NIPES

Journal of Science and Technology Research

Journal homepage: www.nipesjournals.org.ng

Efficiency of Land Use in Longan E-Dor Farming (*Dimocarpus longan* Lour.) in Thai Lai District, Can Tho City, Vietnam

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Article Info

Keywords:
E-dor longan, soil quality, Can Tho, economic efficiency, heavy metals.

Received 12 January 2021
Revised 21 January 2021
Accepted 25 January. 2021
Available online 01 March. 2021

https://doi.org/10.37933/nipes/3.1.2021.7

https://nipesjournals.org.ng

Abstract

The study was conducted to evaluate the economic efficiency and environmental characteristics of the E-dor longan (Dimocarpus longan Lour.) farming model. Economic efficiency and chemical use related issues were assessed by interviewing farmers field survey. Soil samples were collected in the longan fields and the rice paddy field for comparison. Soil samples were collected in the longan models with different land conversion times (>5 years, 3-5 years, <1 year). The soil quality indicators including pH, organic matters (OM), total nitrogen (TN), total phosphorus (TP), total potassium (K) and heavy metals (Fe, Mn, Ni, Cr, Cu, Zn, Pb, and As) were analyzed. The average total income from longan cultivation was higher than that of rice, with about 92.6 million VND/ha, the profit/capital ratio from longan cultivation was 1.48 (excluding the labor) and 1.31 (including the labor). The longan model was evaluated using more fertilizers and pesticides than rice cultivation. Soil analysis results showed that pH was not suitable for the development of longan. The levels of OM, TKN, TP, and K in longan cultivation were lower than those in rice cultivation. Heavy metals such as Mn, Fe, Cu, Zn, Pb, Ni, Cr and As were still within the permissible limits of QCVN 03-MT: 2015/BTNMT and FAO (2001), but Fe, Mn, Zn, Cr were found to tend to be higher in longan model and accumulated over cultivated time. The initial research results showed that the yield of E-dor longan was still low, so it has not brought about high economic efficiency, the soil quality was not suitable for the development of longan; Therefore, it is necessary to have appropriate cultivation and soil improvement measures to improve longan crop. This study provides preliminary information on the economic efficiency and environmental problems of switching from rice cultivation to E-dor longan farming.

1. Introduction

In the face of economic pressures and problems related to water and land use in the Mekong Delta. It is considered as one of the fertile alluvial deltas with a natural area of about 4 million ha (accounting for 12% of the country's area), of which agricultural and fishery production area is about 2.6 million ha accounting for 65%. Shifting cultivation can be considered as a trend and choice for many areas, especially coastal areas, low-fertile and acidic areas [1]. Although the conversion can bring economic benefits, there are also many risks associated with environmental problems during long-term farming; Typically, ineffective use or abuse of harmful input sources.

Can Tho city has a total agricultural land area of 113,152.23 ha in 2015, of which the area for perennial crops was 23,241.63 ha. According to the Ministry of Agriculture and Rural Development

(2013) [2], the production of fruit trees was focused and developed in the direction of export, becoming the main crop of the city. Can Tho with an area of concentrated plantation around 6,000 ha/5 types of fruit trees. As of June 2020, the area of fruit trees in Can Tho was about 20,811 ha, accounting for 94.32% of the total area of perennial trees; increasing 12.70% (2,345 ha) compared to 2019. Meanwhile, according to the 2019 statistical results [3], many farmers converted their rice crop with a total area of more than 2,292 ha; in which, the area converted to fruit trees (mango, durian, longan, orange, and pomelo) was 1,274 ha; concentrated in Phong Dien, Co Do, Thot Not, Cai Rang and Thoi Lai districts. Specifically, longan is one of the main fruit trees in Can Tho city, with a total area of more than 1,830 ha, which is higher than the orientation of the Ministry of Agriculture and Rural Development as of 2020 (1000 ha) [2]. In Can Tho, the cultivated area of longan has tended to increase significantly in recent years, especially in Thoi Lai district. Many farmers in Thoi Lai district have converted their inefficient, unprofitable fields, mixed garden land and non-specialized gardens to cultivating E-dor longan (*Dimocarpus longan* Lour.). In addition, the market demand is relatively high, many farmers have changed their crop structure from growing rice, growing vegetables or other inefficient fruit trees to growing E-dor longan. The conversion of land use can affect soil quality, as plowing during the reclamation process, using uncontrolled fertilizers that can contaminate soil environment. This study was conducted to evaluate economic efficiency and environmental issues in the E-dor longan cultivation model in Thoi Lai district, Can Tho city. The results of the present study can help in setting up measures to improve the environment and as a basis for future studies on transforming farming patterns in agriculture.

2. Methodology

The study was carried out in both qualitative and quantitative methods, in which qualitative data was collected through interviewing farmers in the longan farming. Quantitative data was obtained by collecting soil quality samples in the longan farming at different stages of land transformation (<1 year, 3 - 5 years, ≥ 5 years).

2.1 Interview methods

The selection criteria for the respondents for the study were households that switched to growing longan from <2 years, 2 - 5 years and ≥ 5 years (n = 10). Semi-structured interview method was conducted to collect information on farming techniques and costs in the households cultivating E-dor longan in Thoi Lai district, Can Tho city which is considered to be the place to carry out the transformation of the most farming model. Based on the information gathered during the interview, economic efficiency was calculated through the total cost, total income, profit and the rate of return. The rate of return can reflect the efficiency of capital use in production; In addition, the profit margin also showed the relationship between profitability and production costs, the higher the ratio, the more efficient production was. Specifically, when the rate of return is greater than 1 means there was profit (good land use efficiency), less than 1 means no profit (poor land use efficiency). The collected data is calculated by formula (1), (2), (3) and (4).

