	152.6^{a}	210.5d	262.4^{a}
2021.9.16	178.8^{b}	316.8^{a}	220.8^{a}	226.1^{a}	187.4^{bc}	176.5^{b}	141.1^{ab}	182.7^{a}	285.0^{a}	207.8^{a}	177.9^{a}	187.2^{a}	256.2^{a}	695.2^{a}	183.2^{a}	216.3^{a}	114.9^{bc}	57.7^{b}	309.1^{bc}	181.1^{ab}

[1]LAFL: liquid of anaerobic fermentation from Livestock. [2] The same letter in the same column of means no significant difference with 0.05 level according to Duncan's multiple range test.

Table 6. Comparison of soil Ca between the areas of LAFL irrigation and CK for ten crops.

Analysis dates	Jujube		Lemon		Banana		Pingpo		Yellow coconut		Sweet potato		Dragon fruit		Cocoa		Betel nut		Guava	
	CK	[1]LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL
2021.4.19	4032.8^{b2}	4354.1^{a}	1512.4^{ab}	1944.6^{ab}	954.4^{b}	1326.7^{ab}	747.1^{bc}	1476.1^{c}	460.2^{b}	1150.2^{ab}	775.1^{b}	826.9^{c}	1541.9^{b}	3357.4^{b}	2160.4^{ab}	1999.8^{b}	2508.8^{a}	1330.3^{b}	1079.8^{a}	1064.^{b}8
2021.5.17	4824.5^{ab}	4259.4^{a}	674.2^{b}	1717.0^{b}	1041.9^{b}	1188.8^{b}	538.2^{c}	1966.4^{a}	343.4^{c}	490.4^{c}	955.1^{bc}	1461.1^{bc}	3645.1^{a}	4667.5^{a}	2000.5^{b}	2759.2^{ab}	1640.2^{b}	1416.9^{ab}	965.6^{a}	1903.3^{a}
2021.6.17	4655.5^{ab}	4324.3^{a}	1448.5^{ab}	1781.3^{b}	1025.8^{b}	1323.4^{ab}	542.1^{c}	1746.6^{b}	411.8^{bc}	617.7^{bc}	841.6^{b}	1096.8^{bc}	1903.9^{b}	3589.1^{b}	2032.2^{b}	2261.5^{ab}	2049.0^{a}	1370.3^{b}	1051.2^{a}	1840.8^{a}
2021.7.16	4692.3^{ab}	4343.7^{a}	1113.3^{b}	1813.5^{ab}	1020.8^{b}	1267.4^{ab}	696.2^{bc}	1958.4^{a}	357.7^{c}	1145.3^{ab}	822.9^{b}	1127.9^{bc}	3629.9^{a}	4079.4^{a}	2007.0^{b}	2557.9^{ab}	2447.4^{a}	1374.1^{b}	1033.2^{a}	1618.8^{a}
2021.8.16	4321.6^{b}	4746.2^{a}	1670.9^{ab}	2902.5^{ab}	2438.7^{ab}	2003.7^{a}	3116.3^{a}	1681.8^{bc}	822.1^{ab}	1959.1^{a}	1018.7^{bc}	3711.3^{a}	3194.0^{ab}	4058.9^{a}	3837.4^{a}	2042.5^{b}	2094.3^{a}	2928.4^{a}	1029.1^{a}	2396.7^{a}
2021.9.16	5746.4^{a}	4474.7^{a}	3141.2^{a}	3298.0^{a}	4269.7^{a}	1530.4^{ab}	828.2^{bc}	2330.5^{a}	1742.9^{a}	730.7^{b}	2486.3^{a}	1448.2^{bc}	4601.5^{a}	4193.3^{a}	2869.7^{ab}	3363.8^{a}	2271.9^{a}	2099.7^{a}	1015.6^{a}	1727.3^{a}

[1]LAFL: liquid of anaerobic fermentation from Livestock. [2] The same letter in the same column of means no significant difference with 0.05 level according to Duncan's multiple range test.

Table 7. Comparison of soil Mg between the areas of LAFL irrigation and CK for ten crops.

