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DETECTING LEAD TOXICITY OF CABBAGE AND LETTUCE CROPS BY USING INFRARED IMAGES

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Abstract

The objective of this study was the possibility of using IR images to detect lead toxicity for Cabbage and lettuce crops. Lead Pb-contaminated were watered with 3 levels of (2, 4,and 6 mg/lit). To distinguish the heavy metal contamination and their impact on vegetative characteristics. For plants, the results showed a poisoning level (2mg/liter). The maximum MTD and NRCT values were 6.3 and 4, respectively. The lowest values under the same level of poisoning were 0.89 and 0.01. The greatest MTD and NRCT values at the poisoning level (4 mg/liter) were 5.3 and 2.5, respectively. The lowest values at the same level of poisoning were 0.19 and 0.07. Additionally, at the same time period with the same poisoning level (6 mg/liter), the maximum values for MTD and NRCT were 5.8 and 0.24, and the lowest values were 1.5 and 0.1. C. For lettuce plants, at a toxic dose of 2 mg/liter. The MTD and NRCT values ranged from 6.2 and 1.5 to 0.2 and 0.09 at the same amount of poisoning, respectively. Intoxication (4 mg/liter). In poisoning level (4mg/liter) the highest values for MTD and NRCT were 3.2 and 1.87 also the minimum value in the same level of poisoning were 0.2 and 0.08. And in the same period with poisoning level (6mg/liter) the highest values for MTD and NRCT were 2.88 and 1.55 also the minimum value in the same level of poisoning were 0.22 and 0.05. Linear regression analysis was performed to predict MTD and NRCT at different days were done .The maximum value of cabbage temperature of air, soil, canopy, and leaf was 35, 30, 27, and 23 °C, also showed the minimum value for the same indices were 17.4, 16.2, 15.5 and 14.5 °C, in poisoning level (2mg/liter). In poisoning level (4mg/liter) the maximum value of cabbage temperature of air, soil, canopy, and leaf were 40, 35, 28, and 31 C, also showed the minimum value for the same indices were 14, 15, 16. and 17.9 °C. While the maximum value of lettuce temperature of air, soil, canopy, and leaf was 33.6, 30.6, 28.6, and 26 °C, also showed the minimum value for the same indices were 18.9, 17.8, 15.4 and 13.6 °C, in poisoning level (2mg/liter). In poisoning level (4mg/liter) the maximum value of Lettuce temperature of air, soil, canopy, and leaf were 40, 32.7, 28.6, and 26 °C, also showed the minimum value for the same indices were 24, 21, 18. and 13.7 °C.

Key words*: *cabbage and lettuce, Lead Pb-contaminated,, thermography, detect, heat, water, stress

INTRODUCTION

Detection of Pb toxicity in food has long been in demand.We deliberate that infrared discriminant analysis is an effective method to accurately and quickly conduct qualitative analyses of lead toxicity for Cabbage and lettuce. This method may have applications in other crops and other pesticide residues. According to world vegetable production data, cabbage is the 4th most grown product (70,997,938 and 70,459,086 tons) in 2014 and 2015. However, according to Bursa and Turkey fresh vegetable production of cabbage is the most grown 8th (34,761- 33,476 tons and 733,081-766,675 tons) product [6].

Lettuce (*Lactucasativa* L.) is a leafy vegetable crop regarded as one of the major greenhouse-grown plants, owing to its high productivity and economic value [7].

The majority of the world's food and sustenance comes from plants. Heavy metal poisoning is a severe problem that not only affects the physiology of plants and has negative consequences that can lead to considerable production loss; it also has an impact on consumers of these diseased plants and moves up the food chain [4].

Reduced root lengths, chlorosis, and stunted growth are the non-specific signs of Pb toxicity.

Once within the cell, Pb alters the permeability of the cell membrane, hormonal changes, inhibition of several enzymes with sulfhydryl groups, decrease in water content, and altered mineral feeding. Pb poisoning slows down the growth of seedlings and prevents germination. Because lead toxicity alters the ultrastructure of the chloroplast and prevents the synthesis of vital pigments like chlorophyll and carotenoids in addition to plastoquinone, plants exposed to lead toxicity experience negative effects on their photosynthetic processes. In addition, by shutting down the Calvin cycle and electron transport chain, it also hinders the production of carbon dioxide by closing stomatal pores [11].

