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Effect of Irrigation with Wastewater on Growth, Yield and Heavy Metals Concentration of Some Plants in Koya City

A thesis submitted to the Faculty of Science and Health at Koya University as partial fulfillment for the degree of Master of Science in Biology

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بسم الله الرحمن الرحيم

(وَقُلْ رَبِّ زِدْنِي عِلْماً)

صدق الله العظيم

سورة طه آية [١١٤]

Supervisor's Approval

Hereby I (Asst. Prof. Dr. Arol Mohsen Anwar) state that this thesis entitled (***Effect of Irrigation with Wastewater on Growth, Yield and Heavy Metals Concentration of Some Plants in Koya City***) was prepared under my supervision at the department of Biology, the Faculty of Science and Health at Koya University by (Zhakaw Mustafa Saeed) as partial fulfillment for the degree of Master of Science (MSc) in (Eco- Physiology).

I have read and reviewed this work, and to the best of my knowledge, I believe that it is an original work.

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Dedication

I gratefully dedicate this thesis to my dear parents, dear husband, my sonsو my parents-in-law, Siblings and all my teachers who taught me even with a letter.

Zhakaw

Acknowledgments

I would like to get started with, I thank (ALLAH) for the blessing that enabled me to complete and conduct this study successfully, the lord of the universe, a blessing on Muhammad (peace and prayerupon him).

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LIST OF ABREVIATION

Cd	Cadmium
Chl. a	Chlorophyll a
Chl. b	Chlorophyll b
cm	Centimeter
Cu	Copper
EC	Electrical Conductivity
FW	Fresh Weight
g	gram
H.M	Heavy Metals
kg	Kilogram
L	Litter
mg	Milligram
mg kg^{-1}	milligram per kilogram
Mn	Manganese
O.M	Organic matter
N	Nitrogen
P	Phosphorus
K	Potassium
Pb	Lead
XRF	X-ray Fluorescence Spectroetry
Zn	Zinc
µm	micrometer

Summary

This study was conducted in an open field in Koya city, include five locations around Koya city, one location of (well water- Hamamok as control) and four locations of wastewater (Kany qara, Shawgerawa, Alyawa and Azady) locations, during the 2021–2022 winter season to study the effect of wastewater irrigation on some features of vegetative growth, yield component and physiological characteristics of chard (*Beta vulgaris L.)*, celery (*Apium graveolense)*, broad bean *(Vicia faba)* and wheat *(Triticum aestivum L.)* plants.

The results of chard showed irrigation with wastewater caused decrease in plant height and leaf number in all locations except Azady, but caused increase fresh and dry shoot weight in all locations, number of stomata significantly increased in some locations. Also irrigation with wastewater caused to decrease chlorophyll b, total chlorophyll and carotene content in all locations, and heavy metals cadmium (Cd) and lead (Pb) were higher than standard level in all studied locations with control location, Alyawa also had higher copper (Cu) and Kany qara location have Zinc (Zn) higher than standard level.

The results of celery showed wastewater irrigation caused to significantly increase plant height and leaf number only in Kany qara, and increase fresh and dry shoot weigh in Kany qara and Shawgerawa, and significantly increased number of stomata only in Kany qara, and significantly increase chlorophyll a and total chlorophyll in all locations except Azady. Also heavy metals, cadmium (Cd) and lead (Pb) higher than standard level in all studied locations including control location, while metals copper (Cu) , Zinc (Zn) and manganese (Mn) were lower than standard level in all studied locations with control location.

The results of broad bean showed irrigation with wastewater significantly decrease plant height in all locations, and caused to increase leaves number, leaf area (cm^2), number of pods $plant^{-1}$, number of seeds $plant^{-1}$, fresh and dry pod weight in Kany qara and Azady locations. It also caused to increase flowering days in Kany qara and Shawgerawa locations, with maturity days in all locations except Shawgerawa, decreased filling period in Kany qara and Shawgerawa locations. Number, length and width of stomata showed a significantly increase in some locations,

and increase chlorophyll a, total chlorophyll and carotene in Kany qara and Shawgerawa locations, but chlorophyll b increase only in Shawgerawa location**.** Also broad bean pod have metals cadmium (Cd), lead (Pb) and copper (Cu) higher than standard level in all studied locations including control location, while metals Zinc (Zn) and manganese (Mn) were lower than standard level in all studied locations including control location.

The results of wheat showed irrigation with wastewater caused to increase plant high in all locations except Alyawa, but number of tillers and leaves with flag leaf area significantly increased in all locations, days flowering decreased in all locations except Azady have the same days, filling period was higher in all locations except Alyawa and maturity days was higher in Shawgerawa and Azady locations, lower in Alyawa and same with Kany qara. Number of stomata showed significantly decrease, but increase chlorophyll b, total chlorophyll in Kany qara and Shawgerawa but, carotene content increase in all locations except Alyawa. Number and weight of spikes, seed index, grain yield, biological yield, and harvest index showed a significant increase in all locations except Alyawa, but length of spike and straw yield increased in all locations. Also wheat grain have heavy metals Cd and Pb higher than standard level in all locations including control location, the metal Cu was higher than standard level in locations of Kany qara, Alyawa and Azady, and the content of Zn was higher than standard level only in Alyawa location. while the metal manganese (Mn) was lower than standard level in locations of Hamamok and Kany qara while was within standard level in locations of Shawgerawa, Alyawa and Azady.

CHAPTER ONE

1. INTRODUCTION

Shortage of clean water for irrigation has given rise to the use of alternative sources, such as wastewater which is removed from residential and commercial establishments Sulaivany and Al-Mezori, (2007). Around 20 million acres of land are planted utilizing sewage water worldwide Ali et al., (2019). It is a significant alternate water supply for irrigation Zavadil, (2009). Various heavy metals and hazardous compounds are present in wastewater, when compared to the effects of lithological processes, human actions such as industrial, agricultural, residential, and petroleum practices have the ability to raise the amounts of heavy metals to dangerous levels Hama and Darwesh, (2019) ; Ahmed and Gulser, (2019).

Heavy metal poisoning of the environment is a widespread issue; as plants can absorb heavy metals, they may enter the food chain and expose people to them Intawongse and Dean (2006).

Although metallic elements are often essential for living organisms, they become toxic when present at high concentrations Sarma et al., (2011). The so-called chemical forms in which heavy metals occur are the following: water-soluble metals as free cations, complexed or adsorbed in organic matter, adsorbed or occluded in oxides, and associated with clay minerals or primary minerals. Soluble and exchangeable forms are considered really mobile and assimilable by plants, and metal forms bound to the crystalline lattice of clay minerals by isomorphic substitution would be in the opposite end Ahumada et al., (1999)

Because waste water typically contains significant levels of organic matter and macro- and micronutrients, applying it to soil enhances soil characteristics and is beneficial for plant growth and productivity Singh and Agrawal, **(**2010) ; Ali, et al., **(**2019). In Koya city farmers using wastewater due to shortage source of water for vegetables and crops.Vegetables are a crucial component of the human diet because they provide proteins, carbs, vitamins, minerals, and trace elements Chary et al., **(**2008).

The major effect of wastewater on crop productivity is due to the presence of heavy metals, which are well-known to negatively affect crop productivity Shahid et al., (2018).

The Celery is a highly favoured vegetable for its fiber content and nutritional value Yommi et al., (2013). Because of its ability to thrive in soils with poor water availability, tolerate settings with high saline concentrations, and tolerate both cold and hot temperatures, chard is an attractive food crop. Abdel-Rahman et al., (2017). It is an excellent food for regulating blood pressure because of its high potassium level, which also aids in the body's release of water Hailay and Haymanot, (2019) A cool-season perennial legume with a high protein content, faba beans are also an excellent source of vitamins, minerals, and a wide range of bioactive compounds., and improves soil fertility Karkanis et al., (2018). The fact that it is cultivated on 3.6 million hectares of land across more than 50 nations demonstrates its significance for food and agriculture, which results in an annual production of 4 million tons Mkhinini et al., (2018).

wheat (*Triticum aestivum* L.) is the leading cereal crop and is an important staple food Hussain, et al., **(**2022). Although wheat crops can be grown in a variety of locations, the growth physiology and yield can be affected by many climatic factors as well as the availability of soil nutrients, including macro and micro components Ali, **(**2021). On the other hand, the distribution of heavy metals and nutrients in the agricultural environment farms, also effect on vegetative growth and yield component which irrigated by waste water has not yet been evaluated in Koya city, for this reason this study was selected to study:

The following goals were aimed in this study:

- Studying the advantages of wastewater irrigation because it contains the necessary nutrients for vegetative growth , yield and yield components of chard, celery, broad bean pod and wheat grain.
- Studying the disadvantages of wastewater by determining the concentration of accumulated metals in plants irrigated by wastewater to determine its validity to consume by human according to safe limits consume.
- On the other hand the academic studies were depended on pod experiment while the farmers in most locations in Koya region are using wastewater for irrigation of vegetative crops.

CHAPTER TWO
2. LITERATURE REVIEW

2.1 Botanical Discribtion

2.1.1 Chard (*Beta vulgaris L.)*

Swiss-Chard (*Beta vulgaris L.*) is the regular used vegetable in the Kurdistan region of Iraq for some common traditional cuisines and commonly cultivated vegetable in this region. It is irrigated with wastewater in some areas of the region. The leaves of Swiss-Chard watered/ irrigated with untreated wastewater were detected with highest heavy metals accumulation, in particular Zn, Pb, Cu Majeed et al., (2022).

Chard is grown for its succulent, dark green leaves, and gardeners frequently use a lot of fertilizer, particularly nitrogen, to increase output and quality as well as financial rewards Engelbrecht et al., (2010).

Swiss chard is a green vegetable that is highly regarded for its nutritious qualities, year-round availability, inexpensive cost, and widespread use in many traditional cuisines in many different parts of the world. Although its region of production is not significant from a commercial stand point, this tiny vegetable provides an intriguing alternative to the present vegetable selection by utilizing its stalks and leaves. The stems are typically cut and cooked like celery, while the leaves can be eaten raw in salads or cooked like spinach Miceli and Miceli, (2014).

2.1.2 Celery (*Apium graveolense)*

Celery is a biennial plant in the Apiaceae family, is abundant in many useful bioactive components, such as phenolic acids, terpenoids, and flavonoids. Celery has antioxidant, anti-inflammatory, anticancer, anti-rheumatic, anti-hypertension, anti-diabetic, and neuro protecting effects. Celery variations are divided into four categories (red, green, white, and yellow) according to the color of the petiole Li et al., (2020; Yan et al., 2022). Vegetables like leaf celery have beneficial anti-oxidative characteristics that lower the risk of many modern ailments Rożek, (2007).

Celery is a highly appreciated vegetable for its fiber content and nutritional value Yommi et al., (2013). People all throughout the world consume vegetables regularly because they are providers of vital nutrients, antioxidants, and metabolites Abrham and Gholap, (2021).

2.1.3 Broad Bean *(Visia faba)*

Faba beans are a cool-season grain legume crop with a high nutritional value. One of the most widely grown legumes in Iraq is the faba bean (*Vicia faba L*.), also known as the broad bean, horse bean, field bean, or tic bean. It is consumed by people Etemadi et al., (2018; Alshummary et al., 2021). Systems that use faba beans have better soil fertility. It is very effective in creating a symbiotic relationship with particular rhizobium bacteria, and they are a good source of vitamins, minerals, and a variety of bioactive substances Karkanis et al., (2018). One of the first domesticated edible legumes is *vicia faba*.

Legumes (*faba bean*) crops are commonly used in crop rotation with cereal crops to improve soil fertility. They serve important roles in both human diets and agriculture, and they help to promote sustainable farming Cillis et al., (2019).

2.1.4 Wheat *(Triticum aestevum L.*)

Wheat crop is considered as a widely adapted crop, it is grown in different environments with various abiotic factors. The wheat growth and development will result from temporal and spatial integration of the physiological processes during the crop life cycle. Every phase of development requires a minimum accumulation of temperature as a crop heat unit before that stage can be finished and the plant can reach the new stage of growth. The physiological processes can be accelerated or slowed by the availability of nutrition and environmental conditions, especially temperature Ali, (2021). Due to its ability to withstand cold temperatures, wheat is one of the species that is best adapted to growing in a variety of conditions Gutierreza et al., (2013). Iraq is situated in a semiarid and arid area, as a result, there isn't enough water to irrigate the farms growing cultivated crops. Kurdistan region is a part of Iraq, so in order to deal with the effects of water scarcity, more crops and vegetables are being widely cultivated in a large area of Kurdistan. One solution to this problem is to use wastewater, but only in a scientifically sound manner that does not compromise the quality of crops, especially those crops (whose leaves or vegetative parts are consumed) Ati et al., (2019).

2.2 Effect of Irrigation with Wastewater on Plant Growth

N, P, and potassium (K), as well as micronutrients like zinc (Zn), manganese (Mn), and copper (Cu), are vital for plant growth in wastewater. It also contains a sizable amount of organic matter. This makes wastewater a useful fertilizer and soil additive that would boost soil fertility and productivity and increase crop production Mohammad and Ayadi, (2004). Plant genetics and environment both affect plant height Al Barri, (2012). The availability of organic matter, which is essential for nutrient storage and soil structure in soils irrigated with domestic wastewater, affects the soil's ability to retain water, drainage characteristics, and resistance to compaction, and it also serves as a source of crucial macro- and micronutrients for plant growth Jaramillo and Restrepo, (2017; Rusănescu et al., 2022). Celery plants in Iraq that were irrigated with sewage water had the highest growth rates, whereas plants in the same soil that were watered with tap water (the control) had the lowest growth rates Saafan et al., (2017).

Both Torabian et al., (2015; Sweththika, et al., 2022) stated high of okra (*Abelmoschus esculentus)* plant was increase when irrigated with wastewater as compared with control. Naz et al., (2022) reported the use of sewage water for irrigation increased the quantity of lettuce (*Lactuca sativa*), carrot (*Daucus carota subsp. Sativus*) , and cauliflower (*Brassica oleracea var. botrytis*) leaves.

In result Naz, et al., (2016) found leaf number of spinach (*Spinacia oleracea*) irrigated with sewage water increased as compared with control (canal water). Also it has been reported that waste water proved better in enhancing leaf number of corn (*Zea mays*) (Alizadeh et al., 2001).

El-Nahhal, et al., (2013) mentioned wastewater cause to increase fresh and dry weight of Chinese cabbage (*Brassica rapa subsp. Pekinensis*) and corn *(Zea mays)*. Also (Sweththika, et al., 2022) found dry weight of okra (*Abelmoschus esculentus*) increase with irrigated of domestic wastewater.

Zaki and Shaaban, (2015) studied on sunflower (*Helianthus*) explain fresh and dry weight accumulation increase in these plants irrigated with sewage water as compared to the control irrigated with well water. Results Torabian, (2010) studied the impact of wastewater on sweet pepper (*Capsicum annuum*) yield components, he claimed that wastewater treatment boosted yield for sweet pepper. Sweththika, et al., (2022) showed fresh shoot weigh of okra plant no significant difference between wastewater and fresh water.

Campbell et al., (1983) reported alfalfa (*Medicago sativa*) irrigated with wastewater have positive effect on dry weight

Zeid and Abou El Ghate (2007) used wastewater cause to increase high , fresh pod weight, dry pod weight, length of bean pod and number pod plant^{-1} of bean (*phaseolus vulgaris)* plant as compared with control, These nutrients may stimulate the hydrolytic enzymes during germination, which in turn increases the amount of the hydrolyzate, such as glucose and amino acids, which may be due to the enhanced potential of sewage to deliver nutrients to the plant and to improve soil qualities. Hirich and wastewater Choukr-Allah, (2014) used different treatment of faba bean (*Vicia faba L.)*, as a result 100% wastewater irrigation showed the highest plant high, leaf area. Mean while El-Okkiah, (2015) work on waste water irrigation on faba beans were done at 25, 50, and 100% concentrations. In comparison to control plants, the application of sewage water to faba bean plants with a modest (25%Sw) concentration considerably boosted plant height, leaf area, number of pods and number of seeds, However, compared to control plants, the height of plants was dramatically reduced by the sewage water at the highest concentration (100% SW). Shekha et al., (2019) reported sewage water caused to maximum plant height of faba bean as compared with control.