Analysis dates	Jujube		Lemon		Banana		Pingpo		Yellow coconut		Sweet potato		Dragon fruit		Cocoa		Betel nut	
	CK	[1]LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL
2021.4.19	233.8^{a2}	147.8^{c}	145.7^{a}	75.3^{c}	21.0^{c}	153.0^{a}	89.7^{a}	119.6^{c}	21.5^{a}	235.3^{a}	35.6^{c}	50.1^{b}	131.6^{b}	272.5^{c}	91.7^{ab}	48.7^{bc}	130.1^{a}	75.1^{bc}
2021.5.17	182.3^{b}	220.3^{a}	84.7^{c}	105.8^{a}	58.3^{a}	36.4^{c}	48.0^{bc}	168.9^{ab}	23.4^{a}	34.0^{b}	64.9^{bc}	85.3^{a}	340.6^{a}	479.0^{a}	43.6^{c}	37.0^{c}	84.5^{c}	56.7^{c}
2021.6.17	208.5^{a}	187.5^{ab}	101.7^{bc}	104.6^{a}	26.0^{c}	122.0^{a}	70.2^{a}	151.8^{b}	23.0^{a}	68.3^{b}	38.2^{c}	81.1^{a}	241.2^{ab}	338.0^{bc}	57.7^{b}	39.0^{c}	130.8^{a}	58.4^{c}
2021.7.16	230.1^{a}	188.0^{ab}	116.0^{ab}	79.9^{c}	36.1^{bc}	137.0^{a}	54.5^{c}	153.6^{ab}	23.4^{a}	91.2^{bc}	62.4^{bc}	69.1^{a}	284.3^{ab}	359.5^{bc}	63.6^{b}	38.5^{c}	101.7^{bc}	63.0^{bc}
2021.8.16	239.4^{a}	165.6^{bc}	111.8^{ab}	87.1^{bc}	47.0^{a}	143.7^{a}	77.6^{a}	212.3^{a}	35.9^{a}	193.0^{a}	108.5^{a}	76.1^{a}	230.4^{ab}	307.9^{bc}	79.3^{b}	138.2^{a}	130.6^{a}	110.3^{a}
2021.9.16	203.8^{a}	210.2^{a}	162.9^{a}	126.3^{a}	55.7^{a}	76.7^{bc}	48.2^{bc}	155.4^{ab}	35.1^{a}	228.7^{a}	62.5^{bc}	70.9^{a}	322.7^{a}	462.8^{a}	108.7^{a}	59.1^{bc}	156.2^{a}	139.8^{a}

[1]LAFL: Liquid of anaerobic fermentation from Livestock. [2] The same letter in the same column of means no significant difference with 0.05 level according to Duncan's multiple range test.

Table 8. Comparison of soil Fe between the areas of LAFL irrigation and CK for ten crops.

Analysis dates	Jujube		Lemon		Banana		Pingpo		Yellow coconut		Sweet potato		Dragon fruit		Cocoa		Betel nut		Guava	
	CK	[1]LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL
2021.4.19	5.54^{a2}	1.66^{a}	1.29^{a}	0.82^{a}	0.44^{b}	0.72^{a}	0.99^{a}	1.68^{a}	0.58^{a}	1.35^{a}	0.60^{b}	0.51^{a}	0.72^{a}	1.29^{b}	0.59^{a}	0.56^{a}	1.50^{a}	1.04^{a}	1.70^{a}	0.82^{b}
2021.5.17	1.31^{c}	1.02^{a}	0.52^{c}	0.63^{a}	0.47^{b}	0.49^{a}	0.68^{a}	1.82^{a}	0.89^{a}	0.62^{b}	0.80^{a}	0.54^{a}	1.65^{a}	2.73^{a}	0.44^{a}	0.64^{a}	0.74^{b}	0.69^{a}	1.79^{a}	2.34^{a}
2021.6.17	1.90^{bc}	1.04^{a}	0.61^{c}	0.73^{a}	0.46^{b}	0.63^{a}	0.93^{a}	1.82^{a}	0.67^{a}	0.62^{b}	0.78^{a}	0.53^{a}	0.82^{a}	2.00^{a}	0.44^{a}	0.62^{a}	1.30^{a}	0.93^{a}	1.71^{a}	1.20^{ab}
2021.7.16	2.64^{bc}	1.42^{a}	1.04^{bc}	0.74^{a}	0.47^{b}	0.59^{a}	0.98^{a}	1.78^{a}	0.78^{a}	0.71^{b}	0.62^{b}	0.53^{a}	1.27^{a}	1.87^{ab}	0.52^{a}	$0.5^{a}8$	1.21^{a}	1.01^{a}	1.76^{a}	1.06^{ab}
2021.8.16	6.19^{a}	1.92^{a}	1.24^{a}	1.04^{a}	2.19^{a}	0.66^{a}	0.93^{a}	2.61^{a}	0.71^{a}	1.27^{ab}	1.39^{a}	0.51^{a}	0.73^{a}	1.41^{ab}	0.52^{a}	0.59^{a}	1.59^{a}	1.14^{a}	1.71^{a}	1.14^{ab}
2021.9.16	1.58^{bc}	1.64^{a}	1.30^{a}	0.67^{a}	0.47^{b}	0.49^{a}	0.74^{a}	1.81^{a}	1.33^{a}	1.91^{a}	0.69^{ab}	0.53^{a}	1.55^{a}	2.71^{a}	1.42^{a}	0.60^{a}	1.40^{a}	1.26^{a}	1.77^{a}	2.11^{a}

[1]LAFL: liquid of anaerobic fermentation from Livestock. [2] The same letter in the same column of means no significant difference with 0.05 level according to Duncan's multiple range test.