Total cost (VND/ha) = Material cost (Fertilizers, pesticides, fuel) + Labor cost (hired labor and home labor) + Opportunity cost (loan interest) (1)

Total income (VND/ha) = Total harvested yield (kg/ha) x Price (VND/kg) (2)

Profit = Total income - Total cost (3)

Rate of return = Profit/Total cost (4)

In addition, information on the use of fertilizers and pesticides was also collected during the interview of the longan farming households. The information collected included the pesticides used, the frequency and doses. The obtained pesticides data will be searched for the classification of active ingredients by domestic and foreign databases as well as their potential impacts on the environment.

2.2 Soil sampling and analyses

In combination with farmer interviews, soil samples were collected according to the guidance of TCVN 7538-2: 2005-soil quality-sampling (Vietnam Environment Administration, 2005). In Garden 1, the study collected 4 sub-soil samples (symbolized from D1.1 - D1.4) (Figure 1a), each sub-sample collected about 1kg of soil. Similarly, 4 sub-samples were collected in garden 2 (D2.1 - D2.3) (Figure 1b), 6 sub-samples from garden 3 (D3.1 - D3.6) (Figure 1c) and 4 sub-sample in the rice field (D4) (Figure 1d). Depending on the available area of the garden, the number of forms is appropriate. Soil samples were collected at a depth of 0 - 20 cm; Samples were stored in plastic bags and labeled. Distribution of the sampling locations was shown in Figure 1.

Table 1. Description of soil sampling locations

Site	Conversion time	Site description
Garden 1 (D1)	> 5 years	Garden land has been cultivated for a long time and converted to longan cultivation. Soil at the time of sampling is high moisture, porous, with soil organisms (worms), the vegetative layer is mainly biodegradable leaves
Garden 2 (D2)	3 - 5 years	Paddy land has been converted to longan for 3 - 5 years. Thick vegetations (mainly leaves), loose soil; the lower layer is much clay and soft.
Garden 3 (D3)	< 1 years	Converted from paddy fields to longan. At the time of collection, the soil is soft, clay-rich and has a straw yellow color because the alum layer is converted to a surface layer.
Rice field (D4)	-	In the period, farmers are flooding the field with water.

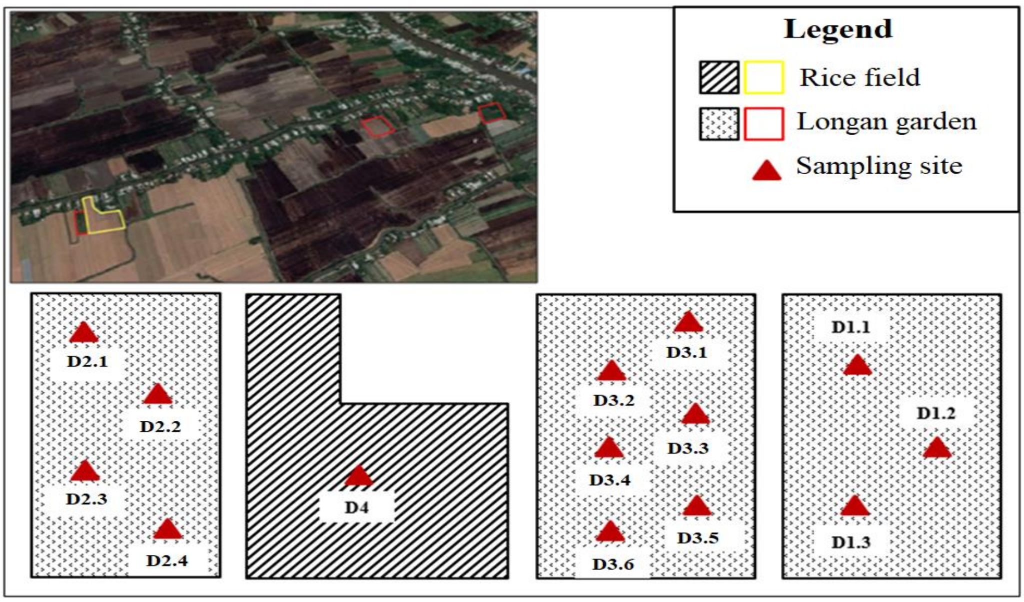

Figure 1. Demonstration of the soil sampling sites

The soil samples after collected in the field were dried at room temperature, grounded and sieved through a 0.5 mm sieve, the soil samples after the sieved were weighed with a weight of 50g/one sub-sample. The sample was then mixed again to obtain a pool sample representing a garden. The prepared samples then were used for analysis of pH, organic matter, total nitrogen, total phosphorus, total potassium and heavy metals (Mn, Fe, Cu, Zn, Pb, Cr and As). In which, organic matter was analyzed by Walkley-Black dichromate (Walkley-Black dichromate wet oxidation method), total nitrogen (TN) was analyzed by Kjeldahl method, and total phosphorus (TP) was analyzed by colorimetric method after the digestion using the mixture of H_2SO_4 and $HClO_4$. For heavy metal analysis, the prepared samples (0.5g) were digested using a microwave digester (Microwave digester, Milestone, Ethos) using the method of the US Federal Bureau of Environmental Protection (EPA3051) by adding 10 mL of 65% nitric acid and operating under 1,000 watts of power, 175^oC for 5 min 30s and then maintained at 175^oC for 10 min [4]. Heavy metals including Mn, Fe, Cu, Zn, Ni, Pb, Cr and As were determined by atomic absorption spectrophotometer (AAS, Agilent, AA240).