Slima and Ahmed, (2020) stated irrigation with wastewater cause to decrease number of leaves of pea plant. As a result, okra's (*Abelmoschus esculentus*) leaf area increased when it was irrigated with home wastewater Sweththika et al., (2022).

On the stem, pod distribution may be predominately basal, evenly spaced along the stem, or predominately terminal. One to three pods are present in each node Terzopoulos et al., (2004). The number of pods per plant is the character that contributes most to grain yield of common bean, since it presents the highest correlations with grain yield Araújo et al, (2012). Nowwar et al., (2023) reported number of pods and number of seeds plant^{-1}, declined when irrigated with wastewater.

Green pod yield per plant showed positive and significant association with number of pods per plant, pod length, number of seeds per pod Singh, et al., (2009). On the other hand result Shannag et al., (2021) in compared to the control, the fresh weight of broad beans was reduced by 23.5% and 12.6% and dry pods weight by 42.5% at the plants receiving effluents from Wadi Hassan wastewater and Zarqariver wastewater, respectively.

Only 13–64% of faba bean blooms yield pods; flowering is influenced by sowing date, moisture, meteorological conditions, and geographic location. In actuality, the genotype and growth conditions affect the amount of blooms produced per node and per plant Suso, et al., (1996). Abebe et al., (2019) mentioned increase nitrogen content in wastewater locations caused to delay flowering days of green pod

Grain legumes go through numerous significant phenological stages that define their life cycle. These phases include the emergence of seeds, vegetative development, flowering, setting and filling of pods, and physiological maturity, in order to determine the final output of faba beans, it is crucial to induce flowering, maintain blooms, and develop seeds Etemade et al., (2018). Lemma (2019) stated increase nitrogen content caused to delay days maturity of green pods and barley, respectively.

The stage at which the grain has reached its maximum weight is typically used to determine the maturity of grain. The quantity of photosynthates that are translocated to the grain affects gram weight. The rate and duration of the translocation processes, sometimes referred to as the rate and duration of grain filling, determine the amount of translocated photosynthates Jongkaewwattana et al., (1993). Silva et al., (1993) indicated pod-filling period of soybean and cowpea increase with increase nitrogen content. Al-Refaee et al., (2004) the length of the pod and the quantity of seeds pod are closely connected.

Aziz et al., (1995) observed that wastewater improved all growth and yield metrics, and wastewater supported greater growth of the wheat crop as seen by higher values for plant height and leaf number. Kanwal et al., (2020) revealed that lead toxicity reduces plant height. Wheat plant height significantly declined with treatment of sewage at the concentrations (75% and 100%), while increased at lower concentrations (25% and 50%) Dash, (2012). El Rasafi et al., (2016; Repkina et al., 2023) they mentioned increase rate of Zn cause to decrease high of mustard plant. Akbar et al., (2021) stated high of wheat plant significant increased with municipal wastewater irrigation as compared with control. In India the wastewater irrigation caused decrease in the height and number of rice leaves AL-Huqail et al., (2022).

One important agronomic characteristic, tiller number, is hypothesized to influence yield, possibly through canopy structure and light absorption Ali, (2021). The genotype, availability of water, and availability of nutrients all affect the number of tillers in wheat Oscarson, (2000). Alghobar and Suresha, (2016) reported a number of tillers and plants of rice were affected by wastewater irrigation, ground water produced the least amount of tillers per plant while wastewater produced the most Rahman et al., (2014) mentioned increasing of nitrogen cause increasing the number of tillers of wheat plant. Ali et al., (2021) study obtained the highest number of tiller barley plant at high levels of nitrogen.

The primary organ for photosynthesis is the flag leaf, which is also the most significant source organ for synthesis and output of assimilates during the reproductive stage. In cereal crops, the flag leaf also controls ultimate plant development and yield formation Biswal and Kohli, (2013). Increasing nitrogen cause increasing the expansion of flag leaf area by increasing cell number and cell expansion Kumari, (2011; Ali, 2021).

The final grain yield of spring wheat may be influenced by the rate of grain filling and the length of the grain filling phase (*Triticumaestivum L.)* NassandReiser, (2002).

2.3 Effect of Irrigation with Wastewater on Stomata Charechteristics

The number and distribution of stomata per unit leaf area play a significant role in these processes by regulating CO^2, O^2, and moisture exchange between the leaves and the atmosphere. Stomata are essential to the physiology, adaptation, productivity, and adaptability of plants. They are closely linked to transpiration and photosynthesis processes that occur in their leaves Khudhur, (2013). Except for the roots, practically all plant parts have tiny microscopic pores called stomata. The number and density of stomata vary depending on the species of plant, but several elements, including light, osmotic regulators, CO^2, water availability, and heat, have a big impact on how the stomata are regulated Mujdeci et al., (2011).

Since changes in transpiration resulting from changes in stomatal structure and function affected the accessibility of nutrients content to the leaves, the concentration of mineral nutrition was indirectly correlated with stomatal density and guard cell size in wastewater-treated plants Hajihashemi et al., (2019).

Compared to areas with ground water irrigation chard (*Beta Vulgaris L.*) plants at wastewater irrigation sites had increased stomatal conductance Singh and Agrawal, (2010).

Holguin et al., (2022) found barley (*Hordeum vulgare*) plants irrigated with wastewater had lower stomata density than the plants irrigated with ground water. Hajihashemi et al., (2019) reported that the control plant's stomatal density was higher at levels of 25% and 50% wastewater dilution, whereas levels of 75% and undiluted wastewater significantly reduced it. Since stomatal holes regulate water loss through transpiration and CO^2 assimilation during photosynthesis, they are essential for a plant's physiology Holguin et al., (2022).

El-Okkiah , (2015) said that as compared to control, all sewage water treatment significantly reduced the number of stomata/mm2, length, and width.

Through their control of CO^2 intake and water loss, stomata are important players in the trade-off between photosynthetic carbon fixation and water transpired, and they play a significant role in plant management Dunn et al., (2019). Guo et al., (2023) research exposure to heavy metals can also result in fewer stomatal cells, reduced stomatal counts are a result of high Cu and Cd exposure in wheat and tomatoes. Samarah et al., (2020) found stomata resistance have no significant difference between fresh water and wastewater.

2.4 Effect of Irrigation with Wastewater on Photosynthesis Pigments

Chlorophyll is a vital component of plant life that helps plants produce ATP from the light energy from the sun. It is also a useful biomarker for determining how stressed or exposed to toxins a plant is, as it promotes chlorophyll biosynthesis while inhibiting the activity of CO^2 fixation enzymes Mkhinini et al., (2018).

Chard (*Beta Vulgaris L.)* rich in phyto pigments such as chlorophyll and carotenoids. The human body's immunological, detoxification, and antioxidant systems are all improved by phytopigments, which also play a bigger part in controlling blood sugar Reif et al., (2013; Abdel-Rahman et al., 2017 ; Ivanović et al., 2018).

Sharma et al., **(**2010) investigated the impact of bioaccumulation of cadmium (Cd) and zinc (Zn) on the physiological properties of carrots, only adverse correlations were found between Zn build up in soil and stem. The interaction of Cd or Zn with the functional -SH group of chlorophyll producing enzymes during the several steps of chlorophyll biosynthesis may also be to blame for the decrease in chlorophyll concentration in leaves. The plants that are most susceptible to an alkaline environment lowered the amount of photosynthesis by closing their stomata, which also decreased transpiration and CO^2 absorption by the plant.

Increases in Cu content may directly affect the photosynthetic system by causing chlorophyll levels to drop Martins and Mourato, **(**2006).

High concentrations of the carotenoid and chlorophyll pigments, as well as other nutrients including vitamins A, C, and K, can be found in swiss chard's leaves and stalks. In vegetable production systems, enhancing these nutritional properties through various cultural techniques, such as mineral nutrient levels, has become a standard practice Barickman and Kopsell, (2016).

Daud et al., (2016) work results of wastewater effects on maize (*Zea mays)* seedlings showed a decrease in chlorophyll a and b

While Abdel Latef and Sallam, (2015) found the content of chlorophyll a of sewage-irrigated maize plants markedly increased but there are no appreciable changes in the levels of carotenoids in control and sewage-irrigated maize (*Zea mays)* plants.

Torabian et al., (2015) reported chlorophyll content in okra (*Abelmoschus esculentus)* plant was increase when irrigated with wastewater as compared with control.

while Hajihashemi et al., (2019) obtained the carotenoids significantly increased in response to all levels of wastewater irrigation. Singh and Agrawal, (2010) stated total chlorophyll and carotenoid were higher in palak (chard) (*beta vulgaris*) plants of wastewater irrigated sites. Also chlorophyll content of spinach (*Spinacia oleracea*) increased in use of irrigation with sewage water as compared with control (canal water) Naz, et al., (2016).

In result Zeid and Abou El Ghate (2007) found increase chlorophyll a, b and carotene content for bean (*phaseolus vulgaris)* by using sewage water. But El-Okkiah (2015) used sewage water irrigation considerably increased chl.a, chl. b and total chlorophyll when compared to control plants in faba bean plants with low concentration (25% Sw). However, when compared to control plants, the amount of sewage water with the greatest concentration (100 percent SW) dramatically decreased chl.a, chl. b and total chlorophyll.

As compared to control plants, the chlorophyll a content of the bean (*Vicia faba*) plants subjected to 50% of treated waste water decreased dramatically, but chlorophyll b decreased at 50% and 100% of treated waste water according to Mkhinini et al., (2018).

Dash (2012) stated the chlorophyll content in wheat seeding was increased up to 50% treatment of sewage and there after declined gradually at high concentrations. Bojovic and Stojanvic, (2005) reported that measurements of the highest chlorophyll content in wheat plants were made on soil that had received phosphorus and nitrogen fertilizer, the lowest chlorophyll content in this plant organ too was measured on unfertilized soil. Gassama et al., (2015) found higher chlorophyll a and chlorophyll b in rice leaf plant at lower municipal wastewater concentration (25%), but chlorophyll a and chlorophyll b decreased in 100% municipal wastewater concentration. The results Liu et al., (2002) showed that compared with control, the wheat under sewage irrigation was decreased chlorophyll a.

Pb stress cause to decrease chl. a, b, total chlorophyll and carotene content Kanwal et al., (2020).

Hajihashemi et al., (2020) showed that the amount of chl. a, chl. b, total chl. and beta-carotene decreased when wastewater was used. This is because using untreated wastewater in agriculture can lead to high concentrations of accumulated macronutrients (Ca, K, Mg, Na, P, S, and Si), micronutrients (Fe, Zn, Cu, and Mn), and heavy metals (Ag, Cd, Co, Ni, and Pb), which can interfere with physiological processes, limit metabolite biosynthesis, inhibit photosynthesis. Salakinkop and Hunsha (2014) as a result of having higher chlorophyll, crops grown on sewage-irrigated land exhibited improve growth and photosynthesis.

2.5 Effect of Irrigation with Wastewater on Accumulation of Heavy Metals in Plants

Generally speaking, sewage water from cities can be a source of metals, yet it is nevertheless used to cultivate veggies there. Using this poisonous metal-filled waste water to irrigate vegetable plants can result in a number of physiological problems Duruibe *et al.*, (2007; Ganjo and Jaf, 2012; Ali, et al., 2019). Heavy metal ingestion at high levels can have major health effects. Anemia, high blood pressure, severe effects on the brain, kidney, lung, bone, liver function, blood type, and other critical organs are a few examples Radha and Qadir, (2023).

Long-term consumption of contaminated leafy vegetables with heavy metals may result in entering the food chain, that brought the necessity of a systematic monitoring to make timely decisions to avoid severe health effects Majeed et al., (2022). Anita and Madhoolik, (2012) discovered that Cd and Pb levels in edible tissues were beyond the permissible limits, whereas the accumulation of heavy metals in *beta vulgares* plants was three times greater in shoots in waste water-irrigated sites. Eliku and Leta, (2016) swiss chard (*Beta vulgaris L.*), carrots (*Daucus carota subsp. sativus*) tomatoes (*Solanum lycopersicum*) and green pepper (*Capsicum*) were grown using waste water, among the vegetables tested, tomato accumulated Cd the least, whereas carrot had the lowest levels of Cu and Pb, the highest Cu amounts were found in green pepper, while the highest Cd and Pb values were found in Swiss chard.

Mamand, (2008) studied on (Cd, Mn and Zn) levels in certain plants watered by sewage from Hewler City's main sewage canal, the total mean concentrations of Cd in vegetables were high: 0.44, 0.35, 0.4 and 0.34 mg kg^{-1}.DW recorded for chard (*Beta vulgaris L.*), celery (*Apium graveolens*), leek *(Allium porrum)* and onion (*Allium cepa*) respectively, while for Mn the average concentrations 25.83, 24.84, 25.32 and 24.07 mg kg^{-1}.DW detected for the above vegetables respectively, the mean Zn concentration of chard, celery, leek and onion were: 18.5, 17.5, 17.44 and 16.87 mg kg^{-1}.DW, respectively.

In result of Rashid and Mohammed, (2015) showed a significant build-up of heavy metals, the values of Pb and Cu in plants irrigated with wastewater were 0.312 mg kg^{-1} and 0.140 mg kg^{-1}, respectively, while in the control group, Pb and Cu were 0.060 mg kg^{-1} and 0.088 mg kg^{-1}, respectively. Tariq, (2021) investigated the concentrations of highly toxic metals like Cd, Pb, Cu, and Zn, a study in the Turaq area used waste water for irrigation of chard, celery, cress, and leek. The results showed that, with the exception of Cu, all checked metals in all selected vegetables exceeded WHO/FAO safe limits.

As the concentration of heavy metals in sewage water heavy metals (Cd and Pb) in faba bean seed plants increased dramatically El-Okkiah, (2015). Chaoua et al., (2018) showed that all metals Zn, Pb, Cu and Cd in the *Vacia faba* irrigated with wastewater exceeded the acceptable limits.

High amounts of Pb may have hazardous consequences in people, which can lead to issues with hemoglobin synthesis, issues with the kidneys, gastrointestinal tract, joints, and reproductive system, as well as acute or long-term nervous system damage Govind and Madhuri, (2014). Slima and Ahmed, (2020) stated irrigation with wastewater caused a highly significant increase Pb, Cd, Cu, Zn and Mn concentrations in seed of pea plant, and the concentration of Cd and Pb was in the phytotoxic range.

Zn (96.9 mg kg^{-1}) and Cu (60.3 mg kg^{-1}) were found in peppermint leaves that had been irrigated by the El-Saff wastewater canal Farrag et al., (2016). Abu-Elela et al., (2021) study which assessed the levels of heavy metals (Zn, Pb, Cu, and Cd) in vegetables (faba bean, cabbage, onion, garlic, zucchini, capsicum, eggplant, potato, okra, and green bean) grown in the western Giza governorate of Egypt and irrigated with wastewater, revealed that green bean shoots accumulated more Zn (96.7 mg kg^{-1}) than other grown vegetables. Onion stems had a copper content (60.9 mg kg^{-1}) that was higher than acceptable levels (40 mg kg^{-1}).

One of the principal crops and a crucial element of the national diet is wheat plants can absorb environmental heavy metal pollution, which could enter the food chain Intawongse and Dean, (2006). The amount of heavy metals that build up in plants is influenced by their species and level of metal absorption khan et al., (2008). Grain consumption is safe as long as metal accumulation stays within acceptable levels. However, when accumulations go over the allowable limit, they have harmful effects and can cause a number of different disorders in people Al-Othman et al., (2012). When irrigated with sewage water, wheat is an essential cereal food grain crop that must be handled properly to reduce any risks related with its eating Hussain, et al., (2022).