Heavy metal pollution, particularly in mining regions, is a serious environmental issue. Using wastewater from the Nagodi mining site as irrigation, the study compared the accumulation of heavy metals in the stems, leaves, and roots of Lactucasativa (lettuce), Brassica oleracea L. varcapitata (cabbage), and Daucuscarrotavarsativa (carrot). A pot experiment was carried out utilizing topsoil (0–20 cm). Using an atomic absorption spectrophotometer, it was determined how differently copper (Cu), lead (Pb), iron (Fe), manganese (Mn), cadmium (Cd), and zinc (Zn) accumulated and translocated in vegetable roots, stems, and leaves. The amount of Cd in D. carrota's various sections ranged from 0.070 to 0.090 mg/Kg. The stem of L. sativa has the highest content of Mn (17.30 mg/Kg). The roots of B. oleracea absorbed Fe at a high rate (139.6 mg/Kg). D. carrota roots had the highest content of copper (0.221 mg/kg), and Brassica roots had the highest concentration of zinc (35.35 mg/kg). The amount of cadmium in L. sativa and B. oleracea was less than the detection threshold (0.002 mg/Kg). The three genotypes' Pb absorption was below the detection threshold (0.005 mg/Kg). Vegetables grown with such effluent may be regarded safe for food even if heavy metals were absorbed, their quantities were below WHO/FAO approved limits [1].

Water hyacinths were used as test subjects for the effects of lead toxicity, and it was discovered that high lead concentrations severely impede plant growth. It was shown that the lead mostly builds up in the tissues of the roots, petiole, and leaves. It can be argued that water hyacinths have effective defenses against lead toxicity because the activity of antioxidant enzymes likewise rises with increased lead stress [8].

Water, soil, and plant samples were taken from the El-Khashab canal (polluted water), the Al-Bagoria canal (Nile water), and the cultivated land locations nearby in order to evaluate the effects of wastewater irrigation on soil and plants. In wastewater samples and soil under wastewater irrigation, the values of EC, SAR, available N, OM, and the majority of heavy metals (Fe, Mn, Zn, Cu, Co, Cr, and Pb) were considerably higher than in control. In order to be employed as phytoextractors, the cabbage, lettuce, and turnip acquired significant concentrations of metals in their various organs, particularly in their shoot. Most of the examined plants had heavy metal concentrations that were over the allowable range. According to this study, the El-Khashab Canal's effluent increased the OM content and soil fertility. but with dangers, as high metals can endanger organic farming. Vegetables, especially leafy ones, have a strong capacity to absorb, translocate, and accumulate large quantities of heavy metals in their edible sections, making the agricultural soils in this region unsuitable for cultivating them. However, at this location, other plants might be grown [5].

The potential human health risks of zinc (Zn), copper (Cu) and iron (Fe) contamination to native inhabitants through the food chain were assessed in Pinetown, Durban, where their irrigation processes are from the Umgeni River passing through the highly industrialised Pinetown area. River water, vegetables (cabbage and lettuce) and soil were analysed for Zn, Cu and Fe; transfer factor, health risk index anddaily intake of metals were also calculated. The concentrations of heavy metals indicated the pattern trend as Fe Zn Cu for both cabbage and lettuce. The levels of transfer factors for heavy metals ranged from 0.02 mg/kg to 1.89 mg/kg. The health risk index (0.0002–01430) was found to be within the recommended range [9]. As a practice to maintain the quality of the water, all plant-based N monitoring methods have the same essential drawback. They can give a hint as to the crop's current N status. A suitable tissue N value, however, does not predict future N fertilization needs and so cannot precisely identify locations where in-season N application can be minimized or postponed because plant diagnostics are insensitive to soil NO3-N availability. In conclusion, the average annual N uptake in commercial lettuce fields was 145 kg•ha-1, with an average daily uptake of 4 kilogram N/ha/d. Without affecting crop production, current commercial N fertilization rates can be significantly reduced [2].

Under various source-sink manipulation treatments, such as defoliation (DF), spike shading (SS), and half spikelets removal (SR), the photosynthetic properties of flag leaves as well as the accumulation and remobilization of pre-anthesis dry mass (DM) and nitrogen (N) in vegetable organs in nine wheat cultivars were investigated. The SS treatment, according to the results, boosted the flag leaf's photosynthetic rate (Pn) in source-limited cultivars, but had no appreciable impact on sink-limited cultivars. The Pn of flag leaf reduced after the SR treatment. In certain cultivars, grain DM buildup was constrained by the source, while in others, it was constrained by the sink. The source supply was the key factor limiting grain N buildup [12].

Developing an array of sensors and innovative technologies is important in meeting agricultural demands of a larger population. Current technology for measuring plant health or diagnosing disease is expensive, invasive, and often requires sending samples to central facilities for processing [10].

Canopy temperature variability (CTV) as the range (maximum minus minimum) of CT sensed with the infrared thermometer during a particular measurement period [3].

The objective of this study was the possibility of using IR images to detect Lead Pb-contaminated for Cabbage and lettuce crops.