Analysis results of soil were compared with QCVN 03-MT: 2015/BTNMT on allowable limits of some heavy metals in the soil [5] and some other related studies. In addition, One-way Anova analysis using the Ducan test was used to evaluate the significant differences in soil physicochemical properties between longan gardens at different conversion time. The difference was considered significant when $p < 0.05$, corresponding to a 95% confidence level. Statistical analysis was performed using SPSS version 20.0 software (IBM SPSS Statistics for Windows).

3. Results and discussion

3.1 Land use efficiency of the E-dor longan farming

The survey results showed that the number of households with an area of longan cultivation under 0.3 ha accounted for the highest rate of 36.4%, followed by the households with a longan cultivation area of 0.3 - 0.5 ha, accounting for 36.3%. The longan planting area ranges from 0.6 to 1 ha (accounting for 27.3%) and there is no household with an area larger than 1 ha. In general, the production area of E-dor longan of farmers was small and scattered. This can make it difficult to encourage farmers to join cooperatives or deploy VietGAP and GlobalGAP models.

In addition, land use efficiency was assessed through the economic efficiency of land use models. The results of cost calculation have recorded that the total investment cost for one ha of E-dor longan in 2020 was about 40.02 million VND (not to mention the depreciation costs of equipment, labor tools and the initial cost for the first year such as, costs increase, costs of equipping equipment and tools). With prices ranging from 12-20 thousand VND/kg and the average yield of about 4.13 tons/ha, the average profit of farmers was 52.58 million VND/ha. However, according to the results of previous study by Tan (2018) [6] in O Mon district, Can Tho city, the average yield was 20,995 tons/ha and the average profit was 489.73 million VND/ha. This can be seen that the yield of E-dor longan of farmers in Thoi Lai district was very low. The reason may be that, there are many newly converted areas, so farmers do not have experience in planting and care techniques.

The E-dor longan model only brings about average economic efficiency, the rate of return/capital was only 1.31 (including home labor). This can be explained by the year 2020, the longan consumer market was affected by the disease situation (Covid-19 pandemic), so the longan price was lower than in the previous years. From the survey, it was observed that the capital efficiency as well as the average profit/year/ha of the longan cultivation model brought higher economic efficiency than those from the three rice crops per year and 2-rice crop + 1 upland crop/+ fish in 2015 in Thoi Lai district with average profit margins of 1.12, 1.06 and 1.27, respectively [7]. Thus, the conversion of crops structure of farmers in terms of economy was appropriate. The survey results of this study also showed that there were two reasons for the conversion from other crops (rice, vegetables, fruit trees) to E-dor longan. The first reason was due to economic factors, accounting for about 55% of farmers decided to convert to longan cultivation. The study by Tan (2018) [6] also reported that on average, farmers earned a profit of 511.5 million VND/ha in 2017 (excluding home labor), which was considered a relatively high level of profit in agricultural production. The second reason was said to be relatively easy farming techniques (easy to care for, less time consuming than vegetables, rice). This was because the E-dor logan has outstanding properties such as broad adaptability, less pest attack, good waterlogging and drought tolerance thanks to the root systems.

Table 2. Cost and profit in the E-dor longan farming model

Costs	Amount (million VND/ha)	Proportion (%)
Fertilizers	22.35	55.85
Pesticides	4.14	10.34
Fuel	1.65	4.13
Hired labors	5.17	12.91
Home labor	6.71	16.77
Interest rate	0	0
Total cost	40.02	100
Total revenue	92.60	-
Net profit	59.29	-
Profit with home labor	52.58	-
Rate of return/capital *	1.48	-
Rate of return/capital **	1.31	-

*Notes: * not included home labor; ** included home labor*

3.2 Current status of fertilizers and pesticides use

From the survey results, it was shown that farmers only applied fertilizers according to their experience, most of the households applied fertilizers with relatively low levels and 100% of the surveyed households only used inorganic fertilizers. According to the report of Trinh (2000) [8] that longan from 5 years old can be applied 600 g N, 150 g P_2O_5 and 800 g K_2O/tree for good yield. For longan, this amount of fertilizer increases by 10% each year, the maximum amount of fertilizer is 10 years old and then does not increase [9]. This indicated that farmers did not pay attention to the balanced fertilization, compared to the recommended amount, they applied excess phosphorus, but lacked nitrogen, potassium, and larger plants but applied less fertilizer compared to small plants (Table 3). The reason for the unbalanced fertilization was that most households use NPK complex fertilizers (20-20-15, 16-16-16, 15-15-15) to fertilize the trees. But not using single fertilizers to mix the right proportions.