The results of Hassan et al., (2013) a study on the concentration of metals like Cd, Pb, Zn, Cu, and Mn in wheat grains irrigated by wastewater showed that most of the metals, such Zn, Cu, and Cd, had concentrations over the threshold levels for food specified by international laws, but Pb and Mn, were below the safe limits. Salakinkop and Hunsha, (2014) claimed that sewage irrigation increased the buildup of heavy metals in wheat plant sections. Farahatet al., (2017) showed that under wastewater irrigation, the grains of wheat and maize contained dangerous levels of Pb and Cd. Khan et al., (2017) showed that concentration of heavy metals Cd, Cu, Zn and Mn in soil and wheat grains increased due to supply of waste water, Mn showed highest bio-concentration factor. High Cd levels cause damage that can be seen as chlorosis, growth inhibition, browning of the root tips, and ultimately death Nagajyoti et al., (2010). Shrinkage of leaf surface area, yellowing, formation of necrotic spots, suppression of leaf growth, and leaf rolling are seen in plants exposed to dangerous levels of Cd Ozyigit and Nazligenc, (2020).

2.6 Effect of Wastewater on Yield and Yield Components of Wheat Plant

generating spikes plant^{-1} in grain number, serving as a source of assimilate throughout the grain filling period, and producing grain yield. Potentially linked to an increase in grains is an increase in the number of spikelets Knezevic et al., (2019). Aziz et al., (1995) noted that wastewater increased number and length of spike, 1000 grain weight, number of grain/panicle and yield of wheat plant increasing with wastewater irrigation as compared with well water. Result of Samarah et al., (2020) found that there were no significantly differences in spike number of barley plant^{-1} among fresh water and wastewater.

The variation in the spike length trait within the population will be minimal in the case of cultivars anticipated for heavy usage of wheat, even if spike length is one of the significant yield-related factors via grain production per plant, the influence of the spike length has been observed in path analysis with regularity Mladenov et al., (2019). Grain yield is directly adversely affected by spike length Waqar-Ul-Haq and Akram, (2010). Mojid et al., (2016) indicated positive impact on most growth and spike length of wheat with wastewater treatment. Due to the high concentration of contaminants in untreated industrial effluent, end users and the ecosystem in the soil may be at risk, spike length could be decreased to lessen the hazardous impacts of wastewater Sahar et al., (2017).

The spike productivity is inversely proportional to the spike^{-1} grain weight and number, the relationship between spike weight, total grain yield, and grain weight spikes plant^{-1} is positive Knezevic et al., (2015). Mojid et al., (2016) demonstrated that wastewater treatment had a good impact on the majority of growth and grain in the wheat spike.

Increased grain weight has been strongly correlated with improved grain yield Tshikunde et al., (2019). Akbar et al., (2021) stated 1000 grain weight of wheat plant significant increase with municipal wastewater irrigation as compared with control. Mousavi and Shahsavari, (2014) found maximum 1000-seed weight of maize plant significantly increased at using wastewater

According to Salakinkop and Hunsha, (2014) continuous sewage irrigation boosted soil fertility, which led to a higher wheat grain yield on sewage-irrigated land than on bore well-irrigated land, increased soil fertility, as shown by higher levels of accessible plant nutrients including nitrogen, phosphorous, copper, manganese, and zinc in sewage-irrigated land, may be one of the primary factors contributing to enhanced growth and yield. Mojid et al., (2016) demonstrated that wastewater treatment has a positive impact on wheat's overall growth and output. As opposed to that Sahar et al., (2017) because of the high concentration of contaminants, untreated industrial effluent can be dangerous for end users and the environment.

Farahat et al., (2017) the findings demonstrated that, as compared to crops grown with freshwater irrigation, wastewater-derived crops had reduced morphological features, decreased vegetative biomass, and produced lower yields of wheat and maize. Hajihashemi et al., (2020) as indicated wastewater reduces grain production, the critical nutrients for crop growth and development N, P, K, frequently thought of as being found in wastewater. Additionally, it is thought to be a cheap source of nutrients, economical, and capable of boosting plant yield. Holguin et al., (2022) discovered that wastewater irrigation increased barley grain production in comparison to irrigation using ground water. Singh et al., (2012) realized that the effects of irrigation with sewage and well water on various crops were examined, wheat produced more grain than gram, but gram produced more straw, which was superior to wheat. According to Akbar et al., (2021) irrigation of municipal wastewater increased wheat plant grain yield significantly when compared to control. Ding et al., (2020) stated P fertilization and organic amendment enhanced of wheat straw yield.

A crop with a high biological yield is one whose genetic make up influences the expression of specific genes that can raise above-ground biomass, grain weight, and grain yield Rebetzke et al., (2012; Tshikunde et al., 2019). Alizadeh et al., (2001) reported that watering of maize plants with wastewater during all growth phases resulted in the greatest biological output. According to Mojidi et al., (2016; Akbar et al., 2021) the statement irrigation of wheat with municipal wastewater increased its biological yield substantially when compared to control. Wheat plants grew better in municipal wastewater thanks to organic matter and an abundance of nutrients (N, P, and K).

index for harvest rise in harvest index is primarily responsible for the rise in grain yield of new wheat varieties, which is positively and significantly connected with harvest index Zafarnaderi et al., (2013). Grain yield and HI were found to have a linear, positive relationship over time, indicating that HI can increase yield gains even further Tshikunde et al., (2019). Future advances in yield may depend on generating higher harvest biomass output while retaining HI. HI of certain widely used cultivars was released and reached their theoretical maximum limit Shearman et al., (2005). The plant's dry matter and grain weight, which are ultimately dependent on the availability and uptake of nutrients, particularly nitrogen, are directly related to the harvest index Ullah et al., (2018). Mojid et al., (2016) reported harvest index (HI) of wheat plant was statistically identical between wastewater and control. Harvest index was significantly increased by increasing nitrogen fertilization levels Asif et al., (2012). Also Arif et al., (2017) mentioned increase rate of potassium significantly cause to increase harvest index of wheat plant.

2.7 Effect of Irrigation with Wastewater on Heavy Metals Accumulation in Soil

concentrations of lead, cadmium and copper in the soil of roadsides in Elazig, Turkey, that the lead concentration were between 1.3 to 45 mg kg^{-1}, Cd ranged between 78 - 527 mg kg^{-1}, and the copper were in the range of 11.1 – 27.9 mg kg^{-1} Bakirdere and Yaman, (2008)

A study was carried out by Mamand, (2008) on (Cd, Mn, and Zn) levels in some vegetables irrigated by wastewater of the main canal in Erbil city. Results of soil analysis showed that the total average concentration of Cd, Mn and Zn were 3.45, 249.81 and 74.15 mg kg^{-1}, respectively recorded.

Cd, a non essential heavy metal, is toxic metal even at low concentrations in the soil, Cadmium can accumulate and redistribute in different plant parts, causing visible injuries, altered metabolic activities and reduced photosynthesis at different growth stages Sharma et al., (2010). Is one of the ubiquitously distributed most abundant toxic elements in the soil Asati1 et al., (2016).

In humans some trace elements have been associated with cancer and cardiovascular disease Maier and Bray, (1993). Mn is a naturally presenting element in the soil, the 12^{th} most abundant element in the earth's crust and comprises about 0.10% of the earth's crust Ahmed, (2017b).

Hajihashemi et al., (2020) Cd, Cu, Mn, Pb, and Zn can accumulate in the soil as a result of long-term wastewater irrigation of farm lands. Ahmed and Gulser, (2021) studied soil contamination with heavy metals in the soil Duhok, Erbil, sulaemany and Koya, the higher contents of Zn and Cu were in the soil of Dhok and Sulemania than the soil of Erbil and Koya.

CHAPTER THREE

3. MATERIALS AND METHODS

The study included carrying out four experiments in four of the vegetable fields in Koya city , Erbil, Kurdistan Region-Iraq during the winter season of 2021-2022. This research used one source of well water as a control (Hamamok) and four sources of waste water (Kany qara, Shawgerawa, Alyawa and Azady) which used as irrigation by farmers in Koya city, in order to conduct the water analysis.

3.1 Water Samples

By using a (0.5) liter polyethylene bottle which was rinsed twice with water before filling then adding one drop of toluene according to Baba, (2010). The samples were kept in cool boxes. Heavy metals in collected water were determined by using ICPE- 9820 shimadzu in Atmosphere Company for Environmental and Laboratory Services.

Table 3.1 *Physiochemical Characteristic and Heavy Metals Concentration in the Water Samples for Chard and Celery Experiments*

Locations / Metals	Hamamok	Kany qara	Shawgerawa	lyawa	Azady
Ec(dS.m)	o.46	0.79	0.88	1.10	0.87
PH	6.95	7.0	6.90	6.98	6.97
Cod (ppm)	210	370	250	260	410
N (ppm)	1	35.3	39	55.1	31.3
P (ppm)	15.5	11.3	14.225	0.75	38.85
K (ppm)	0.1	14.6	16.8	16.4	11.8
Cd (mg/L)	0.002	0.013	0.002	0.002	0.011
Pb (mg/L)	0.01	0.01	0.01	0.01	0.01
Cu(mg/L)	0.01	0.04	0.01	0.02	0.01
Zn(mg/L)	0.046	0.072	0.031	0.022	0.034
Mn (mg/L)	<0.001	<0.001	<0.001	<0.001	<0.001

Table 3.2 *Physiochemical Characteristic and Heavy Metals Concentration in the Water Samples for Broad Bean and Wheat Experiments*

Locations / Metals	Hamamok	Kany qara	Shawgerawa	Alyawa	Azady

EC (dS.m)	0.40	0.91	0.95	1.20	0.94
pH	8.05	7.71	7.58	7.83	7.83
COD (ppm)	185	162	158	108	132
N(ppm)	9.762	64.897	65.273	55.1	58.15
P(ppm)	3.275	13.575	15.3	6.625	7.275
K(ppm)	2.4	16	16.8	12.4	14.5
Cd (mg/L)	<0.001	<0.001	<0.001	<0.001	<0.001
Pb (mg/L)	<0.001	<0.001	<0.001	<0.001	<0.001
Cu (mg/L)	0.003	<0.001	<0.001	<0.001	<0.001
Zn (mg/L)	<0.001	0.031	0.023	0.014	0.011
Mn (mg/L)	<0.001	<0.001	<0.001	<0.001	<0.001

3.2 Soil Sampling

The soil samples were collected from studied locations as mentioned above for heavy metal and nutrition's analysis. The soil samples were taken within a depth 0-30 cm, according to Mohammad and Mazahreh, (2003).

The samples were placed in polyethylene bags and brought back to the laboratory, then air-dried sieved and stored for chemical analysis Ismaeel, (2015). Soil texture was determined by using hydrometer method ASTM, (2017).

Heavy metals analysis were done at the laboratories of Science college, Salahaddin University-Erbil by using XRF (X-ray fluorescence spectrophotometer) Genius 5000XRF Mamand et al., (2020).

And the chemical and physical properties of the soils were determined by Agricultural Research Center/Ainkawa/Erbil.

Table 3.3 *Some Chemical and Physical Properties of the Studied Soils for Chard and Celery Experiments*

Property	Hamamok	Kany qara	Shawgerawa	Alyawa	Azady
EC(Ds/m)	0.1	1.1	0.4	0.7	0.3
pH	7.43	7.61	7.87	7.82	7.73
Organic Matter(%)	2.21	2.47	1.35	1.04	1.19
Nitrogen %	0.12	0.13	0.11	0.07	0.09
Phosphorus(ppm)	25.5	32.5	22	16	14.5
potassium(ppm)	153	240	150	132	148
Sand(%)	19.71	39.4	10.0	40.0	20.5
Silt(%)	60.00	49.3	59.1	45.2	61.9
Clay(%)	20.29	11.3	30.9	14.8	17.5
Soil texture	Silty Loam	Loam	Silty clay loam	Loam	Silty Loam

Table 3.4 *Some Chemical and Physical Properties of the Studied Soils for Broad Bean and Wheat Experiments*

Property	Hamamok	Kany qara	Shawgerawa	Alyawa	Azady
EC(Ds/m)	0.5	0.8	0.4	0.2	0.3
pH	7.54	7.70	7.90	7.67	7.87
OrganicMatter(%)	1.52	1.94	1.45	1.65	1.75
Nitrogen %	0.29	0.26	0.21	0.18	0.31
Phosphorus(ppm)	62	88.5	73	56	62
potassium(ppm)	152	492	226	136	152

3.3 Study Area

Koya district located 60 km south east of Erbil city, is one of the largest district belongs to Erbil governorate Othman et al.,(2012). The five different locations in Koya city were determined, The geographical selection for the locations were :Hamamok (36°05'33"N 44°36'53"E) ,Kany qara (36°03'51"N 44°37'39"E), Shawgerawa (36°03'47"N 44°38'19"E), Alyawa (36°03'42"N 44°37'06"E) and Azady (36°04'15"N44°38'45"E).

Fig. 3.1: Map of Koya District Showing the studied sites is indicated:

S1 (Hamamok), S2 (Kany qara), S3 (Shawgerawa), S4 (Alyawa), S5 (Azady)

3.5 First Experiment Include Leafy Plants: Chard

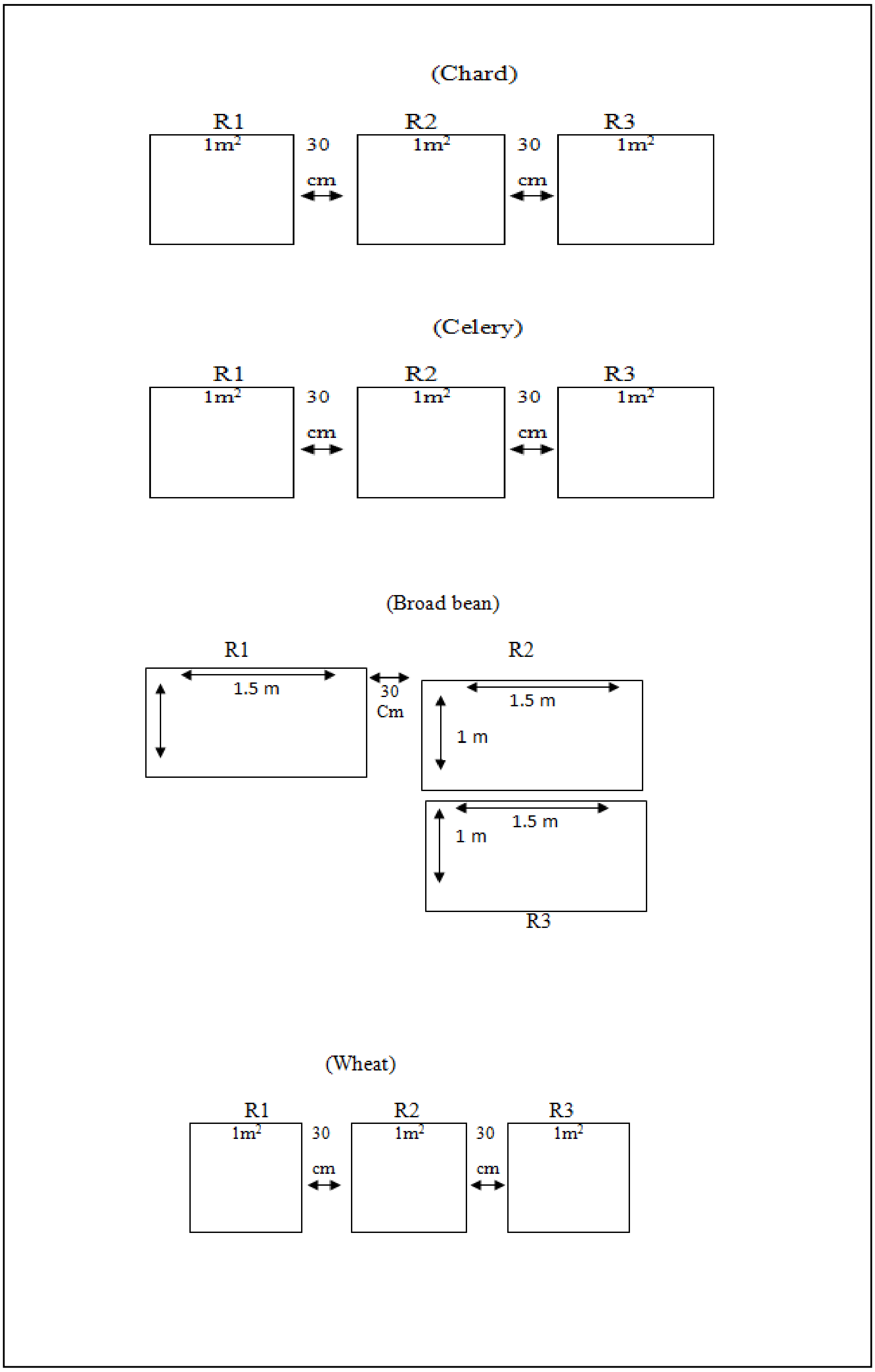
3.5.1 Chard Plant

The land was plowed the leveled for preparing the seedbed, which consist of 15 experiment units in 5 locations which are Hamamok (well water- control), (Kany qara, Shawgerawa, Alyawa and Azady) location of sewage water. In 7/10/2021 Chard plant (*Beta Vulgaris*) cultivated by using local chard seed 20g for each m^2

The irrigation in the first week were three times a week, and in the second week were twice a week, after that were once a week.