MATERIALS AND METHODS

A greenhouse pot experiment was conducted to investigate the effect of lead Pb [heavy metals (HMs)] toxicity and availability for lettuce and cabbage. The soil was contaminated with lead by 9 doses of Pb were given with irrigation water during the period from 8/1/2021 to 11/2/2021 Pb-contaminated soil was watered with 4 levels of (0, 165, 250 and 500 mg/lit). The plants were irrigated with water contaminated with heavy metals and plant leaves for this experiment and then they were tested at Central Laboratory Tanta University laboratories. The results regarding heavy metals analysis in plant leaves are presented in Table 1.

Table 1. Heavy metals analysis for Plant leaves samples

Sample ID	Analyte	Mean
Cabbage R1	Pb 217.000	0.709 mg/L
Cabbage R2	Pb 217.000	0.647 mg/L
Cabbage R3	Pb 217.000	0.516 mg/L
Lettuce R2	Pb 217.000	26.16 mg/L
Lettuce R3	Pb 217.000	36.34 mg/L

Source: Central Laboratory Tanta University laboratories. Own determination.

Poisoning treatments Pb-contaminated

Nine doses of Lead Pb were given with irrigation water during the growth period. Pb-contaminated plant was watered with 4 levels of (0, 165, 250 and 500 mg/lit). The plants were irrigated with water contaminated with heavy metals and plant leaves with 4 levels of (0, 165, 250 and 500 mg/lit). Plant poisoning program with lead nitrate with 5 dose start on, Sunday 8/1/2021, end at 26/1/2021 Lettuce and cabbage crops were sprayed with three concentrations of lead nitrate as a control treatment only as follows: - Dose No. (1) on Sunday 8/1/2021

Dose No. (2) on Thursday 12/1/2021

Dose No. (3) on Tuesday 17/1/2021

Dose No. (4) on Saturday 21/1/2021

Dose No. (5) on Thursday 26/1/2021.

Heat Indices Basics IR

To consistently compare plant temperature across the plant age, we calculated the deviation of Tp from ambient temperature (dTp=Tp - Ta), a measure often used in field.

Canopy Temperature CT

Van Zyl J.L. (1986) Canopy temperature measured with the infra-red can be utilized successfully to indicate water stress in grapevines by comparing them to well-irrigated reference vines.

ΔT normalized canopy or leaf temperature = T_{canopy}-T_{air}orT_{leaf} - T_{air}............................(1)

MTD, maximum temperature difference= T_{leaf_max}-$T_{leaf-min}$.....................................(2)

NRCT, normalized relative canopy temperature= $\frac{(T\ leaf - Tminimum)}{(Tmaximum - Tminimum)}$...........................(3)

RESULTS AND DISCUSSIONS

Detecting Heat Stress at different poisoning levels for Cabbage and Lettuce Crops

Using IR image to measure the temperature of air, soil, canopy, and leaf shower in Figures 1, 2 and 3) were affected by different poisoning levels for Cabbage and lettuce crops. The collaboration between the irrigation days and lead nitrate poisoning levels has an effect on cabbage and lettuce temperature indices. the results were discussed during poisoning levels 2, 4, and 6 mg/liter. During the period from 28/1/2022 to 9/2/2022, with the control level of fertilization (0%) and irrigation (100% ETC),

Detecting Heat Stress at different poisoning levels for Cabbage Crops

Figure 4 showed the maximum value of cabbage temperature of air, soil, canopy, and leaf was 35, 30, 27, and 23 °C, also showed the minimum value for the same indices were 17.4, 16.2, 15.5 and 14.5 °C, in poisoning level (2mg/liter). In poisoning level (4mg/liter) the maximum value of cabbage temperature of air, soil, canopy, and leaf were 40, 35, 28, and 31 C, also showed the minimum value for the same indices were 14, 15, 16. and 17.9 °C as showed in Figure 5, And in the same period with poisoning level (6 mg/liter) as showed in Figure 6 the maximum value of cabbage temperature of air, soil, canopy, and leaf were 35, 31.8, 27.6, and 23 °C, also showed the minimum value for the same indices were 13.8, 15, 16. and 17 °C. As showed in Figure 7 and with the poisoning level (2mg/lit)**,** showed the maximum value of maximum temperature difference, and normalized relative canopy temperature were 6.43. and 0.2 °C, also showed the minimum value for the same indices were 1.5 and 0.2 °C. Linear regression analysis was performed to predict MTD and NRCT at different days. The following equation represents the relationship.

MTD: y = 0.4167x -18577 $R^2 = 0.92$
NRCT: y = 0.009x-401.21 $R^2 = 0.9959$

As showed in Figure 8 and with the poisoning level (4mg/lit)**,** showed the maximum value of maximum temperature difference, and normalized relative canopy temperature were 6.43. and 0.2 °C, also showed the minimum value for the same indices were 1.5 and 0.2 °C.

Linear regression analysis was performed to predict MTD and NRCT at different days. The following equation represents the relationship.