Table 3. Current status use of fertilizers in E-dor longan

No.	Years of the longan	Fertilizers	Dose (g/tree)	Yearly average (kg/ha/year) *	Three-rice crop (1 year) **
1	< 2 years	N	354.0	590.0	318.7
		P	354.0	590.0	239.7
		K	262.5	437.5	216.6
2	2 - 5 years	N	340.0	566.7	-
		P	340.0	566.7	
		K	255.0	425.0	
3	≥ 5 years	N	336.25	560.4	-
		P	336.25	560.4	
		K	348.75	581.2	

*Note: * calculated with the density 6x6; ** Kiem (2015)* [10]

Furthermore, compared with the 3-crop rice model in An Giang [10], the amount of fertilizer used for longan cultivation was assessed at a higher level. Therefore, the high fertilizer use and the garden soil mount high, farmers applied fertilizers by scattering fertilizers on the soil surface. This could lead to the nutrient loss in E-dor longan model may be higher than that in rice farming practices. According to the research by Dung (2017) [11], only about 20% of phosphorus added to the soil by fertilizer is usable by the plants, 75% was fixed in the soil, 5% was eroded and 1% was deep penetration. Because phosphate fertilizers are difficult to dissolve compounds and are easily fixed in the soil, they often need to be applied at higher amounts than recommended to provide timely phosphorus demand for plants. This can lead to higher phosphorus concentration in soil, increasing phosphorus leaching into the environment, affecting water quality.

Table 4. Current use of pesticides in the E-dor longan farming

STT	Tên thương mại	Active ingredients	Toxic group[1]	Potential impact [2]
1	Regent 800WG	Fipronil CTHH: $C_{12}H_4Cl_2F_6N_4OS$	II	Low solubility in water, low volatility and not much mobility in the environment. Quite stable in soil systems but less so in aquatic and sediment systems. Very toxic to humans and bioaccumulates in the natural food chain. Fipronil is highly toxic to mammals, birds and bees but slightly less against fish, aquatic invertebrates, aquatic plants and earthworms..
2	Super Bomb 200 EC	Hexythiazox CTHH: $C_{17}H_{21}ClN_2O_2S$	III	Less soluble in water (20ºC), harmful to other organisms at low levels. Substances can cause cancer in humans. Low water solubility, volatile, not leaked into groundwater. Moderately toxic to mammals and does not bioaccumulate.

		Pyridaben CTHH: $C_{19}H_{25}ClN_2OS$		Highly toxic to most aquatic organisms and honey bees, but less to earthworms and birds.
3	Tami 1.9 EC	Emamectin Benzoate CTHH: $C_{49}H_{75}NO_{13}$	II	Solubility in water is low, with relatively little volatility. Low bioaccumulation potential. However, it is likely to become a groundwater pollutant. Less toxic to the user.
4	Tasieu 1.9 EC		III	
5	Susupes 1.9 EC		III	

Note: [1] Classification followed by WHO, [2][12] *Lewis et al. (2016)* [13]

E-dor longan grows strongly, easy to set fruit, high yield, especially leaves only mildly infected with dragonfly disease and rarely attacked by pests. So basically, the amount of pesticides farmers spraying for longan was almost very low, about 2-3 times/year. The study by Tung (2013) [14] and Nhan (2018) [15] on a three rice-crop farming model in Kien Giang and Hau Giang reported that the frequency of spraying pesticides was 3 times/crop was 7-8 times/crop, respectively. Meanwhile, Giao et al. (2020) [16] has recorded that on average, each household growing rice in Tan Thanh commune sprayed 5.5 times/crop. As can be seen that the frequency of spraying pesticides on longan cultivation tended to be lower than rice cultivation. In addition, the five pesticides including Regent 800WG, Tasieu 1.9 EC, Super Bomb 200 EC, Tami 1.9 EC and Susupes 1.9 EC belonged to 4 groups of active ingredients (Fipronil, Hexythiazox, Pyridaben and Emamectin Benzoate) were commonly used in the longan cultivation (Table 4). These pesticides are on the list of pesticides permitted for use in accordance with Circular No. 10/2020/TT-BNNPTNT dated September 9, 2020 on the List of pesticides permitted for use and banned in Vietnam [17]. For the three rice-crop cultivation model, there were about 137 pesticides (67.2% of the toxic group III (dangerous), 31.1% of the toxic group II (high toxicity), 0.8% of the toxic group I (very toxic). and 0.8% of different poisonous groups IV (careful) were used [14]; in which, about 40 pesticides were used regularly [16]. This proved that the pesticide used in the rice cultivation model is much higher than that of the E-dor longan cultivation model. In addition, the results have shown that farmers only used pesticides when they observed insects or pests on the plants and used the recommended dosage on the instructions. However, in the process of using pesticides there was no appropriate protection health and management of pesticide casings after use. Therefore, it is necessary to take measures to minimize the exposure of active substances to the human body because the pesticides used in longan cultivation are composed of toxic compounds. The risk of poisoning to the people who come into contact with and consumers of agricultural products, affecting the environment and degrading agricultural ecosystems.