On 29/11/2021, Chard plant samples were collected and returned to the laboratory as soon as possible. Plant samples were dried at 65 °C till a constant weight for 72 hours in the oven, then grind with stainless steel mill and stored for chemical analysis Zheljazkov and Warman, (2004).

Table (3.5*) The Diagram of the Field Experiments for the Chard, Celery, Broad Bean, and Wheat in Hamamok, Kany qara, Shawgerawa, Alyawa and Azady Locations.*



3.6 Morphological and Vegetative Growth of Chard and Celery Plant

3.6.1 Plant Height (cm)

It was measured by metric tape line from the soil surface to the apical point of the main shoot.

3.6.2 Number of Leaves $Plant^{-1}$

The total number of leaves in each plant was counted from ten randomly selected chard plants for each replication (Engelbrecht et al., 2010).

3.63 Fresh Weight of Shoot (g)

The shoot after washing with water, dried with cotton fabrics, weighed by using sensitive balance at plant cutting (Engelbrecht et al., 2010).

3.6.4 Dry Weight of Shoot (g)

TheFresh shoot put in an oven at 65°C till a constant weight for 72 hours then weighed by a sensitive balance (Tudela, et al., 2017).

3.6.5 Stomata Characteristics

In the morning five leaves were chosen, placed in plastic bags, and transported to the lab. The epidermal peel slides were examined using the lasting impressions method. In this technique, a thick area of clear nail polish was placed on the surface of the leaf, covering at least one square centimeter. Allowing the nail polish to dry completely, I then sealed the dried nail polish patch with clear cellophane tape.Next, peel a corner of the tape, the fingernail polish, and the leaf peel to remove the nail polish patch. This is a leaf impression that was mounted on slides, labeled as the adaxial and abaxial surfaces, and then studied under a light microscope (DM300, Leica Microsystems, China) with a camera attached. The image was then analyzed using analysis software using the ScopeImage 9.0 (H3D) program (Rai andMishra, 2013).

3.6.5.1 Number of Stomata (mm^2)

Leaf impression on slides was examined under 40x by in micron light microscope. Numbers of appeared stomata on lens field were counted for eachadaxia land abaxial all leaves surface.

3.6.5.2 Length and Width of Stomata (µm):

Leaf impression on slides was examined under 40x by microscope. Length and width of stomata guard cells of adaxial and abaxial leaf surfaces were measured in(µm) with scaled ocular lens.

3.6.6 Chemical Compositions (Photosynthesis Pigments)

3.6.6.1 Chlorophylls and Total Carotenoids Content ($mg.g^{-1}$)

The amount of chlorophyll a, b, and carotenoids were estimated according to (Lichtenthaler and Wellburn, 1983). Leaf material was collected, and 0.4 g of fresh leaves mixed with 20 ml, 80% acetone then grained by mortar pestle and filtered by filter paper after that the extract was placed in a 25 ml glass vial (dark bottle) to prevent evaporation and avoid oxidation of pigments, and then read the results by spectrophotometer at 663, 646 and 470 nm wave lengths. Chlorophyll a, chlorophyll b, and total carotenoids were calculated as follow:

$$\text{Chlorophyll a (mg/L)} = (12.21 \times A663) - (2.81 \times A646)$$

$$\text{Chlorophyll b (mg/L)} = (20.13 \times A646) - (5.03 \times A663)$$

total Chlorophyll was content gained by summation of chlorophyll a and b.

$$\text{Total carotenoids} = (1000 \times A470 - 3.27 \times \text{Chl a} - 104 \times \text{Chl b})/229$$

Where, A is Absorbance, Chl a chlorophyll a, and Chl b chlorophyll b.

For converting the concentration from mg/L to mg/g fresh weight, each value multiplied by (extraction volume / sample weight × 1000).

3.6.7 Chemical Elements

This analysis was done at the laboratories of Science College, Ecological Department, University of Salahaddin by using XRF (X-ray fluorescence spectrophotometer). This is a recognized analytical method for evaluating both qualitative and quantitative elements. It is a multi-element, simultaneous method that is also non-destructive, making it appropriate for plant analysis where about (5g) of dry plant material was powdered and compressed by (Die press machine) to obtain a disc which is used by XRF device (Genius 5000 XRF) (Mamand et al., 2020).

3.6.8 Bio-Concentration Factor (BCF) in Chard Plant

The following equation was used to determine the BCF, a parameter used to represent the transfer or mobility of metals from polluted soils to specific plants and to assess the impact of wastewater-irrigated plants on human health concerns:

$$BCF = Cv/Cs$$

Where Cv and Cs are the concentrations of heavy metals ($mg\ kg^{-1}$) in the edible section of plants and soil, respectively, and BCF is the bio-concentration factor Tariq, (2021).

To evaluate the associated health risks of wastewater-irrigated plants, the BCF assessment is required. If BCF is less than 1, the vegetable merely has the capacity to absorb metals; if BCF is greater than 1, the vegetable has the capacity to accumulate metals. Oliva and Espinosa, (2007) ; Chaoua et al., (2019).

3.7 Second Experiment of Celery Plant

The locations were irrigated for soft plowing and preparing the best seedbed, which consist of 15 experiment units in 5 locations which are Hamamok (well water- control), (Kany qara, Shawgerawa, Alyawa and Azady) sewage water. On 7/10/2021 Celery plants (*Apium graveolens L*) cultivated in the same five locations by useding on Najafi celery seed with 60 g for each m^2 .

The irrigation in first week were three times a week, and in the second week were twice a week, after that were once a week.

On 31/12/2021, Celery plant samples were collected and returned to the laboratory as soon as possible. Plant samples were dried at 65 °C till a constant weight for 72 hours in the oven, then grind with stainless steel mill and stored for chemical analysis Rashid and Mohammed, (2016).

3.8- Third Experiment Include Legume Plant (Broad Bean)

Broad bean (Fito- LUZ DE OTONO) was cultivated in (20 November, 2021) in Koya city which including 5 locations Hamamok (irrigated by well water- control), while the locations of (Kany qara, Shawgerawa, Alyawa and Azady) irrigated by sewage water, with three replications , and the space between seeds were 30 cm, with 5 cm soil depth

The broad bean fields irrigated with waste water only three times because we depend of rain fall, one irrigation in the end of November due to less of rain as shown in table (3.6), but onother irrigation in April, which rate of rane fall was 10.2 mm according to table (3.6)

first irrigation was on 26/11/2021.

second irrigation was on 1/4/2022.

Third irrigation was on 9/4/2022.

On 20 April, 2022 plant pods were collected and returned to laboratory as soon as possible and dried to constant weight at 65 °C (for three days) in the oven, then grind with stainless steel mill then stored for chemical analysis Sadiq, (2015)

Figure (3.2) The Celery of the Field Experiments.

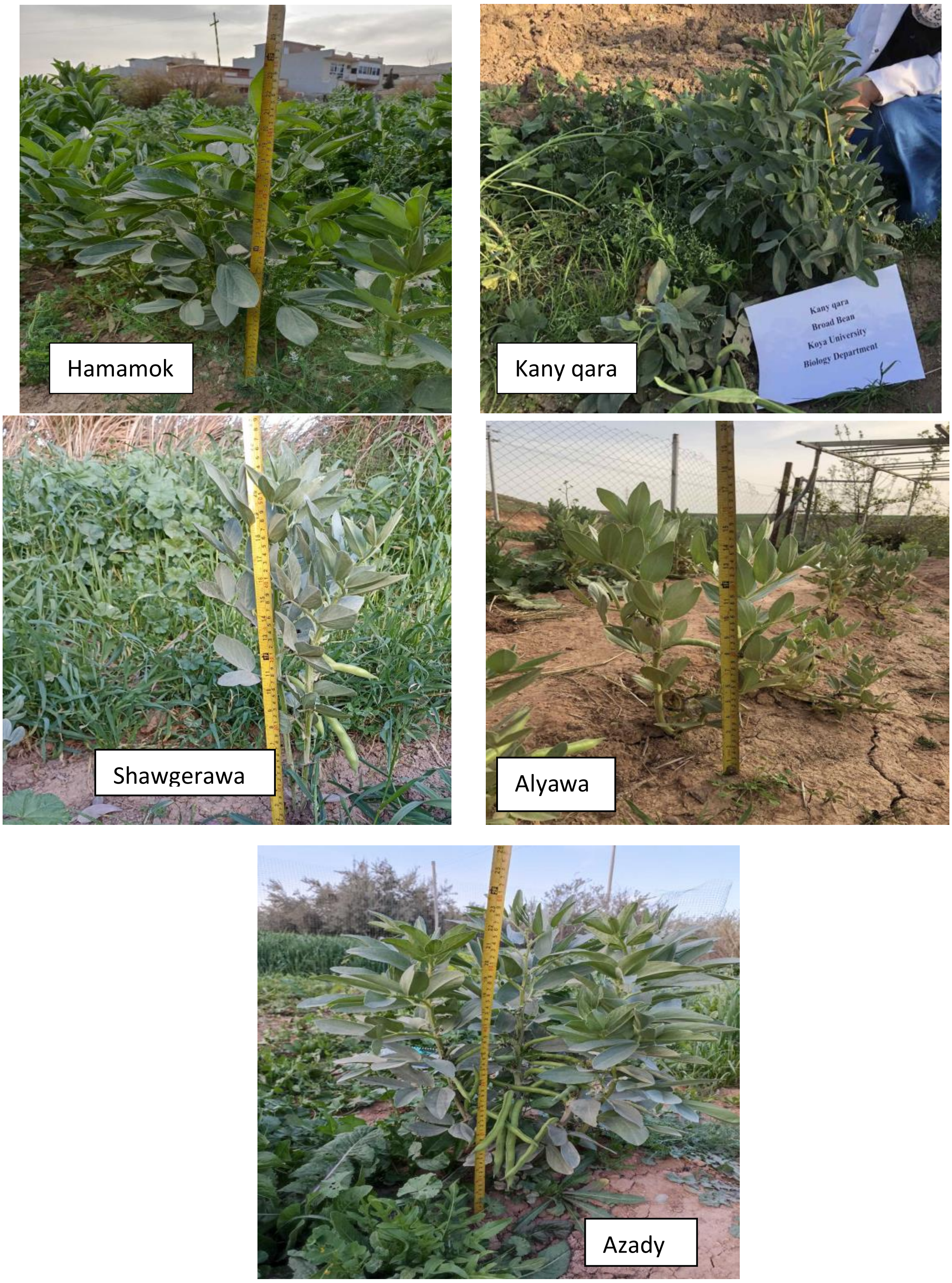


Figure (3.3) The Broad Bean Field Experiments

3.8.1 Morphological and Vegetative growth

Five plants collected randomly in each plot for studying Morphological and Vegetative growth.

3.8.1.1 Plant Height (cm)

plant height was determined by measuring the distance between the soil surface and the terminal growing point for plant stem (Etemade et al., 2018).

3.8.1.2 Number of Leaves Plant^{-1}

The mean number of leaf per plant was recorded in each plot (Omar, 2016).

3.8.1.3 Leaf Area(cm^2)

Total Plant leaves area= known leaf area × Total dry leaf weight/ known dry leaf weight

3.8.1.4 Number of Pods Plant^{-1}

The total number of pods per plant was calculated (Hasan, 2022).

3.8.1.5 Number of Seeds Plant^{-1}

The number of seeds for each pod calculated Hasan, (2022)

3.8.1.6 Fresh Pod Weight Plant^{-1}(g)

the mean weight of pods per plant was recorded in each plot Omar, (2016).

3.8.1.7 Dry Pod Weight Plant^{-1}(g)

fresh pods plant dried in oven at 65°C for 72 hours till weight fixed by precious sensitive balance.

3.8.1.8 Number of Days from Seeding to 50 % Flowering (day)

It counted number of days from seeding to 50% flowering Yehmed et al., (2022)

3.8.1.9 Number of Days to 50% Pods Maturity (day)

It counted number of days from seeding to 50% pod maturity Yehmed et al., (2022)

3.8.1.10 Grain Filling Period (day):

counting number of days from 50 % flowering to 50 % pod maturity (filling period).

3.8.2 Morphological and Vegetative growth of first pod

3.8.2.1 Height of the First Pod(cm)

Measuring the distance between the soil surface and the first pod joined on the plant stem Etemade et al., (2018)

3.8.2.2 Length of the First Pod Plant (cm)

it was measured pods length by metric tape line.

3.8.2.3 Number of Pods in the First Node Plant^{-1}

ounting number of first pods per plants.

3.8.2.4-Number of Seeds in the First Node per Plant^{-1}

Counting number of seeds in first node Plant.

3.8.2.5 Fresh Weight of the First Pod per Plant (g)

weighting the pods in first node by sensitive balance.

3.8.2.6 Dry Weight of the First Pod Plant (g)

weighting the pods in first node after its drying in oven at 65°C for 72 hours till fixing the weight using sensitive balance.

3.8.2.7 Stomata Characteristics

As shown in the chard plant experiment.

3.8.2.8 Chemical Compositions (photosynthesis pigments)

3.8.2.9 Chlorophylls and Total Carotenoids Content

As shown in the chard plant experiment.

3.8.2.10 Chemical Elements

As shown in the chard plant experiment.

3.8.2.11 Bio-concentration factor (BCF) in broad bean plant

As shown in the chard plant experiment.

3.9 Fourth Experiment: Cereal Crop - The Wheat

The third experiment included cultivation of wheat (*Triticum aestivum L*), (Hawler 4) which were obtained from Koya Agriculture Research Center .

The wheat seeds cultivated on 31/12/2021 in Koya city at 5 locations which are Hamamok (well water- control), (Kany qara, Shawgerawa, Alyawa and Azady) wastewater, with three replications for each locations with five lines in each plot.

Each line cultivated with 3g seeds and space between lines was 25cm, it is meaning each replication consist of 15 gm of wheat seeds and harvested date was 28 May 2022. But at the end of work the wheat I produced was eaten by a bird at Alyawa location, there for cause to decrease grain yield in this location.

The supplementary irrigation dates by waste water were as follow :

First irrigation was on(1/4/ 2022).

Second irrigation was on (9/4/ 2022).

Third irrigation was on (17/4/ 2022).

3.9.1 Morphological and Vegetative Growth

3.9.1.1-Plant Height (cm)

height of the plant was measured by metric tape line from soil surface to wheat spike base during the physiological maturity and then calculated average height (cm) of ten plants Intsar et al., (2019).

3.9.1.2- Number of Tillers (tiller m^{-1})

total emerged tillers were counted per square meter for each plot Naby, (2020).

3.9.1.3 Number of Leaves (leaf tiller^{-1})

number of leaves for each main tiller were counted which were observed by the naked eye Hussein, (2023)

3.9.1.4 Flag Leaf Area (cm^2)

selected a mean of 10 flag leaves of the main shoot for plot and then was calculated according to the AL-Hassnawi and Al-Burki, (2022)

Flag leaf area = L max. x W max. x index factor

Maximum flag leaf length = L max.