Table 9. Comparison of soil Mn between the areas of LAFL irrigation and CK for ten crops.

Analysis dates	Jujube		Lemon		Banana		Pingpo		Yellow coconut		Sweet potato		Dragon fruit		Cocoa		Betel nut		Guava	
	CK	[1]LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL
2021.4.19	43.69^{b2}	50.63^{bc}	20.30^{c}	9.47^{b}	19.24^{a}	8.14^{c}	215.46^{a}	131.14^{a}	8.71^{c}	176.98^{a}	19.46^{c}	247.10^{a}	52.96^{c}	24.25^{a}	59.31^{b}	71.00^{b}	14.30^{b}	24.53^{b}	40.13^{a}	140.81^{a}
2021.5.17	34.20^{b}	29.58^{c}	59.23^{a}	8.21^{b}	7.95^{b}	21.31^{bc}	225.47^{a}	80.13^{b}	12.88^{bc}	16.95^{c}	74.48^{a}	16.53^{c}	168.08^{a}	56.18^{a}	106.48^{ab}	212.26^{a}	9.55^{b}	10.17^{b}	76.04^{a}	43.62^{b}
2021.6.17	37.51^{b}	37.32^{b}	44.76^{bc}	9.17^{b}	16.52^{a}	10.31^{c}	217.08^{a}	115.01^{a}	10.48	69.54^{bc}	44.35^{bc}	201.47^{a}	146.76^{a}	29.05^{a}	102.29^{ab}	197.18^{a}	13.28^{b}	23.87^{b}	55.53^{a}	114.29^{ab}
2021.7.16	35.04^{b}	39.84^{b}	40.77^{bc}	9.19^{b}	17.51^{a}	20.90^{bc}	223.34^{a}	123.80^{a}	11.71^{c}	69.13^{bc}	67.61^{a}	53.59^{bc}	140.64^{a}	43.96^{a}	69.18^{b}	141.13^{a}	11.71^{b}	18.55^{b}	74.16^{a}	110.63^{ab}
2021.8.16	117.81^{a}	100.70^{a}	64.48^{a}	32.89^{a}	16.86	16.52^{c}	285.78^{a}	117.26^{a}	35.86^{bc}	95.82^{bc}	50.51^{a}	258.83^{a}	70.10^{bc}	25.86^{a}	151.65^{a}	94.29^{b}	39.03^{a}	99.85^{a}	51.49^{a}	141.87^{a}
2021.9.16	34.98^{b}	47.66^{bc}	55.19^{a}	9.13^{b}	22.53^{a}	120.19^{a}	285.63^{a}	138.56^{a}	86.70^{a}	89.16^{bc}	68.34^{a}	62.13^{bc}	160.52^{a}	47.60^{a}	70.07^{b}	182.84^{a}	59.93^{a}	53.27^{ab}	74.58^{a}	126.30^{ab}

[1]LAFL: Liquid of anaerobic fermentation from Livestock. [2] The same letter in the same column of means no significant difference with 0.05 level according to Duncan's multiple range test.

Table 10. Comparison of soil Cu between the areas of LAFL irrigation and CK for ten crops.