3.3 Soil quality in E-dor longan farming

3.3.1 Nutrients in the soil

The analytical results (Table 5) showed that the pH value ranged from 4.76 ± 0.02 - 5.39 ± 0.02 and there was a statistically significant difference between orchards with different conversion time. In general, according to the assessment scale of Hung (2004) [18], soil pH in all 4 locations was low pH, weak acidic [19] and was considered to be typical of alluvial soil in Vietnamese Mekong Delta [20]. The highest pH value was 5.39 ± 0.02 at D3 position - the soil was planted with E-dor longan for less than 1 year, the reason could be that the soil was treated with lime by the farmer. The lowest value was 4.76 ± 0.02 at position D2 - the land was planted with rice for 3 to 5 years. The decrease in pH from the D3 position can be caused by many factors such as a part of the cation absorbed by the plant; because during the first 3 years, the tree grew fast and well (young tree period). Another reason for reducing soil pH was due to the long-term use of nitrogenous chemical fertilizers such as NPK, DAP [21]. The study by Van (2008) [22] pH values ranging from 5.5 - 6.0 are suitable for the development of longan; therefore, all three locations were lower than the appropriate range for longan growth. Moreover, at 3 locations of longan cultivated soil with pH <5.0, plants can be poisoned with Al, Mn, Fe [23]. For rice cultivation, due to being in the period when farmers keep water to wash the rice field, the pH may increase to 6-7 and not affect the growth and development of rice plants.

Table 3. Characteristics of soil in the longan farming

Parameter	**Unit**	**D1 (> 5 years)**	**D2 (3 – 5 years)**	**D3 (< 1 years)**	**Rice field**
pH		4.99 ± 0.02^b	4.76 ± 0.02^d	5.39 ± 0.02^a	4.93 ± 0.02^c
OM	%	4.13 ± 0.07^b	4.30 ± 0.18^b	3.89 ± 0.11^c	7.72 ± 0.11^a
TN	%	0.16 ± 0.00^b	0.09 ± 0.00^c	0.09 ± 0.00^d	0.28 ± 0.00^a
TP	%	0.05 ± 0.00^b	0.06 ± 0.00^a	0.04 ± 0.00^d	0.05 ± 0.00^c
K	%	0.07 ± 0.00^b	0.11 ± 0.001^a	0.10 ± 0.001^c	0.08 ± 0.002^c

In addition to pH, the organic content in the soil was also considered an important component determining soil quality and the presence of heavy metals in the soil because reducing organic matter can reduce the locking, reducing the supplying nitrogen, phosphorus, potassium and trace elements and reducing crop yield [24]. The content of organic matter at 3 locations of longan cultivation was moderate (3.89 ± 0.11 - 4.30 ± 0.18%) based on the rating scale [18], ranged from much lower than the organic matter content in field soil. In which, the lowest content wass determined at position D3 (3.89 ± 0.11%); This was as expected due to the fact that the lower soil layer has just been brought up, but most of the content of organic matter was highly concentrated in the surface layer [25]. In addition, the soil has only grown in a short time, so the amount of vegetation and dead plant residue in the soil was not high. ANOVA analysis results also showed that the organic matter content in 3 longan soil locations was statistically significant different from that of the organic matter content in rice cultivation (p <0.05); However, there was no difference in the study between the longan cultivation model that was converted 3 - 5 years and over 5 years (p> 0.05). The main difference between the organic matter content of rice versus longan cultivation was explained by the decomposition of straw under continuous inundation [26,27]. While the soil conditions weree high, organic matter was easily washed away into water bodies. Moreover, the organic matter content in the surface layer must be at least 3.5% to be suitable for plants [28]; therefore, the content of organic matter in the soil at 4 locations was suitable for plants.

Through the analysis results Table 3 showed that the total nitrogen ranged from very low (0.09 ± 0.00%) to medium (0.28 ± 0.00%) [29], with a statistically significant difference at all survey sites (p <0.05). Nitrogen content in soil was lowest at less than 1 year and 3-5 years (0.09 ± 0.00%) and highest in rice field (0.28 ± 0.00%) corresponding to organic matter because 95% of total nitrogen was reported related to organic matter; However, this correlation was not tight because the total nitrogen content depends on plant abundance and fertilization regime [20]. The total nitrogen content in the longan soil group was lower than that in the rice field, the reason may be that the fertilization technique in the longan cultivation model was mainly spraying on the surface, leading to easy leaching out than rice cultivation.

Phosphorus content in soil usually varied from 0.04 ± 0.00 - 0.06 ± 0.00%, the difference was statistically significant (p <0.05). The lowest phosphorus content was at position D3 (<1 year), this can be explained by the soil layer below that has just been tugged up as a surface, inorganic phosphorus content in soil was usually higher than organic phosphorus and increased with surface depth while organic phosphorus content was highest in the surface layer. On the other hand, high iron content in soil and low pH condition (4.76) fixed phosphorus in soil. In addition, the total phosphorus content at positions D1 (> 5 years) and D2 (3-5 years) were higher than D3 (<1 year) due to the return of phosphorus from plant residue and chemical fertilizers. In general, the analyzed soil samples have total phosphorus content reaching the poverty level, only D3 location (<1 year) was evaluated at very poor level [30]. However, in practice, in terms of soil fertility, total phosphorus is not of great significance because most phosphorus exists in a form that is not useful to plants [31]. Soils with total phosphorus content greater than 0.1%, crops will yield high and stable [32]. Therefore, plants may not be provided with enough phosphorus if there are no measures to improve and provide nutrients to the soil.

After nitrogen and phosphorus, potassium is the third most important nutrient for crops, especially the tree with high sugar [33]. The analytical results from Table 3 showed that the total potassium content ranged from 0.07 ± 0.00 - 0.11 ± 0.001% and there was a statistically significant difference between the transition time. However, the Ducan test did not find a significant difference between paddy land and longan conversion land <1 year. According to the Kyuma scale (1976)[34], the total potassium content in the soil was at medium level, only at the D1 site it was poor. According to Dang and Hung (1999) [32], the total potassium content in the soil> 0.29% is evaluated as a soil capable of high and stable productivity. The useful form of potassium for plants is metabolic potassium, which accounts for only 0.8 - 1.5% of the total potassium [35]. Consequently, soil potassium content at the survey sites may not be able to provide the crop's sufficient amount of potassium. In general, soil nutrient content was assessed good during the period from paddy to longan for 3 years. However, longan cultivated land was reported to have lower nutrient content than rice cultivated land.