Minimum flag leaf width = W max.

Index factor = (0.95)

3.9.1.5 Number of Days From Seeding to 50% Flowering (day)

Counting Number of Days From Seeding Till Flowering Ali, (2021).

3.9.1.6 Grain Filling Period (day)

Counting number of days from flowering to physiological maturity Ali, (2021).

3.9.1.7 Number of Days From Seeding to 50 % Physiological Maturity (day)

Counting number of days from seeding till maturity Ali, (2021).

3.9.1.8 Stomata Characteristics

As shown in the chard plant experiment.

3.9.1.9 Chemical Compositions (photosynthesis pigments)

3.9.1.10 Chlorophylls and Total Carotenoids Content:

As shown in the chard plant experiment.

3.9.2 Grain Yield and Yield Components

3.9.2.1 Number of Spikes (spike.m^{-2})

The average number of spikes per meter was recorded at harvesting Ali, (2021).

3.9.2.2 Length of Spike (cm)

The spike length was measured in centimeters from the base of the spikelet to the tip of the spike excluding awns.at harvesting Ali, (2021).

3.9.2.3 Grain Yield $Spikes^{-1}$(g)

The mean weight of grain per ten spikes was calculated in each plot at harvesting**.**

3.9.2.4 Seed Index (g)

Counting 1000 grain from each plot then weighting with accurate balance at laboratory jalal, (2023).

3.9.2.5 Grain Yield (ton ha^{-1})

One meter length was harvested from each plot of wheat then threshed seeds and calculated by grams with accurate balance at laboratory and transferred to ton per hectare jalal, (2023).

3.9.2.6 Straw Yield (ton ha^{-1})

Straw yield refers to the Biological yield subtracted from it grain yield.

Straw yield = Biological yield – grain yield.

3.9.2.7 Biological Yield (ton.ha^{-1})

It was calculated by harvesting one meter length of matured wheat from each plot from soil level and measured the whole plant by grams with accurate balance then transferred to ton per hectare Naby, (2020).

3.9.2.8 Harvest Index %

It was estimated by expressing the ratio of grain yield to biological yield of wheat for each plot Donald and Hamblin, (1976).

HI = (Grain Yield / Biological Yield) x100 .

3.9.3 Chemical Elements

As shown in the chard plant experiment.

3.9.4 Bio-Concentration Factor (BCF) in Wheat Plant

As shown in the chard plant experiment.

3.10 Meteorological Data and Soil Properties

Table (3.6) illustrates the maximum and minimum temperatures, relative humidity and the amount of rain fall in the field during the planting season which were registered by the Agro-Meteorological Station in Koya city, Erbil

Table 3.6 *Maximum and Minimum Temperature and Relative Humidity and the Amount of Rain fall During the Growing Season (2021-2022).*

Months	Koya location				
	Temperature/°C		Relative humidity(%)		Rain fall/mm
	Maximum	Minimum	Maximum	Minimum	
October 2021	31.51	20.03	52	42.77	4.5
November 2021	23.96	15.06	39.76	34.96	4.6
December 2021	18.06	8.70	64	50.19	113.4
January 2022	11.74	4.22	77.35	65.09	132.6
February 2022	17.42	8.67	61.75	49.71	42.5
March 2022	16.74	12	63.51	47.77	35.1
April 2022	28.66	16.5	45.83	33.7	10.2
May 2022	30.22	19.61	42.54	34.16	25.3
June 2022	40.06	27.26	27.266	21.06	0.0
July 2022	42.87	30.06	19.96	14.48	0.0

3.11 Experimental Design and Statistical Analysis

Data were statistically analyzed using one way analysis of variance complete randomized design (CRD) to compare the effect of each irrigation water source in each locations on the charechteriziticity of studied plants. The mean values were compared using Duncans at 5% probability level. All statically analyses were carried out using the SAS software program (Al-Mohammadi and Al-Mohammadi, 2002).

CHAPTER FOUR

4. RESULTS AND DISCUSSIONS

4.1 First Experiment Chard

4.1.1 Effect of Wastewater on the Vegetative Growth Characteristics of Chard Plant

4.1.1.1 Plant Height (cm)

According to the table 4.1, there are significant differences only between both locations Azady and Alyawa , The highest plant Height was (44.56 cm) recorded in Azady location and the lowest plant height in Alyawa was (37.71cm). While no significant differences were seen between Hamamok, Kany qara, Shawgerawa and Azady. High amount of salts in wastewater, according to table (3.1), may be cause to decrease plant height in Kany qara, Shawgerawa and Alyawa locations, These results agree with Mkhinini et al., (2018). On the other hand increase O.M in waste water in Azady location according to table (3.1) can be affective for increasing the plant high, this agree with Singh and Agrawal, (2007). Our result only in Azady agree with Mojiri, et al., (2013), but disagree in other locations. The results of Kany qara and Shawgerawa as shown in table (4.1), agree with Day and Kirkpatrick, (1973), but disagree in other locations.

4.1.1.2 Number of Leaves Plant^{-1}

The results of table 4.1, illustrate non- significant differences on the chard leaf number per Plant in studied locations. The highest leaf number were (6.13 leaf.Plant^{-1}) from Azady location and lowest was (5.33 leaf.Plant^{-1}) in Shawgerawa location. The results show non-significant differences between sewage-irrigated and control.

4.1.1.3 Fresh Weight of Shoot (g)

Table 4.1 showed significant differences only between both locations Azady (470.06 g) and Hamamok (281.02 g), no significant differences shown between other locations. Enhancement of nitrogen fertilizer in wastewater application as shown in table (3.1), may be cause to increase fresh shoot weight, our results in all locations agree with Rusan et al., (2007). As they found that wastewater was only barely irrigated, and the results were higher fresh weight and dry weight than the control. According to Papadakis et al., (2007) findings, the improvement in vegetative growth can be linked to K's participation in plant cell turgor pressure and nutrient and sugar translocation. It is also involved in cell enlargement and triggering young tissue or mersitematic growth Kumar et al ., (2015). Our result in all locations sit in parallet to El-Nahhal, et al., (2013).

4.1.1.4 Dry Weight of Shoot (g)

The highest value (35.54 g) was recorded from Azady location, while the lowest value (21.98 g) was obtained from Hamamok location. It means irrigation with wastewater at Azady location caused 61.96% increase in shoot dry weight. This may be due to the reasons mentioned before in discussing fresh weight.

Table 4.1 *Effect of Wastewater on the Vegetative Growth of Chard*

Locations	Plant height (cm)	No. ofLeaves $plant^{-1}$	Fresh weight (g)	Dry weight (g)
Hamamok	40.5 ab	5.93 a	281.02 b	21.98 b
Kany qara	39.01 ab	5.76 a	378.79 ab	29.88 ab
Shawgerawa	39.0 ab	5.33 a	389.88 ab	30.93 ab
Alyawa	37.71 b	5.93 a	314.81 ab	25.85 ab
Azaday	44.56 a	6.13 a	470.06 a	35.54 a

Means followed by the same letters within column are not significantly different at $p \leq 0.05$ according to Duncan multiple range test.

4.1.2 Effect of Wastewater on Some Stomata Characteristics on Upper & Lower Leaf Surface of Chard Plant:

As shown in the table (4.2) No. of stomata on the upper and lower leaf surface show significantly difference only between both locations Azady and Kany qara. Azady location recorded the highest number of stomata (5.933 and 8.6) stomata. mm^{-2}, respectively. While Kany qara location have the lowest number of stomata (3.733 and 5.266) stomata. mm^{-2} respectively**,** number of stomata from upper and lower surface only in Kany qara lower than control and result of Kany qara agree with Holguin et al., (2022) who reported that barley plants irrigated with wastewater had lower stomata density than the plants irrigated with ground water. An increase in stomata density gave a potential to increase use of water Hajihashemi et al., (2019)**.**

The locations or irrigation with different wastewater and well water were not effected significantly on length and width of stomata.

Table 4.2 *Effect of Wastewateron Some Stomata Characteristics on Upper & Lower Leaf Surface of Chard Plant*

Locations	Stomata Number (stomata. mm^{-2})		Stomata Length (µm)		Stomata Width (µm)	
	Upper leaf surface	Lower leaf surface	Upper leaf surface	Lower leaf surface	Upper leaf surface	Lower leaf surface
Hamamok	5.6 ab	7.133 ab	44.726 a	44.33 a	32.564 a	31.825 a
Kany qara	3.733 b	5.266 b	45.999 a	43.389 a	31.856 a	30.436 a
Shawgerawa	5.733 ab	7.133 ab	44.282 a	42.076 a	31.028 a	30.587 a
Alyawa	5.733 ab	7.666 ab	44.286 a	47.952 a	30.782 a	35.715 a
Azady	5.933 a	8.6 a	44.507 a	44.104 a	31.418 a	31.365 a
Means followed by the same letters within column are not significantly different at $p \leq 0.05$ according to Duncan multiple range test						

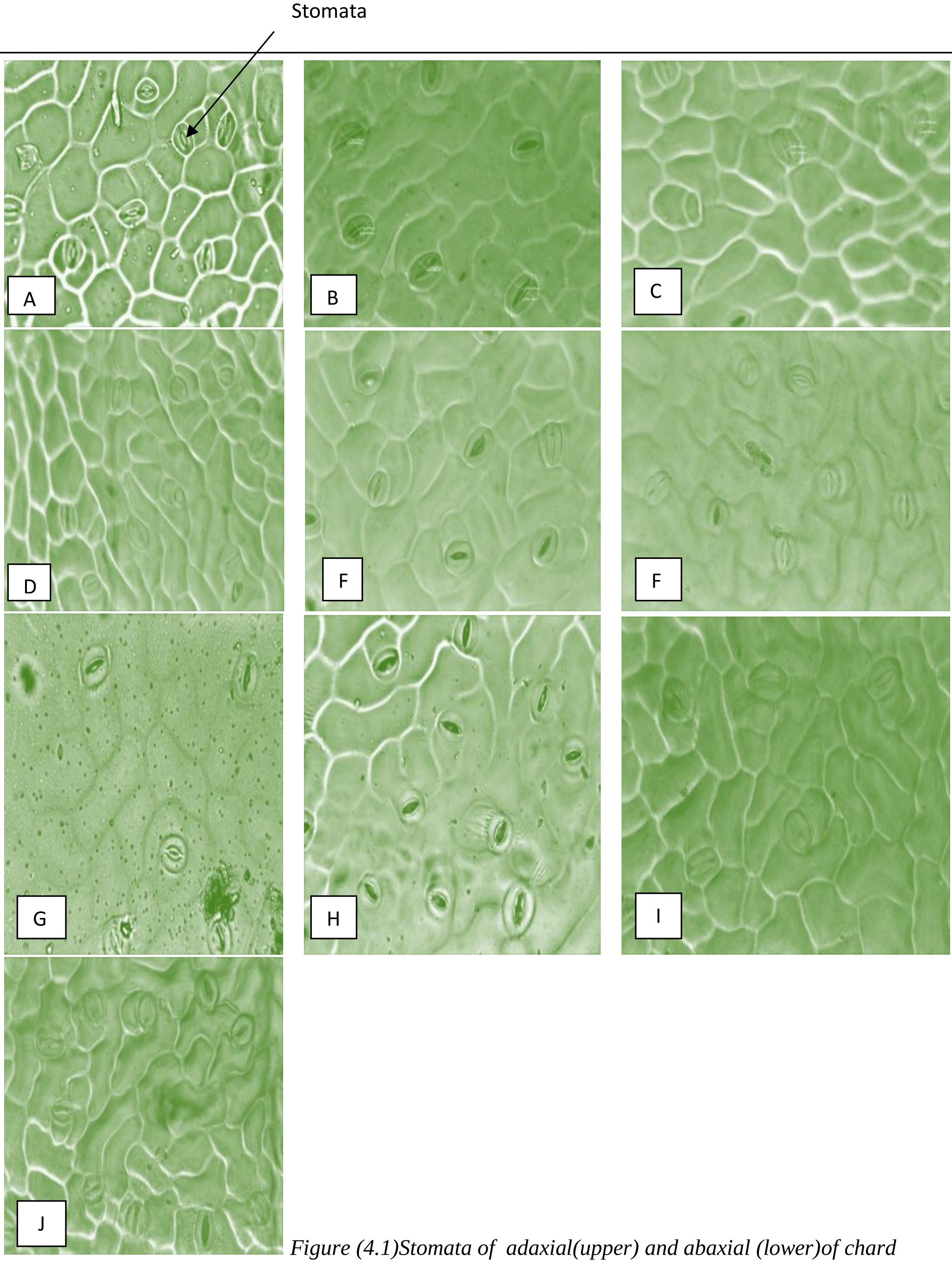


Figure (4.1)Stomata of adaxial(upper) and abaxial (lower)of chard leaves surface of 40x, A. upper surface in Hamamok, B. lower surface in Hamamok, C. upper surface in Kany qara, D. lower surface in Kany qara, E. upper surface in Shawgerawa, F. lower surface in Shawgerawa, G. upper surface in Alyawa, H. lower surface in Alyawa, I. upper surface in Azady, J. lower surface in Azady.

4.1.3 Effect of Wastewater on Photosynthetics Pigments in Chard Leaves

The results in table 4.3, indicated to non significant difference of Chlorophyll a between concentration of chard plant at the studied locations or irrigated with wastewater and well water.

The results in table 4.3, shows significant effects on chlorophyll b, the highest and the lowest value were recorded at Hamamok and Kany qara irrigation of well water and wastewater (0.785 and 0.182) mg. g^{-1}, respectively. The results of all locations agree with result (Naaz and Pandey, 2010) who found chorophyll b were less when lettuce plants were irrigated with wastewater (100 %) irrigation. Also our results in all locations agree with Daud et al., (2016) or this my be due to the dilution effect since Hamamok location recorded the lowest fresh wehigt (table 4.1) on the other hand the concentration of other nutrients such as Mg and Fe may be higher in Hamamok location.

Total Chlorophyll of chard plant leaves, affected significantly by locations or irrigation water type . According to table 4.3, the significant difference only recorded between Hamamok and Alyawa locations which were (1.75 and 0.98 mg. g^{-1}) respectively. This may be due to the reasons mentioned before.

As illustrated in table 4.3 carotene content reached significant level in study locations. The highest rate was (0.530 mg.g^{-1}) recorded at Hamamok location and the lowest content was observed at Kany qara location (0.295 mg.g^{-1}). Our results in all the locations agree with Naaz and Pandey, (2010) who stated Carotene content were less when plants were irrigated with waste water (100%) irrigation. Daud et al., (2016) regarding the effects of wastewater on maize seedlings revealed a decline in carotene content, this degradation stress could be linked with increased activity of chlorophylls or reduced de novo synthesis of chlorophyll. Also our result in all locations were different from Singh and Agrawal, (2010; Abdel Latef and Sallam, 2015).

Table 4.3 *Effect of wastewater on Photosynthetic Pigments in the chard leaves*

Locations	Chlorophyll a ($mg.g^{-1}$)	Chlorophyll b ($mg.g^{-1}$)	Total chlorophyll ($mg.g^{-1}$)	Carotene ($mg.g^{-1}$)
Hamamok	0.966 a	0.785 a	1.751 a	0.530 a
Kany qara	0.839 a	0.182 b	1.021 ab	0.295 c
Shawgerawa	1.040 a	0.250 b	1.290ab	0.356bc
Alyawa	0.635 a	0.342 b	0.977 b	0.353bc
Azaday	0.874 a	0.456ab	1.330ab	0.425ab

Means followed by the same letters within column are not significantly different at $p \leq 0.05$ according to Duncan multiple range test

4.1.4 Concentration of Soil Heavy Metals in all Studied Locations for Chard and Celery Experiment

The results in table (4.4) reveal the soil elements' concentrations (Cd, Pb, Cu, Zn and Mn) in the soils of studied locations which vary from metal to other according locations. Cadmium is naturally presented metal in all soils that is non-essential for plant nutrition Ahmed, (2017b).