MTD: y = 0.112x -04992.2 $R^2 = 0.9473$
NRCT: y = 0.0097x-430.95 $R^2 = 0.9917$

As showed in Figure 9 and with the poisoning level (6 mg/lit)**,** showed the maximum value of maximum temperature difference, and normalized relative canopy temperature were 6.43. and 0.2 °C, also showed the minimum value for the same indices were 1.5 and 0.2 °C.

Linear regression analysis was performed to predict MTD and NRCT at different days. The following equation represents the relationship.

MTD: y = 0.1x -4457.3 $R^2 = 0.9321$
NRCT: y = 0.0147x-653.92 $R^2 = 0.9938$

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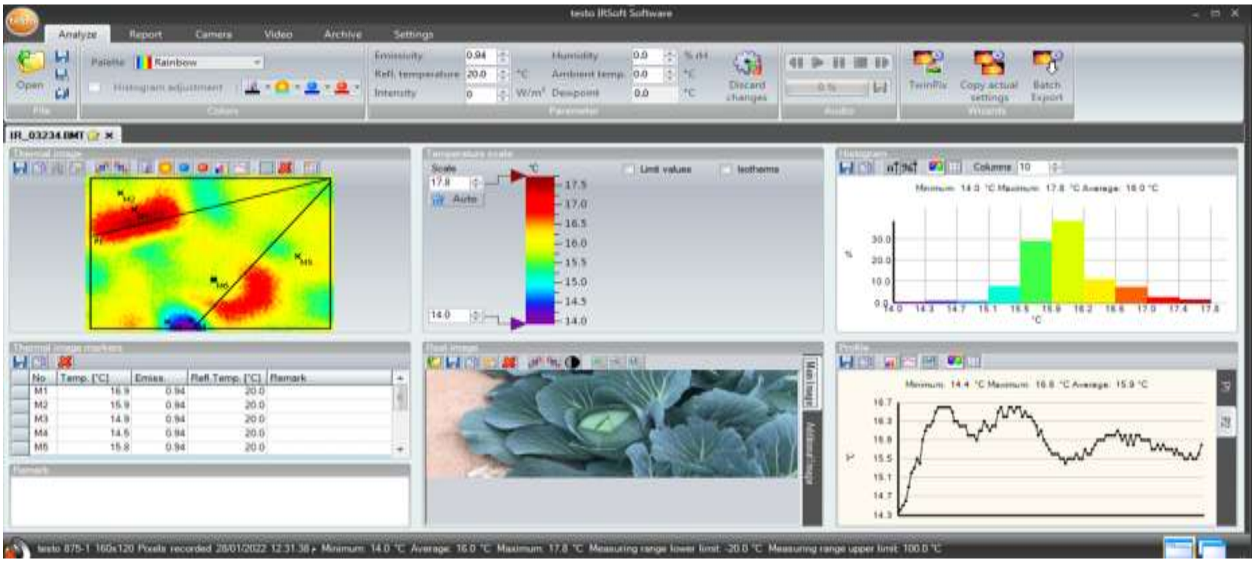

Fig. 1. IR soft interface, ribbon, work space and status bar for poisoning Cabbage Crop
Source: Own determination.

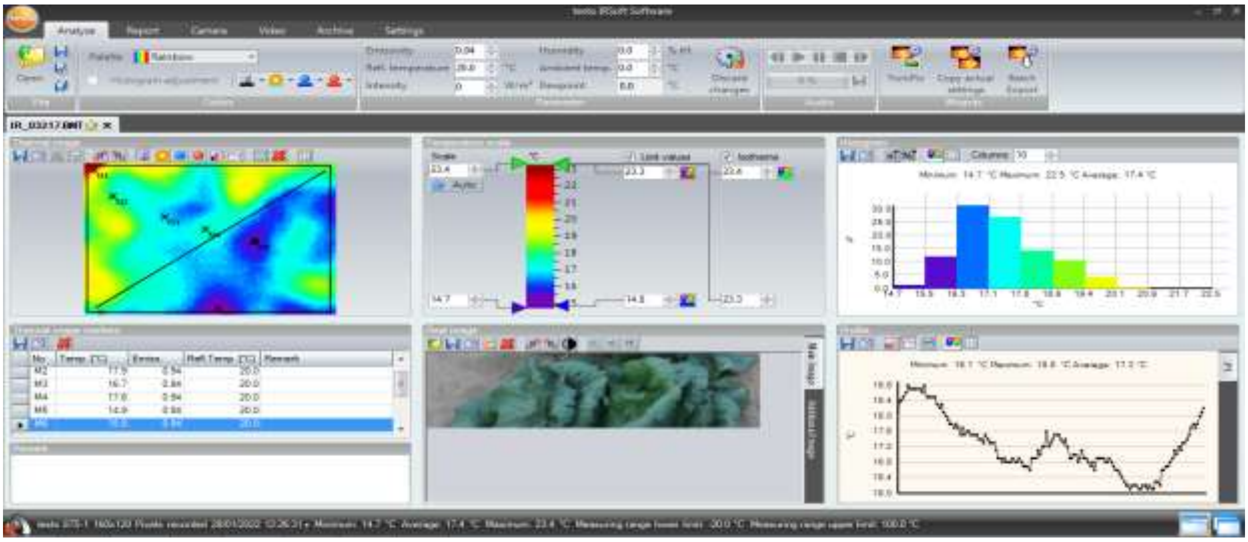

Fig. 2. IR soft interface, ribbon, work space and status bar for poisoning Lettuce Crop
Source: Own determination.