3.3.2 Heavy metals in E-dor longan and rice soils

Iron was found to be the most dominant metal among the essential metals in agricultural soils. This finding was also reported similarly to that of Salem et al. (2020) [21]. The analytical results showed that the total iron content in the soil ranged from 22,767.8 ± 884.1 to 29,856.5 ± 583.8 mg/kg, the average at 3 locations of longan cultivation was 26828 mg/kg. A statistically significant difference was noted between the transition periods to longan cultivation; However, Fe content in longan cultivation less than 1 year was not different from that in rice field (p> 0.05). According to research by Ba and Triet (2000) [36], the solubility of Fe depends greatly on pH, organic matter, mechanical composition, phosphorus content, humidity. Specifically, pH of soil in the study was lower than 5.0, with this value, Fe content will strongly mobile, making plants may have symptoms of poisoning [23]. In addition, mobile Fe will fix phosphorus, making phosphorus content not available for the crop [37]. On the other hand, the variation of Fe in longan and rice cultivation can also be explained by the use of continuous inorganic fertilizers [38]. To overcome iron toxicity, for garden soils can be limed, for field soils can be flooded for a while.

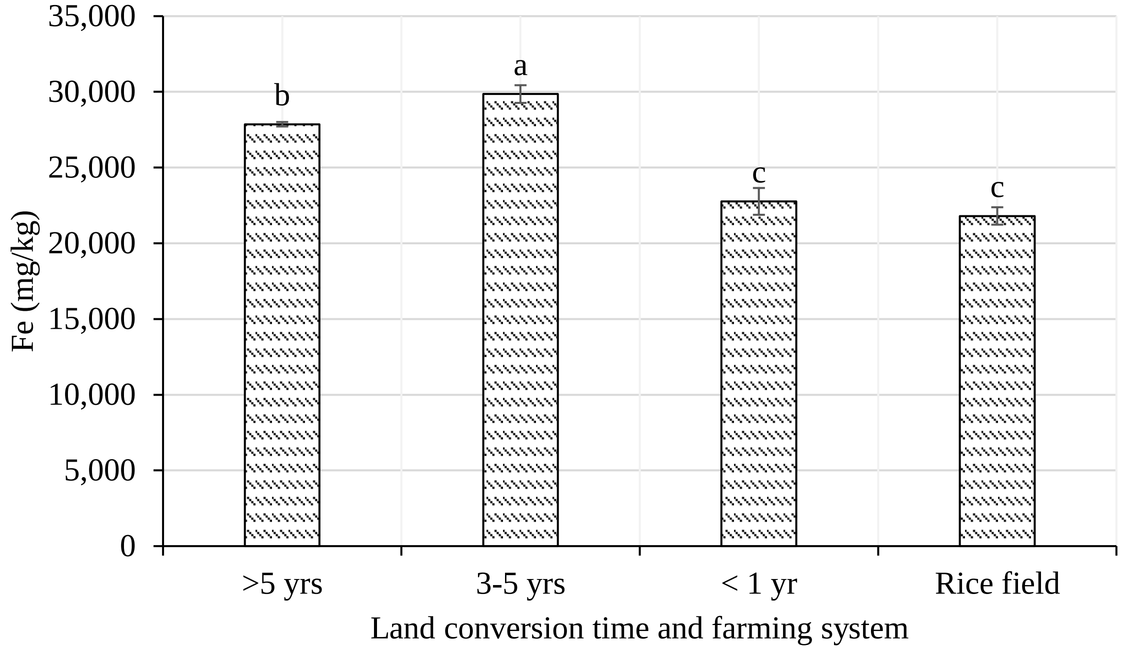

Figure 2. Iron in the E-dor longan and rice field

Mn content in the soil tended to increase gradually over time of cultivation, ranging from 26.90 ± 0.3 - 251.09 ± 0.3 mg/kg; There was a statistically significant difference between the longan and the rice cultivation model ($p < 0.05$). However, Mn concentrations in longan cultivated soils and rice were within the permitted limits of FAO (2001) (2000 mg/kg). According to previous research by Trieu (2009) [23], pH <5.0 could result in Mn become soluble and toxic to plants; therefore, Mn content in the study area may have negative effects on the crop.

Content of Cu in soil ranged from 18.13 ± 0.5 - 32.78 ± 3.2 mg/kg (average at longan orchard was about 21.18 mg/kg). The statistical analysis results showed that there was a difference between longan garden soil and rice field ($p < 0.05$), but there was no difference between the transition period of 3-5 years and greater than 5 years ($p > 0.05$). Compared with the allowable limit specified in QCVN 03 - MT: 2015/BTNMT - agricultural land (100 mg/kg) [5], the copper content in the soil was much lower. However, according to the study of Thuy and Ha (2008) [39] that Cu content in alluvial soils was at medium low level ranging from 13-22.4 mg/kg, averagely 22.5 mg/kg. 31.8 mg/kg. The copper content at all survey points exceeded the absorbable level of plants (> 3.4 mg/kg), which pose risk of accumulation in the soil environment [40].