The result of Cd in Soils show non-significant differences between sewage water irrigation and control.

The concentration of lead in table 4.4 show significantly differences in studied locations, the highest value (13.700 and 13.120) mg kg^{-1} recorded by Azady and Hamamok locations respectively, and lowest value (9.442 mg kg^{-1}) recorded by Alyawa location ,

The Pb content in studied locations were more than (0.047 mg kg^{-1}) which reported by Nahhal et al., (2013), while were less than permissible limits (100 mg kg^{-1}) which is recorded by Bigdeli and Seilsepour, (2008). Or this may be due to the low concentration of Pb in irrigation water.

Copper content in soil samples were non- significantly affected ($p<0.05$) (table,4.4). Our results at all locations were higher than the results which founded by Ali, (2007).

Also the content of Cu at all studied locations is less than permissible limits (100 mg kg^{-1}) according to Bigdeli and Seilsepour, (2008).

As illustrate in table 4.4 the Zinc concentration in studied soils differed significantly, the lowest value was (64.236 mg kg^{-1}) in Hamamok location and the highest value was (145.465 mg kg^{-1}) in Kany qara location that differed significantly from the other locations,

The result of both locations Hamamok and Alyawa were lower than (74.145 mg kg^{-1}) that recorded by Mamand, (2008) in Erbil city.

The content of Zn is lower than permissible limits (300 mg kg^{-1}) in all the studied locations according to Bigdeli and Seilsepour, (2008).

The data in table (4.4) show significant differences between the studied locations according to its content from manganese element which ranged between (303.86 - 752.49) mg kg^{-1}. The highest value was recorded at Alyawa location and the lowest value was recorded at Shawgerawa location.

According to Bigdeli and Seilsepour, (2008) Mn content in the soils of studied locations is less than permissible limit (2000).

Table 4.4 *Concentration of soil heavy metals (mg kg^{-1}) in studied locations for Chard and Celery plants.*

Heavy Metals (mg kg^{-1})	Locations					(Bigdeli and Seilsepour, 2008) Soil (mg kg^{-1})
	Hamamok	Kany qara	Shawgerawa	Alyawa	Azady	
Cd	1.645 a	1.650 a	1.337 a	1.252 a	1.557 a	3
Pb	13.120 a	10.303bc	11.754ab	9.442 c	13.700 a	100
Cu	64.612 a	45.296 a	60.432 a	54.842 a	43.413 a	100
Zn	64.236 b	145.465 a	81.166 b	70.875 b	76.304 b	300
Mn	460.78 b	409.68 b	303.86 c	752.49 a	467.81 b	2000

Means followed by the same letters within row are not significantly different at $p \leq 0.05$ according t multiple range test

4.1.5 Effect of Wastewater on the Heavy Metals Concentration in the Edible Parts of a Chard

The results in table (4.5) reveal the metals' concentration (Cd, Pb, Cu, Zn and Mn) in the edible parts of a Chard plant .The concentration of heavy metals in chard plant vary from metal to other in studied locations.

According to Duncan's test the Cd concentration differed from location to other but not reached significant levels in Chard plant at studied locations. The result of Cd and Pb show non-significant different between sewage water irrigation and control.

As shown in table 4.5, existence of significant difference between the studied locations according to its content from Cu, the highest Cu concentration in chard plants (43.028 mg kg^{-1}) was observed in Alyawa location, while the lowest concentration of Cu (10.964 mg kg^{-1}) was obtained at Azady location. The content of Cu in chard plants at all studied locations were more than (1.86, 9.01and 0.008) mg kg^{-1}, which recorded by Mohamed et al., (2003), Tariq, (2021) and Sadee, (2022) respectively. While there were less than safe limits (40 mg kg^{-1}) FAO/WHO, (2001), except Alyawa with 43.02 mg kg^{-1}.

The results in table 4.5 indicate to significant difference between the studied locations according to its Zn content in chard plants, the lowest concentration (22.874 mg kg^{-1}) was in Alyawa location which didnt differe significantly from Hamamok (24.327 mg kg^{-1}) and Azady (26.938 mg kg^{-1}). While the highest Zn concentration (82.873 mg kg^{-1}) was obtained at Kany qara location which differed significantly from all other locations. Zn content at all locations were less than (77.68 mg kg^{-1}) which recorded by Tariq, (2021) except Kany qara location. Our results in some locations were near to result of Mohamed et al., (2003) (28.1 mg kg^{-1}), except for both locations Shawgerawa (37.615 mg kg^{-1}) and Kany qara (82.873 mg kg^{-1}) According to FAO/WHO, (2001) the Zn content in chard plants at all studied locations were within the safe limits (60 mg kg^{-1}), except Kany qara location (82.873 mg kg^{-1}). This may be due to hight concentration of Zn (145.465 mg kg^{-1}) in the location in comparing with other locations (table 4.4). Or may be due to existing $Znco_3$ in the studed area.

As illustrated in table 4.5, the Mn concentration reached significant levels in the studied locations, the highest concentration was (52.883 mg kg^{-1}) at Alyawa location and the lowest concentration was (31.649 mg kg^{-1}) at Hamamok location. The results of Mn content in studied locations were higher than (30.73 mg kg^{-1}) which found by previous researchers Mohamed et al., (2003). Mn content in chard plant at studied locations were less than safe limits (500 mg kg^{-1}) Gupta et al., (2021).

Table 4.5 *Effect of Wastewater on the Heavy Metals Concentration (mg kg^{-1}) in the Edible Parts of a Chard*

Heavy Metals (mg kg^{-1})	Locations					Safe limits of heavy metals (mg kg^{-1}) vegetables
	Hamamok	Kany qara	Shawgerawa	Alyawa	Azady	
Cd	1.402 a	1.413 a	1.431 a	1.333 a	1.254 a	0.20 (FAO/WHO, 2001) from (Tariq, 2021)
Pb	13.444 a	11.601 a	13.687 a	12.245 a	12.508 a	0.30 (FAO/WHO, 2001) from (Tariq, 2021)
Cu	14.483 c	17.365bc	23.720 b	43.028 a	10.964 c	40 (FAO/WHO, 2001) from (Tariq, 2021)
Zn	24.327 c	82.873 a	37.615 b	22.874 c	26.938 c	60 (FAO/WHO, 2001) from (Tariq, 2021)
Mn	31.649 c	35.533 c	47.010 b	52.883 a	50.583 ab	500 (Gupta et al., 2021)

Means followed by the same letters within row are not significantly different at $p \leq 0.05$ according to Duncan multiple range test.

4.1.6 Bio-Concentration Factor in Chard plant (BCF)

The uptake factor from soil by plants is recognized as Bio-Concentration Factor (BCF). Table (4.6) show the BCF values of heavy metals in chard plants irrigated by wastewater. BCF of Cadmium in studied locations ranged between (0.805 - 1.070), in locations Hamamok, Kany qara and Azady were <1, this indicated that the accumulation of Cd in the chard plants was lower than the accumulation in soil. While BCF in both locations of Shawgerawa and Alyawa has surpassed one (>1) this indicated that the accumulation of Cadmium in chard plant was greater than the accumulation in soil.

BCF of lead at all the studied locations except Azady>1, this reveals that the accumulation of pb in chard plant at all the studied locations except Azady was greater than the accumulation in soil Gupta et al., (2022).

BCF of copper, zinc and manganese at all studied locations <1, it mean that the accumulation of copper, zinc and manganese in chard plant at all studied locations was lower than the accumulation in soil.

Table 4.6 *Bio- Concentration Factor (BCF)of Chard Plants Irrigated by Wastewater.*

Locations	Hamamok	Kany qara	Shawgerawa	Alyawa	Azady
Cd	0.852	0.856	1.070	1.064	0.805
Pb	1.024	1.125	1.164	1.296	0.912
Cu	0.224	0.383	0.392	0.784	0.252
Zn	0.378	0.569	0.463	0.322	0.353
Mn	0.068	0.086	0.154	0.070	0.108

4.2 Second Experiment of Celery Plant

4.2.1 Effect of Wastewater on the Vegetative and Physiological Characteristics of a Celery

4.2.1.1 Plant Height (cm)

In general table (4.7) explains the significant effect of locations or irrigation with wastewater on celery hight (17.33 cm) was recorded from Shawgerawa wastewater, while the lowest value 13.72 cm was obtained from irrigation with well water at the Hamamok location. This may be due to hight concentration of N, P, K and low value of PH for wastewater of Shawgerawa in comparing with their values in well water at Hamamok location (table 3.1)

4.2.1.2 Number of Leaves Plant^{-1}

According to table 4.7, the celery leaf number per plant in the studied sites differed significantly, the maximum number was (4.73 leaf Plant^{-1}) at Kany qara location was indifferent from Hamamok. The lowest was (2.83 leaf Plant^{-1}) at Alyawa location. Increasing organic matter and nutrients in soils irrigated with sewage water in Kany qara according to table (3.3), may be a factor for increasing number of leaves of celery plant in Kany qara, the result agree with Singh and Agrawal, (2010). Also increased EC upon amendment of sewage water as shown in table (3.1), may cause to decrease leaf number in Shawgerawa, Alyawa and Azady locations these results agree with Singh and Agrawal, (2007). Only in Kany qara location our result agrees with Naz et al., (2022), while all the other locations disagree with them.

4.2.1.3 Fresh Weight of Shoot (g)

The results of statistical analysis, which presented in table 4.7, fresh weight of shoot revealed that the variations among the studied sites were significant ($p<0.05$), the highest fresh weight was (15.22 g) at Kany qara location and the lowest fresh weight was recorded at Alyawa location was (4.61 g). According to Saafan et al., (2017) the soil irrigated with wastewater have height rate of organic matter and nutrients, that disagree with our results in Alyawa and Azady soils according to table (3.3), Because, there was decrease organic matter and nutrients in soils with wastewater, may be a factor for decreasing fresh weight. The results of Kany qara and Shawgerawa agree with Torabian, (2010; Zaki and Shaaban, 2015), but Alyawa and Azady locations are different. Also our results in all the locations disagree with Sweththika, et al., (2022).

4.2.1.4 Dry Weight of Shoot (g)

As shown in table 4.7, the dry weight of celery plants at Alyawa location was (0.44 g) dry weight Increasing fresh weight in Kany qara and Shawgerawa cause to increase dry weight in these locations. On the other hand decreasing fresh weight in Alyawa and Azady locations cause to decrease dry weight in these locations as shown in table (4.7). The results of Kany qara and Shawgerawa locations agree with Campbell et al., (1983; Zaki and Shaaban, 2015; Saafan et al., 2017) but Alyawa and Azady locations do not.

Table 4.7 *Effect of Wastewater on the Vegetative and Physiological Characteristics of Celery*

Locations	Plant height (cm)	No. of Leaves plant^{-1}	Fresh weight of shoot (g)	Dry weight of shoot (g)
Hamamok	13.22 b	4.3 ab	10.24 ab	1.27 a
Kany qara	16.12 a	4.73 a	15.22 a	1.69 a
Shawgerawa	17.33 a	3.5 bc	13.26 a	1.38 a
Alyawa	15.32 ab	2.83 c	4.61 b	0.44 b
Azaday	16.28 a	3.53 bc	9.77 ab	1.10 a

Means followed by the same letters within column are not significantly different at $p \leq 0.05$ according to Duncan multiple range test.

4.2.2 Effect of Wastewater on Some Stomata Characteristics on the Upper & Lower leaf Surface of Celery Plant

The result of table (4.8) show the existence of significant differences in the number of stomata in the upper leaf surface in the studied locations. Azady location have the lowest value (2.267 stomata.mm^{-2}), and Kany qara location has the highest value (4.133 stomata.mm^{-2}), while there are no significant differences among other locations.

As illustrated in table (4.8), the length and width of stomata at upper and lower part of leaves was not effected significantly by irrigation with wastewater and well water at studied sites.

Table 4.8 *Effect of Wastewater on Some Stomata Characteristics on Upper & Lower Leaf Surface of Celery Plant*

Locations	Stomata Number (stomata.mm^{-2})		Stomata Length (μm)		Stomata Width (μm)	
	Upper leaf surface	Lower leaf surface	Upper leaf surface	Lower leaf surface	Upper leaf surface	Lower leaf surface
Hamamok	3.267 ab	6.333 a	44.754 a	42.210 a	29.354 a	28.527 a
Kany qara	4.133 a	5.8 a	47.061 a	48.344 a	30.413 a	27.982 a
Shawgerawa	3.4 ab	6.267 a	49.104 a	42.245 a	30.532 a	26.829 a
Alyawa	3.067 ab	5.667 a	45.997 a	42.600 a	31.412 a	23.714 a
Azady	2.267 b	4.667 a	46.128 a	46.338 a	30.171 a	25.438 a
Means followed by the same letters within column are not significantly different at $p \leq 0.05$ according to Duncan multiple range test						

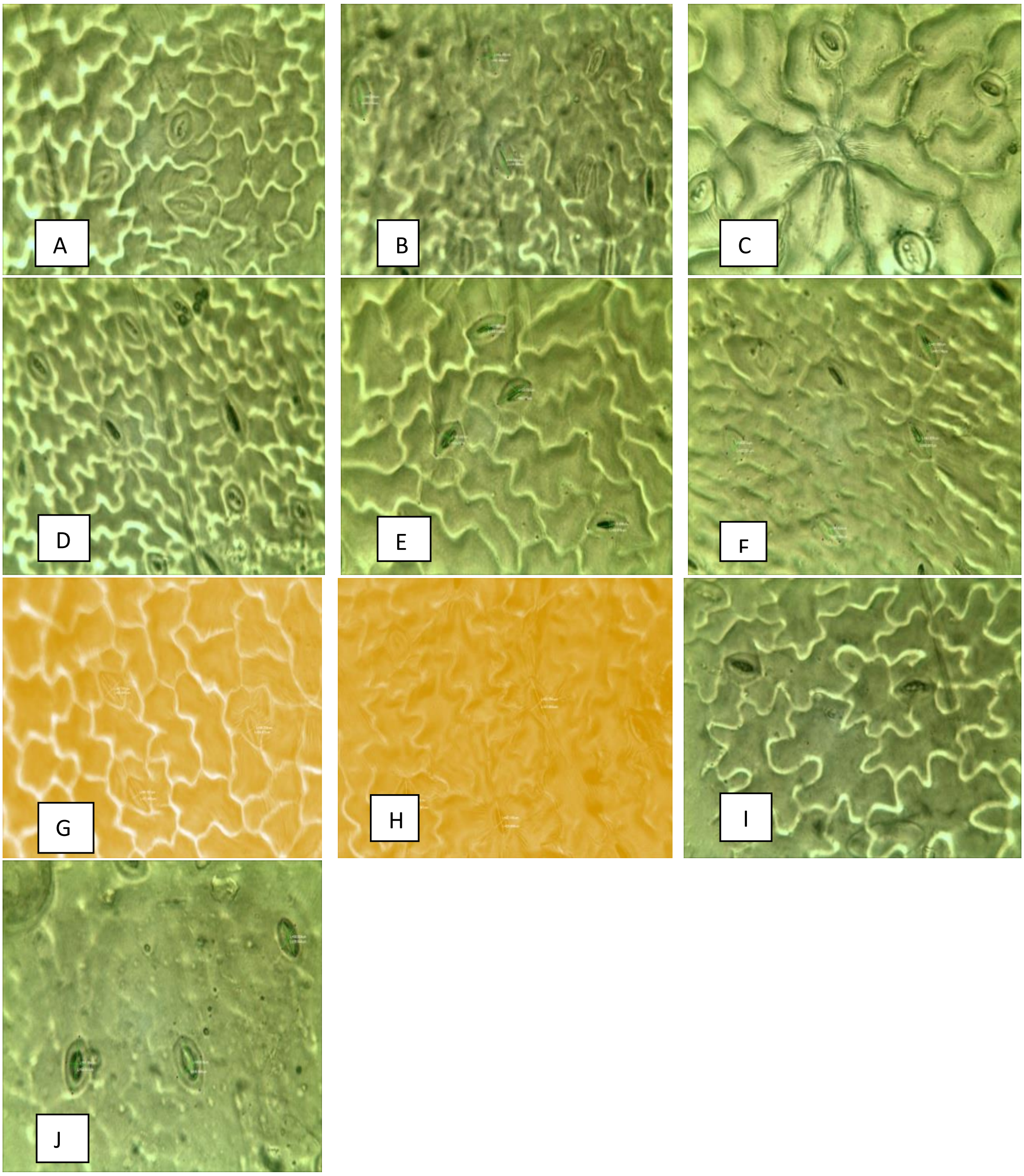


Figure (4.2) Stomata of adaxial(upper) and abaxial(lower) of celery leaves surface of 40x, A. upper surface in Hamamok, B. lower surface in Hamamok, C. upper surface in Kany qara, D. lower surface in Kany qara, E. upper surface in Shawgerawa, F. lower surface in Shawgerawa, G. upper surface in Alyawa, H. lower surface in Alyawa, I. upper surface in Azady, J. lower surface in Azady.