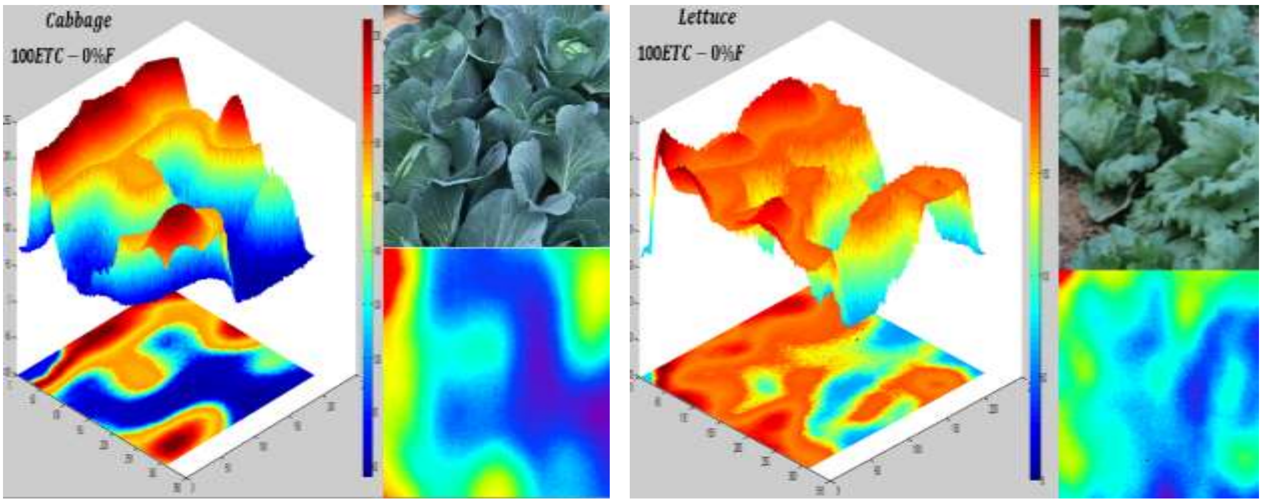

Fig. 3. Cabbage and Lettuce temperature recorded under different levels of poisoning
Source: Own determination.

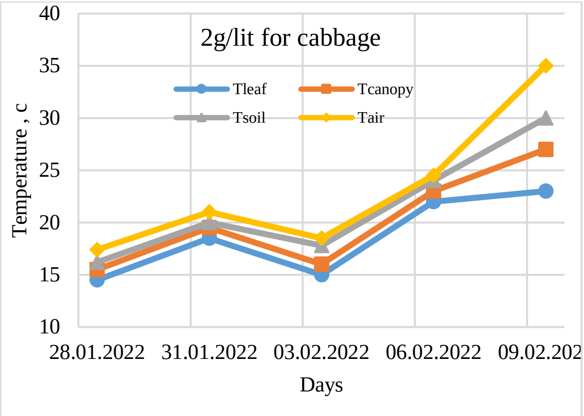

Fig. 4. Effect of poisoning level (2mg/lit) of cabbage crop on maximum temperature difference at different days
Source: Own determination.

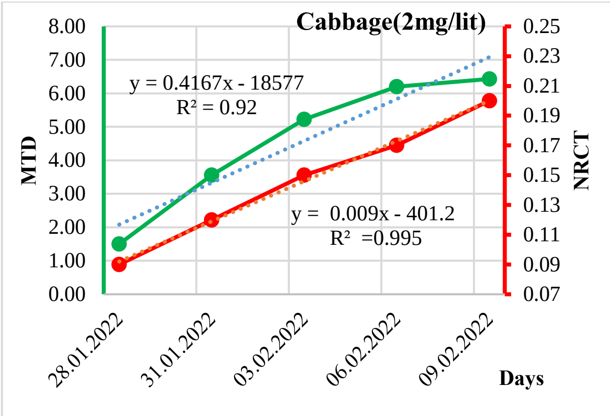

Fig. 7. Maximum temperature difference and normalized relative canopy temperature at different days of cabbage crop atpoisoning treatment(2mg/lit).
Source: Own determination.