Analysis dates	Jujube		Lemon		Banana		Pingpo		Yellow coconut		Sweet potato		Dragon fruit		Cocoa		Betel nut		Guava	
	CK	[1]LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL
2021.4.19	90.11^{a2}	91.21^{a}	91.32^{ab}	78.91^{b}	98.28^{a}	78.55^{a}	88.66^{aa}	78.33^{a}	80.65^{aa}	53.44^{a}	51.86^{a}	53.12^{a}	63.55^{a}	59.11^{b}	112.90^{a}	79.69^{a}	68.88	57.13^{a}	69.12^{a}	64.55^{a}
2021.5.17	95.12^{a}	89.23	95.12^{ab}	93.25^{ab}	79.17^{b}	79.23^{a}	91.87	69.87^{a}	79.32	59.56^{a}	54.97^{a}	54.57^{a}	67.23^{a}	58.63^{b}	117.66^{a}	68.22^{a}	67.23	58.08^{a}	66.65^{a}	66.23^{a}
2021.6.17	88.78^{ab}	87.12^{aa}	83.89^{b}	76.56^{b}	81.32^{b}	91.28^{a}	83.23^{a}	71.82^{a}	67.23^{a}	63.35^{a}	56.66^{a}	60.59^{a}	66.33^{a}	57.22^{b}	99.97^{b}	67.87^{aa}	70.12	57.36^{a}	67.89^{a}	65.84^{a}
2021.7.16	79.45^{ab}	83.59^{a}	89.53^{ab}	80.12^{b}	83.65^{b}	93.33^{a}	59.99^{a}	83.27^{a}	59.89^{a}	68.87^{a}	63.84^{a}	62.66^{a}	59.45^{a}	66.88^{b}	113.22^{a}	62.22	66.56	58.77^{a}	58.91^{a}	60.10^{a}
2021.8.16	110.61^{a}	108.37^{a}	146.68^{a}	130.01^{a}	134.16^{a}	83.83^{a}	79.84^{a}	88.83^{a}	70.41^{a}	67.75^{a}	71.03^{a}	69.64^{a}	70.43^{a}	144.69^{a}	137.85^{a}	61.21^{a}	65.5	57.8^{a}	57.12^{a}	82.75^{a}
2021.9.16	70.62^{b}	69.81^{a}	96.04^{ab}	73.16^{b}	101.95^{a}	63.41^{a}	58.94^{a}	60.57^{a}	65.73^{a}	63.83^{a}	61.1^{a}	63.34^{a}	62.94^{a}	134.16^{a}	118.69^{a}	59.92^{a}	67.9	59.15^{a}	57.15^{a}	65.79^{a}

[1]LAFL: liquid of anaerobic fermentation from Livestock.[2] The same letter in the same column of means no significant difference with 0.05 level according to Duncan's multiple range test.

Table 11. Comparison of soil Zn between the areas of LAFL irrigation and CK for ten crops.

Analysis dates	Jujube		Lemon		Banana		Pingpo		Yellow coconut		Sweet potato		Dragon fruit		Cocoa		Betel nut		Guava	
	CK	[1]LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL
2021.4.19	2.61[a2]	1.39[a]	0.86[a]	3.22[a]	0.29[b]	0.32[a]	1.53[a]	6.89[aa]	0.74[aa]	3.63[a]	0.68[b]	4.31[a]	4.55[b]	5.92[a]	2.63[a]	2.64[a]	1.23[a]	1.64[a]	9.41[a]	8.42c
2021.5.17	2.19[a]	1.93[a]	0.42[a]	3.77[a]	0.23[b]	0.09[a]	0.54[b]	8.37	0.73	0.48[b]	2.70[a]	0.49[b]	8.28[a]	5.84[a]	1.79[a]	3.04[a]	0.53[b]	0.5[b]	8.82[a]	35.03[a]
2021.6.17	2.23[a]	1.86[a]	0.61[a]	3.66[a]	0.27[b]	0.34[a]	1.52[a]	8.29[a]	0.74[a]	1.59[ab]	1.57	4.19[a]	7.67[a]	5.87[a]	2.45[a]	2.8[a]	1.08[a]	1.23[a]	9.18[a]	14.27[b]c
2021.7.16	2.43[a]	1.65[a]	0.86[a]	3.33[a]	0.25[b]	0.14[a]	1.52[a]	7.77[a]	0.74[a]	1.15[ab]	1.67[a]	1.26[ab]	5.05[ab]	5.92[a]	2.11[a]	2.93[a]	0.78[b]	0.53[b]	9.12[a]	11.85[b]c
2021.8.16	3.07[a]	1.55[a]	0.66[a]	3.30[a]	0.27[b]	0.52[a]	1.22[a]	8.85[a]	0.74[a]	2.82[a]	1.63[a]	4.73[a]	6.69[a]	5.72[a]	2.48[a]	2.64[a]	1.58[a]	1.71[a]	5.57[b]	8.89c
2021.9.16	2.37[a]	1.73[a]	1.21[a]	4.14[a]	1.03[a]	1.63[a]	1.17[a]	8.35[a]	0.73[a]	1.47[ab]	1.79[a]	1.32[ab]	5.16[a]	6.79[a]	2.41[a]	3.01[a]	1.02[b]	0.68[ab]	7.81[a]	13.15[ab]

[1]LAFL: liquid of anaerobic fermentation from Livestock. [2]The same letter in the same column of means no significant difference with 0.05 level according to Duncan's multiple range test.

Table 12. Comparison of soil Na between the areas of LAFL irrigation and CK for ten crops.