4.2.3 Effect of Wastewater on the Photosynthetic Pigments in Celery Leaves

Table (4.9) shows the significant influence of irrigation with wastewater on concentration of Chlorophyll a. The highest and lowest value (1.062) $mg.g^{-1}$ were recorded from irrigated with wastewater of Kany qara and well water of Hamamok locations respectively. This may be due to the reasons mentioned before or differing chemical properties of the wastewater of Kany qara and well water (table, 3.1)

The results of chlorophyll b and carotenoid content in Celery leaves, as displayed in table 4.9, demonstrated that no significant differences ($P<0.05$) recorded among the studied sites.

Table 4.9 represents the mean value of total chlorophyll in Celery leaf of the different studied sites. A statistical significant difference ($p<0.05$) was observed between the studied sites. The highest value (1.463 mg g^{-1}) was recorded at Alyawa location and the lowest value (0.781 mg g^{-1}) noticed at Azady location. Increasing chlorophyll a and chlorophyll b in Kany qara, Shawgerawa and Alyawa locations cause to increase total chlorophyll in these locations, as shown in table (4.9). But, decreasing chlorophyll a in Azady location, and increase chlorophyll b in a few value in Azady as compared with control cause to decrease total chlorophyll. Our results in all the locations, except for Azady, agree with Torabian et al., (2015).

Table 4.9 *Effect of Wastewater on the Photosynthetic Pigments in the Celery Leaves*

Locations	Chlorophyll a ($mg.g^{-1}$)	Chlorophyll b ($mg.g^{-1}$)	Total chlorophyll ($mg.g^{-1}$)	Carotene ($mg.g^{-1}$)
Hamamok	0.687 bc	0.261 a	0.948 b	0.417 a
Kany qara	1.062 a	0.347 a	1.408 a	0.454 a
Shawgerawa	0.792abc	0.359 a	1.151ab	0.441 a
Alyawa	1.023 ab	0.440 a	1.463 a	0.452 a
Azaday	0.491 c	0.290 a	0.781 b	0.373 a

Means followed by the same letters within column are not significantly different at $p \leq 0.05$ according to Duncan multiple range test

4.2.4 Effect of Wastewater on Heavy Metal Concentration in the Edible Parts of a Celery:

The findings in (table 4.10) show that the elements Cd, Pb, Cu, Zn, Mn are cumulated in celery plants in different proportion in the studied locations .According to Duncan's test, the content of Cd, Pb, Cu and Zn in celery plant shows non- significant differences between the studied locations,

As illustrated in table 4.10, Mn concentration recorded a significant differences in the studied locations. Maximum value was (51.134 mg kg^{-1}) recorded at Kany qara location, and the minimum value recorded at Shawgerawa location (23.053 mg kg^{-1}). No significant differences were between the locations Hamamok(40.686 mg kg^{-1}), Azady(34.728 mg kg^{-1}) and Alyawa (32.636 mg kg^{-1}). These results higher than (13.09 mg kg^{-1}) reported by Mohamed et al., (2003) and (24.84 mg kg^{-1}) by Mamand, (2008) except Shawgerawa location. The concentration of Mn in celery plant in the studied locations was lower than Safe limits (500 mg kg^{-1}) according to Gupta et al., (2021).

Table 4.10 *Effect of Wastewater on the Heavy Metal Concentration in the Edible Parts of a Celery*

Heavy Metals mg kg^{-1}	Locations					Safe limits of heavy metals in vegetables mg kg
	Hamamok	Kany qara	Shawgerawa	Alyawa	Azady	
Cd	1.34 a	1.448 a	1.287 a	1.322 a	1.224 a	0.20 (FAO/WHO, 2001)
Pb	15.783 a	12.615 a	12.697 a	16.893 a	14.727 a	0.30 (FAO/WHO, 2001)
Cu	33.24 a	32.25 a	23.26 a	24.8 a	33.29 a	40 (FAO/WHO, 2001)
Zn	39.268 a	44.585 a	39.958 a	38.314 a	38.367 a	60 (FAO/WHO, 2001)
Mn	40.686 b	51.134 a	23.053 c	32.636 b	34.728 b	500 (Gupta et al., 2021)
Means followed by the same letters within row are not significantly different at $p \leq 0.05$ according to Duncan multiple range test.						

4.2.5 Bio-concentration Factor in Celery Plant (BCF)

The uptake factor from soil by plant is recognized as Bio-Concentration Factor (BCF). Table (4.11) shows the BCF values of heavy metals in celery plants irrigated by wastewater.

In Hamamok, Kany qara, Shawgerawa and Azady <1, this indicated that the accumulation of Cadmium in celery plant was lower than the accumulation in soil. While BCF of Cadmium in Alyawa has surpassed the value of one, this reveals that the accumulation of Cadmium in celery plant was greater than the accumulation in soil Gupta et al., (2022).

The BCF of lead has surpassed the value of one at all studied locations, this revealing that the accumulation of lead in celery plant was greater than the accumulation in Gupta et al., (2022).

While BCF of copper, zinc and manganese at all the studied locations <1, it mean that the accumulation of copper, zinc and manganese in celery plant at all the studied locations were lower than the accumulation in soil.

Table 4.11 *Bio- Concentration factor (BCF) of Celery plants irrigated by wastewater*

Locations	Hamamok	Kany qara	Shawgerawa	Alyawa	Azady
Cd	0.814	0.877	0.962	1.055	0.786
Pb	1.202	1.224	1.080	1.789	1.074
Cu	0.514	0.711	0.384	0.452	0.766
Zn	0.611	0.306	0.492	0.540	0.502
Mn	0.088	0.124	0.075	0.043	0.074

4.3 Third Experiment Broad Bean Plant

4.3.1 Effect of Wastewater on Vegetative Growth Characteristics of Broad Bean

4.3.1.1 Plant Height (cm)

The result in table 4.12 show significant differences between Alyawa and the other studied locations in the plant height character of broad bean. The highest plant height recorded at Hamamok location (39.93 cm), and the lowest plant height at Alyawa location was (23.73 cm) Also the plant height in Kany qara, Shawgerawa and Azady were (36.02, 37.58 and 37.95) cm respectively. According to table (3.2) high amount of salts present in wastewater irrigation, may a factor for decreasing plant high in all locations, these results in agreement with Mkhinini et al., (2018). and disagree with Zeid and Abou El Ghate, (2007; Shekha et al., 2019).

4.3.1.2 Number of Leaves Plant^{-1}

Table 4.12 refers to the existence of significant difference in broad bean leaf number per plant between the studied sites. The highest leaf number in Kany qara and Azady locations were (56.89 and 57.13) leaf Plant^{-1} respectively and the lowest leaf number in Alyawa location was (22.13 leaf Plant^{-1}). Increase organic matter and nutrients in soils irrigated with wastewater according to table (3.4), cause to increase number of leaves, in Kany qara and Azady locations. The present results are supported by Singh and Agrawal, (2010) . The results of Kany qara and Azady well match with Slima and Ahmed, (2020) but agreed in locations of Shawgerawa and Alyawa.

4.3.1.3 Leaf Area (cm²)

The highest and lowest leaf area plant^{-1} were (326.25 and 130.78) cm² which reached from irrigation Azady and Alyawa wastewater locations respectively. That may be due to the chemical composition of the wastewaters (table 3.1, 3.2). Or due to the reason mentioned before

Shannag et al., (2021) confirmed the results in Alyawa location, However, all the wastewater tested contained greater concentrations of N, P and K than the control, as shown in table (3.2), and produced meaningfully less leaf area than control in Shawgerawa and Alyawa locations. The result of Kany qara, Shawgerawa and Azady agree with Hirich and Choukr-Allah, (2014; Sweththika, et al., 2022) but disagree in Alyawa location.

4.3.1.4 Number of Days from Seeding to 50 % Flowering

Table 4.12 shows existence of significant difference between locations to the days from seeding to 50% flowering ,which were Hamamok (126 days), Kany qara (128 days), Shawgerawa (129 days), Alyawa (125 days) and Azady (125 days).

According to table (3.2), nitrogen content is higher in the wastewater of studied locations than control location. Abebe et al., (2019) indicated that increasing nitrogen cause to delay flowering days of green pod, This might be due to the fact that as increased nitrogen fertilization results increasing the period of vegetative growth of plants because nitrogen is an essential nutrient for plant growth, development and reproduction, this agree with our results in Kany qara and Shawgerawa locations, but disagree in locations of Alyawa and Azady.

4.3.1.5 Number of Days from Seeding to 50 % Pod Maturity

The data shown in table 4.12 demonstrate that there is significant affect of locations to the required days of pod maturity, which ranged from (148 to 154) days. The superiority of Hamamok and Shawgerawa by less days to pod maturity on locations Kany qara (1 day), Alyawa (6 days) and Azady (3 days).

High nitrogen rate found in the wastewater of the studied locations as shown in table (3.2). Abebe et al., (2019; Lemma, 2019) reported the nitrogen increase cause to delay days maturity of green pod. This could be as a result of the fact that nitrogen is a crucial nutrient for plant growth, greater nitrogen fertilization lengthens the period of vegetative growth of plants, development and reproduction, this agree with our results in Kany qara, Alyawa and Azady locations, but the Shawgerawa location have the same days.

4.3.1.6 Grain Filling Period (day)

According to table 4.12, there were differences between locations during grain filling period, the maximum days was (2 days) at Hamamok location, Alyawa and Azady locations and the minimum days was (19 days) in Shawgerawa location, But in Kany qara location reached (20 days). Although there is an increase nitrogen content in wastewater as shown in table (3.2), These results in all the locations are in disagree with those obtained by Silva et al., (1993) mentioned increase nitrogen content cause to increase number of days to grain filling period of soybean and cowpea.

Table 4.12 *Effect of Wastewater on Vegetative Growth Characteristics of Broad Bean*

Locations	Plant height (cm)	No.of Leaves Per plant	Leaf area Per plant (cm²)	No. of days from Seeding to 50 % flowering	No. of days from seeding to 50% pods maturity	Grain filling period (days)
Hamamok	39.93 a	42.40 a	225.46 ab	126.0 c	148 d	21 a
Kany qara	36.02 a	56.89 a	250.55 a	128.0 b	149 c	20 b
Shawgerawa	37.58 a	38.0 ab	240.11 a	129.0 a	148 d	19 c
Alyawa	23.73 b	22.13 b	130.78 b	125.0 d	154 a	21 a
Azaday	37.95 a	57.13 a	326.25 a	125.0 d	151 b	21 a

4.3.2 Effect of Wastewater on Yield Component of Broad Bean Plants

4.3.2.1 Number of pods Plant^{-1}

According to table 4.13, number of pod per plant significantly differed in the study sites. The highest pod Number with no significant differences recorded between locations of Kany qara (7.77 pod Plant^{-1}) and Azady (7.67 pod Plant^{-1}), and the lowest pod number with no significant differences was recorded between locations Hamamok (4.80 pod Plant^{-1}), Shawgerawa (3.75 pod Plant^{-1}) and Alyawa locations (2.40 pod Plant^{-1}). According to table (3.2), phosphate content increase in wastewater locations, which P has a positive effect on number of pod, our results in Kany qara and Azady locations matched with Ghizaw et al., (2001) but disagreed in Shawgerawa and Alyawa locations. The results of Kany qara and Azady, agree with Zeid and Abou El Ghate, (2007). Where as our results in Shawgerawa and Alyawa locations agree with Nowwar et al., (2023).

4.3.2.2 Number of Seeds Plant^{-1}

The results displayed in table 4.13 demonstrated that significant differences ($P<0.05$) between the studied sites in broad bean seeds per plant**,** which ranged from (8.67 to 29.40) seed Plant^{-1} the highest value was recorded at Azady location and the lowest was at Alyawa location. According to table 4.13, increasing number of pod in Kany qara and Azady locations cause to increase number of seed in these locations. The number of pod decreased in Shawgerawa and Alyawa locations, cause to decreasing number of seed plant^{-1} in these locations. The results of

Shawgerawa and Alyawa locations agree with Nowwar et al., (2023) but disagree in locations of Kany qara and Azady.

4.3.2.3 Fresh Pod Weight Plant (g)

Fresh pod weight at broad bean plant was significantly affected by wastewater irrigation in the studied locations ($p<0.05$) in table 4.13, the highest pod weight at Azady location was (144.07 g) and the lowest pod weight at Shawgerawa location was (25.66 g). A greater number of pods lead to higher yield as these two traits have direct association Araújo et al., (2012; Bashir et al., 2015). According to table (4.13), these disagree with Alyawa and Azady locations, but agree in the other locations. The result of Kany qara and Azady locations agree with Zeid and Abou El Ghate, (2007) but disagree in Shawgerawa and Alyawa locations. Shannag et al., (2021) confirmed our result, however, all wastewater tested contained greater concentrations of N, P, K than the control, and produced meaningfully less biomass than control. Rehman et al., (2022) reported Cd stress cause to reduce yield of mung bean, according to table (4.17) and (4.18) disagree with our result.

4.3.2.4 Fresh Pod Weight per Hectare (ton ha^{-1})

In general, significant differences ($p<0.05$) were evident between the studied locations in table 4.13 that were ranged from Shawgerawa location (1.027 ton ha^{-1}) to Azady location (5.763 ton ha^{-1}), The superiority of Azady to Hamamok, Kany qara, Shawgerawa and Alyawa by increasing (133.79 ,41.04 ,335.89 , 308.72 %), respectively.

4.3.2.5 Dry Pod Weight per Plant (g)

As the result of table 4.13 show a significant affecting locations ($p<0.05$) on dry pod weight, the height and lowest values in Azady and Shawgerawa locations were (20.72, 3.48) g, respectively. The superiority of Azady to Hamamok, Kany qara, Shawgerawa and Alyawa by increasing (108.03 ,57.45 ,495.4 , 164.96 %), respectively. As a result as shown in table (4.13), increasing fresh pod weight in Kany qara and Azady cause to increase dry pod weight in these locations. Where as decreasing fresh pod weight in Shawgerawa and Alyawa locations cause to decrease dry pod weight. Our results in Kany qara and Azady agree with Campbell et al., (1983; Zeid and Abou El Ghate, 2007), but disagree in Shawgerawa and Alyawa locations. While the results of Shawgerawa and Alyawa locations agree with Shannag et al., (2021).

Table 4.13 Effect of Wastewater on Yield Component of Broad Bean Plants

Locations	No. of pods plant	No. of seeds plant	fresh pod weight plant (g)	fresh pod weight $ton.ha^{-1}$	Dry pod weight plant (g)
Hamamok	4.80 b	18.83 bc	61.63 bc	2.465 bc	9.96 bc
Kany qara	7.77 a	26.04 ab	102.14 ab	4.086 ab	13.16 ba
Shawgerawa	3.75 b	12.75 cd	25.66 c	1.027 c	3.48 c
Alyawa	2.40 b	8.67 d	35.24 c	1.410 c	7.82 bc
Azaday	7.67 a	29.40 a	144.07 a	5.763 a	20.72 a

4.3.3 Effect of Wastewater on the Vegetative Growth Characteristics of First Pod Broad Bean Plant

4.3.3.1 Height of First Pod (cm)

Table 4.14 statistical analysis results revealed significant differences (P<0.05) between the studied locations on this parameter, which ranged from (12.20 cm) in Alyawa location to (21.08 cm) in Shawgerawa location, and the significant differences were only between Alyawa and Shawgerawa locations. High of first pod was increased in Shawgerawa and Azady locations, and decreased in Kany qara and Alyawa locations.