Zinc content was found to be 62.68 ± 3.2 mg/kg, 49.40 ± 1.5 mg/kg, 29.75 ± 0.1 mg/kg, and 48.81 ± 4.1 mg/kg in longan arable soils at transition times> 5. year, 3 - 5 years and <1 year; Average about 47.27 mg/kg. When compared with QCVN 03 - MT: 2015/BTNMT - agricultural land (200 mg/kg) [5], the zinc content in the soil was many times lower than the permitted limit. The low Zn content was consistent with the results of pH analysis, when the pH <5.5 showed signs of Zn deficiency [23] and the soil lacks Zn when the content was <20 mg/kg [18] . Therefore, Zn content in longan and rice cultivated land was higher than the shortage threshold. However, the concentration of Zn in the soil tended to increase gradually over time of cultivation, which indicated the risk of soil pollution and toxicity to the longan tree. Most of the origin of zinc in the soil is due to soil characteristics, farming techniques, namely the use of fertilizers on the arable layer, perennial soils combined with inorganic fertilization. Zn overdose, plants do not absorb and it has been accumulated in the soil.

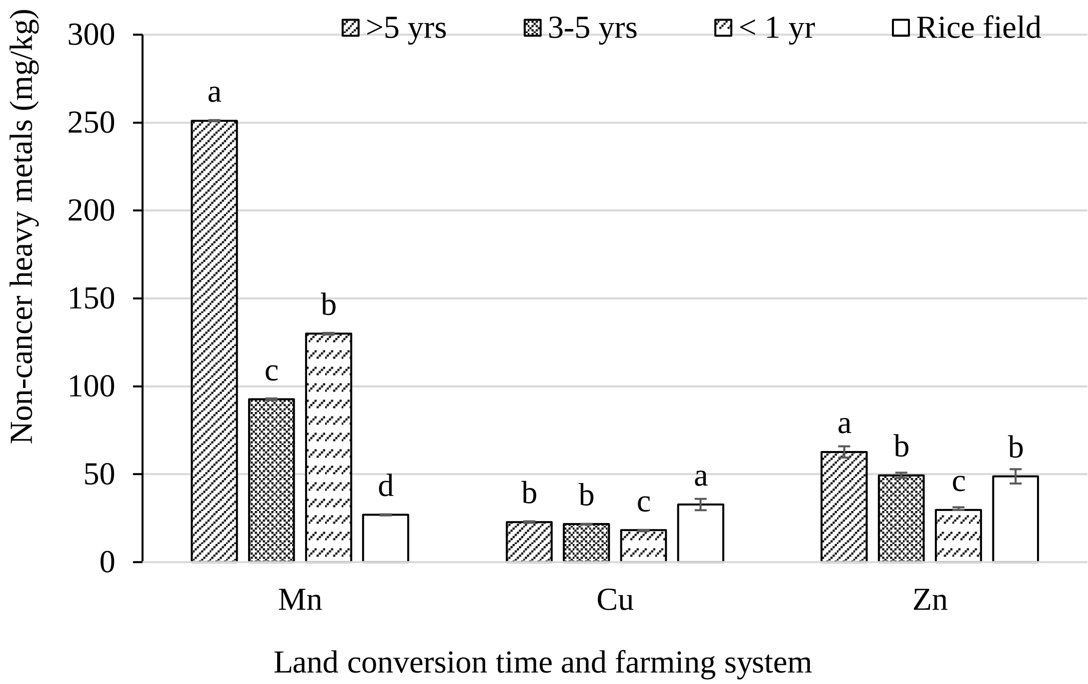

Figure 3. Non-cancer heavy metals in the E-dor longan and rice field

Ni concentrations in longan and rice cultivated soils were found to be below the limits of FAO (2001) (50 mg/kg) [12]. The reported Ni content ranged from 18.70 ± 2.01 - 22.69 ± 1.60 mg/kg (longan E-dor soil) and 22.17 ± 4.24 mg/kg (rice soil); there was no statistically significant difference between the two farming models ($p>0.05$) (Figure 4). The existence of Ni in the soil environment has been suggested by many previous studies as a result of long-term application of fertilizers [41,42]. In addition, Pb was naturally present in the soil with an average concentration of 10 - 84 mg/kg and 29.1 mg/kg for alluvial soils in the Mekong Delta [43], similar to the results of current analysis in longan and rice soil. The analytical results presented in Figure 4 showing that the lead content in the soil at the survey locations ranged from 27.48 ± 2.57 - 49.15 ± 4.28 mg/kg. The average at the three farming locations with E-dor longan was 33.16 mg/kg, the Pb content had Pb accumulation in the soil over the years of cultivation. However, lead content at all survey locations was still lower than the permitted limit of QCVN 03-MT: 2015/BTNMT - agricultural land (70 mg/kg) [5]. In addition, the Pb content did not notice the difference between longan cultivated land> 5 years compared to rice field.

Meanwhile, the concentration of Cr and As recorded in the topsoil was about 60.00 ± 1.05 mg/kg and 7.95 ± 0.26 mg/kg for rice soil and 40.40 ± 1.02 - 63.20 ± 2.08 mg/kg and 6.76 ± 0.62 - 7.08 ± 0.46 mg/kg for longan soil. Cr and As contents were determined to have significant differences between the transition times of longan soil and soil in rice cultivation ($p <0.05$). In addition, the study also showed the difference between the length of longan cultivation times for Cr ($p <0.05$); however, this difference was not noted for As ($p> 0.05$). The abundance of Cr and As content can be attributed to the change of substrate and the use of fertilizers in cultivation [44,45]. These levels were all below the limits of QCVN 03-MT: 2015/BTNMT- agricultural land (150 mg/kg) [5].