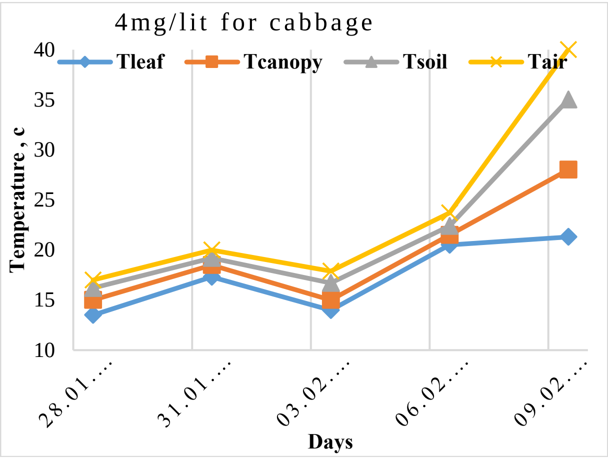

Fig. 5. Effect of poisoning level (4mg/lit) of cabbage crop on temperatures at different days
Source: Own determination.

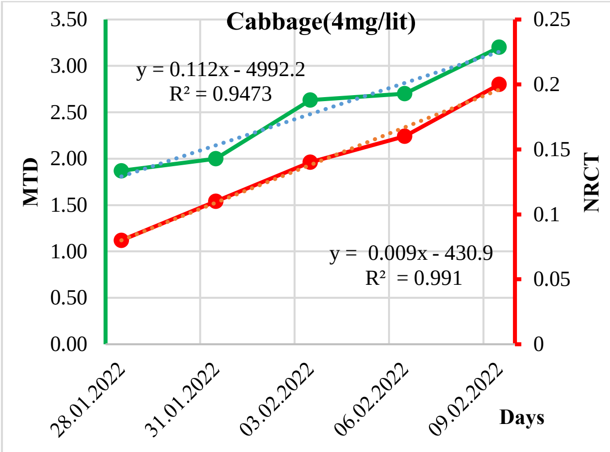

Fig. 8. Maximum temperature difference and normalized relative canopy temperature at different days of cabbage crop at poisoning treatment(4mg/lit).
Source: Own determination.

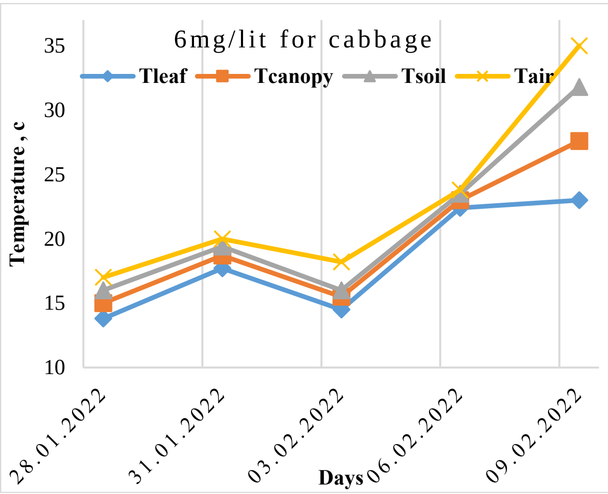

Fig. 6. Effect of poisoning level (6mg/lit) of cabbage crop on temperatures at different days
Source: Own determination.

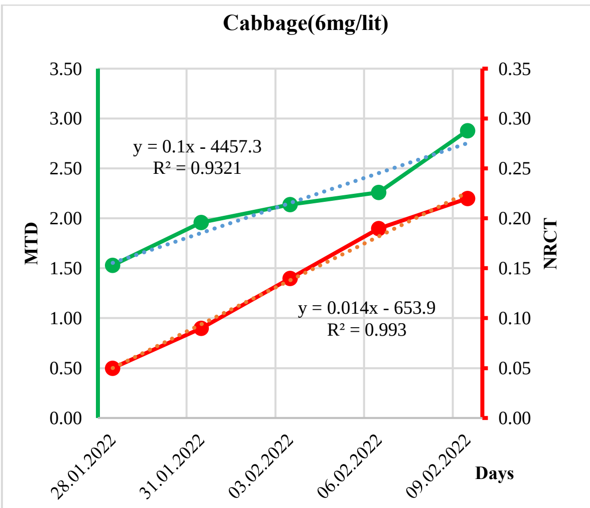

Fig. 9. Maximum temperature difference and normalized relative canopy temperature at different days of cabbage crop at poisoning treatment (6mg/lit)
Source: Own determination.

Detecting Heat Stress at different poisoning levels for Lettuce Crops

During the period from 28/1/2022 to 9/2/2022, with the control level of fertilization (0%) and irrigation (100% ETC).

Figure 10 showed the maximum value of lettuce temperature of air, soil, canopy, and leaf was 33.6, 30.6, 28.6, and 26 °C, also showed the minimum value for the same indices were 18.9, 17.8, 15.4 and 13.6 °C, in poisoning level (2 mg/liter).