Analysis dates	Jujube		Lemon		Banana		Pingpo		Yellow coconut		Sweet potato		Dragon fruit		Cocoa		Betel nut		Guava	
	CK	[1]LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL	CK	LAFL
2021.4.19	166.1[a2]	139.5[b]	127.9[a]	75.6[bc]	111.0[ab]	113.4[ab]	114.2[ab]	86.7[a]	92.2[bc]	89.0[bc]	105.6[a]	76.3[c]	58.8[b]	171.4[a]	80.6[ab]	67.3[ab]	49.1[b]	50.8 [bc]	136.4[a]	72.3[b]
2021.5.17	196.7[a]	243.8[a]	79.3[b]	39.5[c]	34.3[c]	29.4[c]	25.1[d]	40.4[c]	32.2	29.8[c]	39.2[d]	36.8[d]	63.9[ab]	248.3[a]	25.8[b]	29.5[b]	29.1[b]	25.6[c]	153.9[a]	126.1[a]
2021.6.17	180.7[a]	248.3[a]	87.5[b]	52.9[c]	90.1[bab]	54.8[b]	54.4[c]	68.9[bc]	79.9[c]	56.3[bc]	66.5[c]	61.3[cd]	63.6[ab]	222.9[a]	35.7[b]	41.3[b]	38.0[b]	34.3 [c]	152.7[a]	94.6[a]
2021.7.16	196.2[a]	159.5[b]	124.7[a]	143.3[a]	171.3[a]	164.2[a]	199.3[a]	81.6[a]	167.6[a]	153.3[a]	72.9[bc]	122.3[a]	163.5[a]	229.7[a]	104.6[a]	130.2[a]	142.8[a]	148.9[a]	150.4[a]	99.8[a]
2021.8.16	172.2[a]	244.4[a]	107.7[a]	139.6[a]	91.4 [ab]	72.2[b]	63.3[bc]	68.9[bc]	85.0[c]	76.4[bc]	71.8[bc]	96.4[bc]	59.0[b]	175.3[a]	74.6[ab]	102.3[a]	115.5[a]	69.9[bc]	146.6[a]	93.8[a]
2021.9.16	194.8[a]	246.9 [a]	166.4[a]	121.8[a]	127.0[ab]	127.9[ab]	64.3[bc]	85.7[a]	141.5[a]	164.3[a]	99.3[a]	123.0[a]	163.7[a]	238.6[a]	110.9[a]	140.2[a]	152.0[a]	149.7[a]	152.5[a]	96.2[a]

[1]LAFL: liquid of anaerobic fermentation from Livestock.[2]The same letter in the same column of means no significant difference with 0.05 level according to Duncan's multiple range test.

to different crops after months, and the Ca and Mg concentrations of plants will also vary according to different crops. It may be due to the demand on Ca and Mg of different crops at different growth periods. In addition, the content of trace elements of Fe, Mn, Cu and Zn in the soil of the CK area and the LAFL irrigation area were both low, which should be due to the deficiency of trace elements in LAFL. The concentrations of Fe , Mn , Cu and Zn in the plants were reduced after 5 months of testing. The soil Na content in the LAFL irrigation area and the CK area of 10 crops were tested. It was only increased slightly in only 8 crops of in the LAFL irrigation area compared to CK area. Sodium content in all test areas fell below 250 mg/kg before and after experiment. Chen and Lin (2010) believed that soil Na below 250 mg/kg would not cause the injury of crops. This experiment showed that the LAFL irrigation did not make the soil Na content dramatically increased and the soil salinization occurred. The plant Na concentration of 7 crop plants even decreased in the LAFL irrigation area and CK area after 5 months of experiment. Compared with the pre-test, there was no significant increase in the Na concentration of plants in 10 kind of crops. It showed that the LAFL irrigation did not significantly increase the Na concentration of 10 experimental crops.

Conclusion

In this experiment, 10 kind of crops were irrigated with LAFL and the area conventional fertilization by CK to compare the soil properties and plant nutrient concentration. The acidification rate of the soil of LAFL irrigation was slower than that in the CK after 5 months. Because the designed nitrogen fertilizer application rate is similar in the LAFL irrigation and CK area, hence, the difference in soil conductivity is not significant. In terms of nutrient elements, different crops have different content of soil and plant nutrients. It indicated that different crops have different requirements for nutrient elements. LAFL irrigation can not only provide appropriate fertilizers for the crops, but also copper, zinc, and sodium did not cause pollution or plant damage significantly. As a kind of fertilizer, the results of this experiment showed that it is feasible to replace chemical fertilizers by LAFL irrigation.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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