Because the main application of chemical fertilizers with low pH values, the Fe, Mn, Zn, Cr content in the soil in the longan cultivation model tended to be higher than that of rice cultivation. Meanwhile, the contents of Cu, As, Ni and Pb had the opposite direction; but showed signs of gradual increase with time of cultivation. A typical example of NPK fertilizers used to add nitrogen, phosphorus and potassium to longan soil with more frequency than rice cultivation may contain some impurity of heavy metals (As, Cr, Ni and Pb) with phosphate fertilizers were also reported to contain the most heavy metals such as As, Ni, Cr, Cu, Zn [46,47].

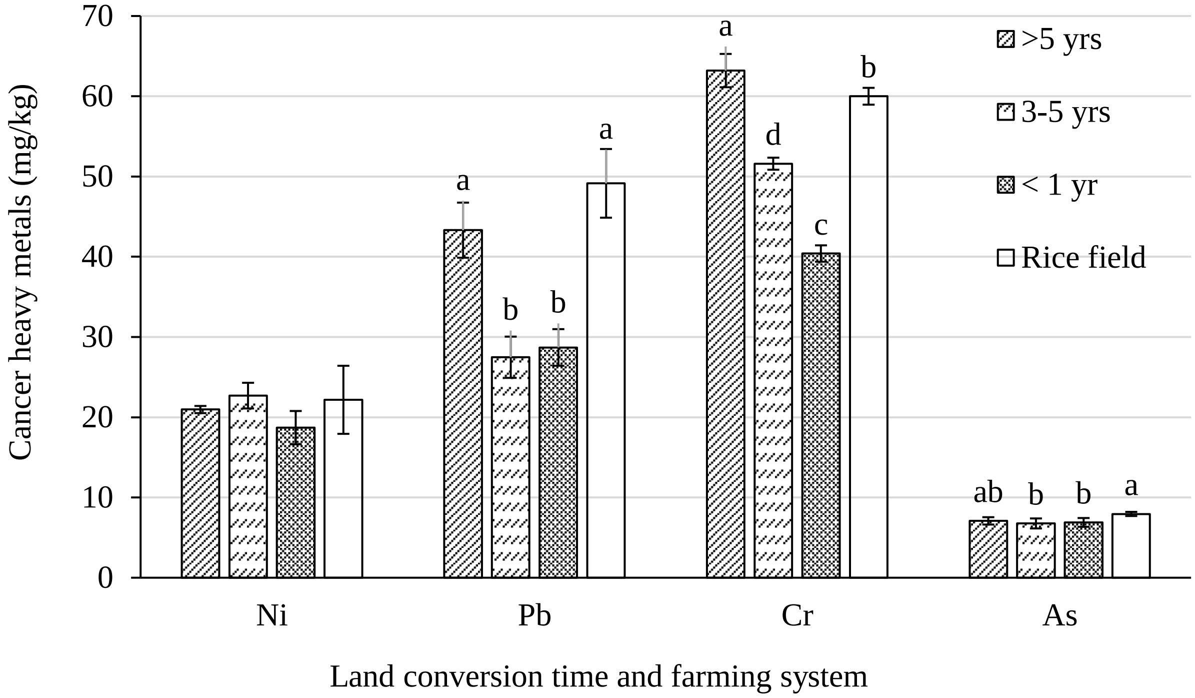

Figure 4. Cancer heavy metals in E-dor longan and rice field

4. Conclusion

The land use efficiency of the E-dor longan cultivation model was higher than that of the rice cultivation model, with the profit/capital ratio of only 1.31 (included home labor) and 1.48 (excluded home labor). However, the amount of NPK fertilizer used in longan orchards was higher than in rice field, so the amount lost to the environment may be higher. In contrast, the amount of pesticides used in longan orchards was much lower (frequency of about 2-3 times) than the amount of pesticides used for rice. The analysis results of soil quality showed that the pH value was not suitable for longan habitat. The organic matter content was assessed to be moderate in longan soils while it was fairly good in rice cultivation. Total nitrogen content in longan soils was low, while in paddy field was assessed to be average. Likewise, the total phosphorus concentrations in the soil at the sites were assessed to be poor and very poor. Total potassium content fluctuated from poor to medium, not meeting the needs of the crops. Most of the nutrient content in longan soils were lower than that in rice cultivation and lowest at a transition period of less than 1 year. Content of heavy metals were within the allowable limits of QCVN 03 - MT: 2015/BTNMT - agricultural land and FAO (2001); however, some heavy metals (Cu, Fe, Mn) have been identified to exceed the absorption capability and are potentially toxic to plants. Four out of eight heavy metals were detected in longan soils higher than in rice cultivation, the remaining heavy metals had lower concentrations in longan soils. Despite this, all heavy metals have been identified as tend to accumulate in the soil over time. In general, research results showed that soil quality in the E-dor longan cultivation model needs improvement measures to bring higher productivity. In addition, the process of digging up soil, farming for long periods has had negative impacts on some physical and chemical properties of the soil.

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