In poisoning level (4 mg/liter) the maximum value of Lettuce temperature of air, soil, canopy, and leaf were 40, 32.7, 28.6, and 26 °C, also showed the minimum value for the same indices were 24, 21, 18. and 13.7 C as showed in Figure 11, And in the same period with poisoning level (6 mg/liter) as showed in Figure 12 the maximum value of lettuce temperature of air, soil, canopy, and leaf were 36, 33, 30, and 27 °C, also showed the minimum value for the same indices were 14.2, 15, 15.8. and 16.7 °C.

With the poisoning level (2 mg/lit), in Figure 13 showed the maximum value of maximum temperature difference, and normalized relative canopy temperature were 6, 3 and 0.89 °C, also showed the minimum value for the same indices were 4 and 0.018 °C. Linear regression analysis was performed to predict MTD and NRCT at different irrigation and fertilization levels. The following equation represents the relationship.

MTD: $y = 0.1867x - 18319$ $R^2 = 0.9526$

NRCT: $y = 0.073x - 3253.1$ $R^2 = 0.9742$

With the poisoning level (4 mg/lit), in Figure 14 showed the maximum value of maximum temperature difference, and normalized relative canopy temperature were 4.30. and 0.19 °C, also showed the minimum value for the same indices were 2.5 and 0.075 °C. Linear regression analysis was performed to predict MTD and NRCT at different irrigation and fertilization levels. The following equation represents the relationship.

MTD: $y = 0.1533x - 6834.5$ $R^2 = 0.9497$

NRCT: $y = 0.0097x - 432.55$ $R^2 = 0.9717$

With the poisoning level (6 mg/lit),in Figure 15 showed the maximum value of maximum temperature difference, and normalized relative canopy temperature were 5.8. and 0.24 °C, also showed the minimum value for the same indices were 1.5 and 0.1 °C.

Linear regression analysis was performed to predict MTD and NRCT at different irrigation and fertilization levels. The following equation represents the relationship.

MTD: $y = 0.3767x - 16794$ $R^2 = 0.9831$

NRCT: $y = 0.0127x - 568.2$ $R^2 = 0.9642$

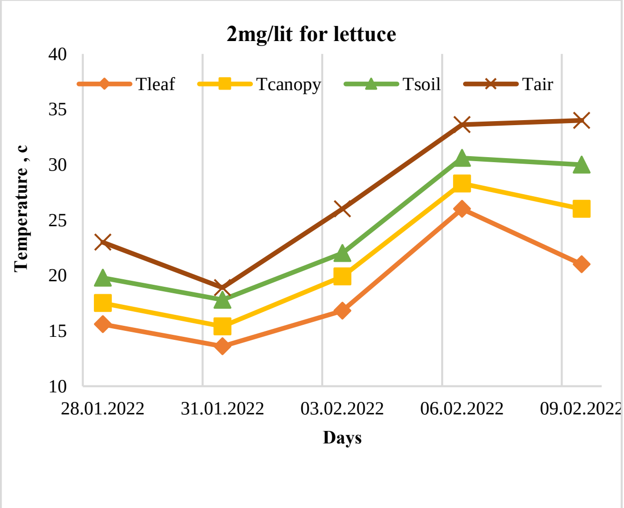

Fig. 10. Effect of poisoning level (2mg/lit) of lettuce crop on temperatures at different days
Source: Own determination.

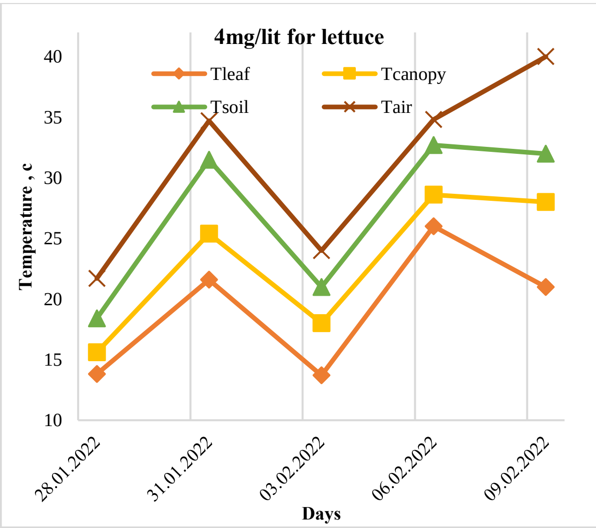

Fig. 11. Effect of poisoning level (4mg/lit) of lettuce crop on temperatures at different days
Source: Own determination.

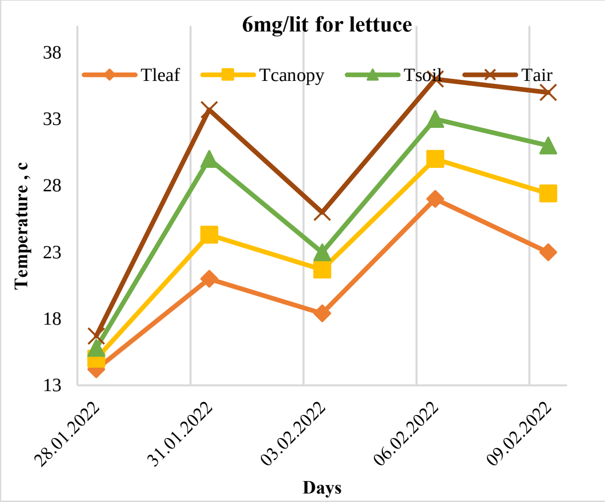

Fig. 12. Effect of poisoning level (6 mg/lit) of lettuce crop on temperatures at different days
Source: Own determination.

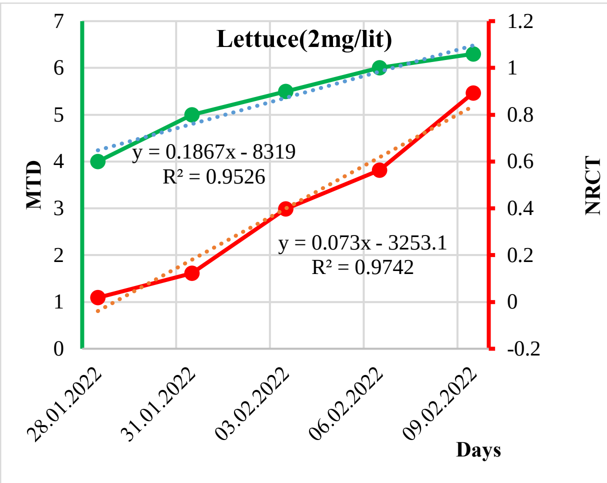

Fig. 13. Maximum temperature difference and normalized relative canopy temperature at different days of lettuce crop at poisoning treatment (2 mg/lit)
Source: Own determination.

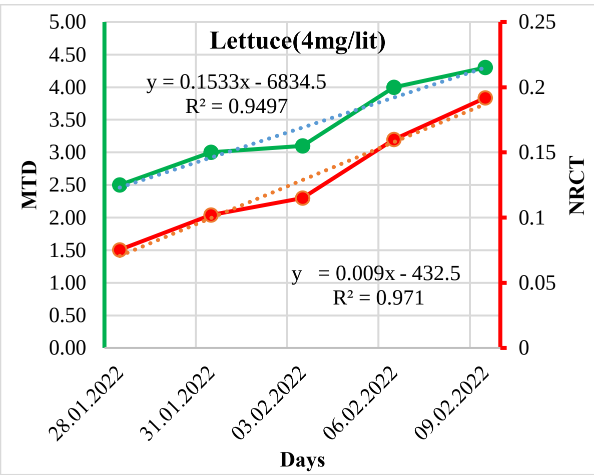

Fig. 14. Maximum temperature difference and normalized relative canopy temperature at different days of lettuce crop at poisoning treatment (4mg/lit)
Source: Own determination.

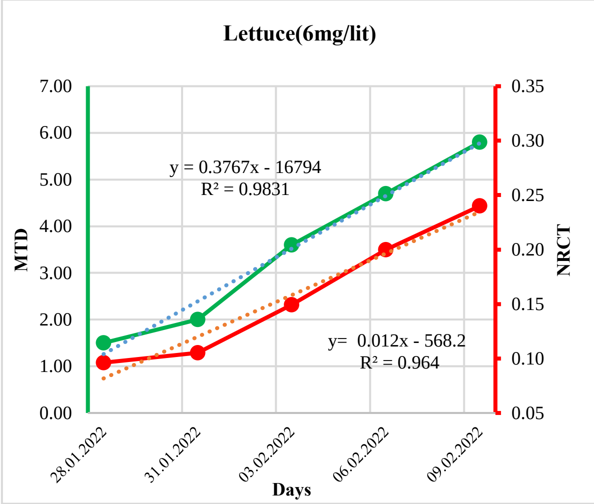

Fig. 15. Maximum temperature difference and normalized relative canopy temperature at different days of lettuce crop at poisoning treatment (6mg/lit)
Source: Own determination.

CONCLUSIONS

Infrared images can be used to detect lead contamination of cabbage and lettuce crops.
The toxicity of lead has been detected for cabbage and lettuce crops.
The results showed lead heating at different levels.
It showed a change in the temperature of leave, soil and canopy, MTD and NRCT vegetative characteristics.
As a final conclusion, the detection of heavy metal toxicity is compulsory for assuring crops growing and yield and also to deliver products of high quality ensuring food safety.

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