4.3.3.2 Length of the First Pod Plant-1 (cm)

The results displayed in table 4.14 demonstrated that non- significant differences in the pod length (P<0.05) between the studied locations.

4.3.3.3 Number. of Pods in the First Node Plant-1

As shown in table 4.14, existence of significant differences (P<0.05) in the number of pods per plant was only between Shawgerawa and Azady locations. The highest pod number was found at Azady location (2.20 pod $Plant^{-1}$), and the lowest pod number was found at Shawgerawa location (1.33 pod $Plant^{-1}$).The differences between Hamamok (2.07 pod. $Plant^{-1}$), Kany qara (1.88 pod. $Plant^{-1}$) and Alyawa (1.87 pod. $Plant^{-1}$) were non- significant, according to table (18) our result increase only in Azady.

4.3.3.4 Number of Seeds in the First Node Plant-1

Statistical analysis results revealed clear significant differences (P<0.05) in the seeds number in the different locations in table 4.14, The highest number was recorded at Azady location (9.67 seed $plant^{-1}$) and Hamamok location was (9.07 seed $plant^{-1}$), While the lowest number was found at Shawgerawa location (5.17seed plant^{-1}). Number of seeds per pod is closely related to the length of the pod, according to table 4.14 our result agree with Al-Refaee, et al., (2004).

4.3.3.5 Fresh Weight of First Pod Plant (g)

The findings in table 4.14 show non-significant effect on Fresh weight of first pod between study locations. Green pod yield per plant has significant association with number of pods per plant Singh, et al., (2009). According to table (4.14) this agree with our results in all the locations except for Shawgerawa location.

4.3.3.6 Dry Weight of First Pod Plant (g)

Table 4.14 shows the dry weight of first pod significant influence only between Azady and Shawgerawa location. The maximum dry weight was (5.9 g) in Azady location and the minimum dry weight in Shawgerawa location was (2.12 g). As a result that shown in table (4.14) decreasing fresh pod weight in all the locations cause to decrease dry pod weight in these locations except for Azady.

Table 4.14 Effect of Wastewater on Vegetative Growth Characteristics of First Pod

Location	Height of first pod (cm)	Length of First pod.plant^{-1} (cm)	No. of pods in first node Plant^{-1}	No. of seedsin first node Plant^{-1}	Fresh weight Offirst Pod Plant^{-1} (g)	Dry weight of first Pod Plant^{-1} (g)
Hamamok	16.00 ab	15.76 a	2.07 ab	9.07 a	31.46 a	4.89 ab
Kany qara	15.33 ab	15.36 a	1.88 ab	8.31ab	26.53 a	3.35 ab
Shawgerawa	21.08 a	13.50 a	1.33 b	5.17 b	16.04 a	2.12 b
Alyawa	12.20 b	14.59 a	1.87 ab	7.40 ab	29.25 a	4.79 ab
Azaday	16.63 ab	17.48 a	2.20 a	9.67 a	29.23 a	5.9 a

Means followed by the same letters within column are not significantly different at $p \leq 0.05$ according to Duncan multiple range test.

4.3.4 Effect of Wastewater on Some Stomata Characteristics on Upper & Lower Leaf Surface of Broad Bean Plant

According to the table (4.15), the number of stomata on upper leaf surface show significant affect by wastewater, the highest and lowest value (3.2 and 1.933) stomata.mm^{-2} were recorded from irrigation with Alyawa wastewater and Hamamok well water.

Also number of stomata on lower leaf surface show significant effect which ranged between (1.867 to 2.8) stomata.mm^{-2}, Shawgerawa location has the highest value and Azady location has the lowest value. Our results in lower surface only in Azady agrees with Holguin et al., (2022) resulted that barley plants irrigated with wastewater had lower stomata density than the plants irrigated with ground water. And the result of lower surface in Azady location agree with El-Okkiah, (2015) but disagreed in the other locations.

As illustrated in table (4.15) upper length of stomata show significantly differences between the studied locations, the maximum value was (76.928 µm) at Azady location, and the minimum value was (66.896 µm) at Alyawa location. Lower length of stomata were significantly differences between both locations of Shawgerawa and Azady locations. The lowest value (66.273 µm) was in Shawgerawa location and the highest value (77.404 µm) was at Azady location.

Length of stomata in upper leaf surface was higher in all the locations except for Alyawa, but for the lower leaf surface in Shawgerawa and Alyawa lower than control. Our result only in Alyawa at upper surface agree with Holguin et al., (2022) who reported the barley plant Stomata length was similar on the abaxial leaf surfaces but different on the adaxial surface, with the lowest stomata length in the plants irrigated with wastewater.

Our results in Alyawa and Shawgerawa locations only for the lower surface agree with El-Okkiah, (2015), but disagrees with the locations of Kany qara and Azady.

Width of stomata on upper leaf surface show no significant differences between the studied locations, as shown in table (4.15). While the lower leaf surface shows significant differences in the studied locations, the highest value was (46.380 µm) at Azady location, and the lowest value was (33.745 µm) at Shawgerawa location.

Width of stomata in upper leaf surface was higher in all irrigation wastewater locations, and in lower leaf surface was higher in all the locations, except for Shawgerawa location it was lower than control. Our results disagree with Holguin et al., (2022) who reported the barley plant Stomata width was similar on the abaxial (lower) leaf surfaces but different on the adaxial surface, with the lowest Stomata width in the plants irrigated with wastewater. Our result in only lower surface of Shawgerawa agree with El-Okkiah, (2015), but disagree in the other locations.

Table 4.15 *Effect of Wastewater on Some Stomata Characteristics on Upper & Lower Leaf Surface of Broad Bean Plant:*

Locations	Stomata Number (stomata.mm^{-2})		Stomata Length (μm)		Stomata Width (μm)	
	Upper leaf surface	Lower leaf surface	Upper leaf surface	Lower leaf surface	Upper leaf surface	Lower leaf surface
Hamamok	1.933 b	2.067 ab	67.119 b	70.369 ab	39.136 a	39.539 bc
Kany qara	2.067 b	2.467 ab	72.288 ab	73.732 ab	41.769 a	43.163 ab
Shawgerawa	2.067 b	2.8 a	67.564 b	66.273 b	43.487 a	33.745 c
Alyawa	3.2 a	2.667 a	66.896 b	69.023 ab	42.021 a	39.645 bc
Azady	2.2 b	1.867 b	76.928 a	77.404 a	41.596 a	46.380 a
Means followed by the same letters within column are not significantly different at $p \leq 0.05$ according to Duncan multiple range test						

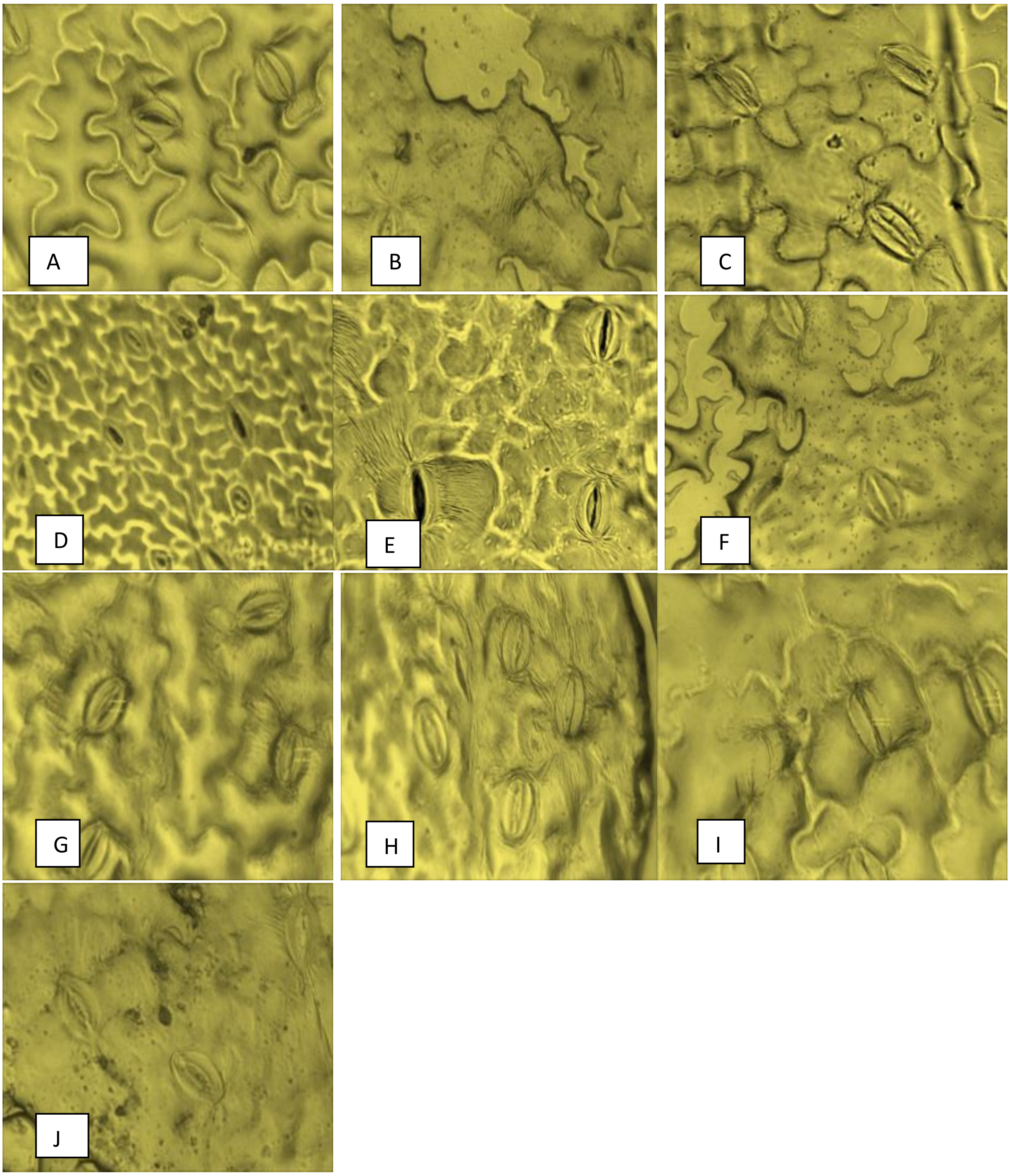


Figure (4.3) Stomata of daxia (upper)l and abaxial(lower) of Broad bean leaves surface of 40x, A. upper surface in Hamamok, B. lower surface in Hamamok, C. upper surface in Kany qara, D. lower surface in Kany qara, E. upper surface in Shawgerawa, F. lower surface in Shawgerawa, G. upper surface in Alyawa, H. lower surface in Alyawa, I. upper surface in Azady, J. lower surface in Azady.

4.3.5 Effect of Wastewater on Photosynthetic Pigments in Broad Bean Leaves:

Table 4.16 reflects significant effect of the studied locations on chlorophyll a content in the broad bean leaves. The chlorophyll a content was ranged from (0.789 to 1.194) mg.g-1. The location of Kany qara superiored to the other locations of Hamamok, Shawgerawa ,Alyawa and Azady by increasing (15.7 , 9.4 , 21.96 , 51,33) %, respectively. khan et al, (2011a) who stated increase chlorophyll a in pea plant, duo to concentration essential plant nutrient N, P and K in wastewater, it may also be Mn contribute to the synthesis of chl.a, that is resulted to stimulation chlorophyll under lower low concentration. The results of Kany qara and Shawgerawa locations agree with Zeid and Abou El Ghate, (2007) but disagree in Alyawa and Azady locations. On the other hand chl.a in Alyawa and Azady lower than control, could be related to the high amount of salts present in wastewater as in table (3.2) accepted by Mkhinini et al., (2018) scientists studied how salts affected various plants and discovered that these changes might be brought about by enzyme activity alterations and detrimental impacts on the photosynthetic process.

According to table 4.16 the existence of chlorophyll b was recorded with differences between the studied locations. The highest value of chlorophyll b was found at Shawgerawa location (0.650 $mg.g^{-1}$), and the lowest value recorded at Azady and Alyawa locations by (0.390 and 0.402) $mg.g^{-1}$ respectively. Increasing N, P and K in wastewater locations according to table (3.2) may be a factor for increasing chlorophyll b. The result of Shawgerawa agrees with Bednarz and Krzepilko, (2009) but disagree with locations of Kany qara, Alyawa and Azady, may be salts effect due to high amount of salts present in wastewater table (3.2) agree with Mkhinini et al., (2018) he studied how salts affected various plants and discovered that these changes could be brought on by altered enzyme activity and detrimental effects on the photosynthesis process. Our result only in Shawgerawa agree with Zeid and Abou El Ghate, (2007), but disagree with other locations.

Total Chlorophyll reached a significant level ($p<0.05$) between the studied locations, as shown in table 4.16, Shawgerawa location reached the maximum value (1.745 $mg.g^{-1}$) and the minimum value (1.179 $mg.g^{-1}$) was recorded at Azady location. Total chlorophyll increases with increasing chlorophyll a and b, or decreased with decreasing chlorophyll a and b as shown in table (4.16). The improvement in total chlorophyll content in Kany qara and Shawgerawa locations, might have been caused by the activity of phosphorus which plays major role in structural and metabolic function in the plant growth and development, as shown in table (3.2) and (3.4). This is due to the fact that phosphorus is a crucial component of many cell components and plays a significant part in a number of essential functions, including photosynthesis, respiration, energy storage and transfer, cell division, and cell growth. Our findings support Nyoki et al., (2014) who studied on cowpea.

Arya and Roy, (2011) stated increase manganese cause to decrease total chlorophyll content , according to table (4.18) this does not agree with our results. The results of Alyawa and Azady agree with Manisha and Angoorbala, (2013) and disagree with Kany qara and Shawgerawa.

As shown in table 4.16 Carotene content differed in the studied locations. The maximum value recorded at Shawgerawa location (0.499 $mg.g^{-1}$) which superior to the other studied locations Hamamok (0.421 $mg.g^{-1}$), Kany qara (0.469$mg.g^{-1}$), Alyawa (0.394 $mg.g^{-1}$) and Azady locations (0.389$mg.g^{-1}$) by increasing(18.53, 6.4,26.65,28.28 %), respectively. The results of locations Kany qara and Shawgerawa agree with Zeid and Abou El Ghate, (2007). On the other hand carotenoid content in Alyawa and Azady was lower than control, could be related to the high amount of salts present in wastewater table (3.2) our results were reported by Mkhinini et al., (2018) He studied how salts affected various plants and discovered that these changes could be brought about by enzyme activity alterations and detrimental impacts on the photosynthesis process. Rehman et al., (2022) reported Cd stress significantly reduced the biosynthesis of photosynthetic pigments (carotenoid) of mung bean plants, according to table (4.17) and (4.18), this agree with our result in Azady, while disagree in Alyawa.

Table 4.16 *Effect of Wastewater on Photosynthetic Pigments in the Broad Bean Leaf*

Locations	Chlorophyll a ($mg.g^{-1}$)	Chlorophyll b ($mg.g^{-1}$)	Total chlorophyll ($mg.g^{-1}$)	Carotene ($mg.g^{-1}$)
Hamamok	1.032 ab	0.524 ab	1.557ab	0.421 ab
Kany qara	1.194 a	0.505 ab	1.698 a	0.469 ab
Shawgerawa	1.095 a	0.650 a	1.745 a	0.499 a
Alyawa	0.979 ab	0.402 b	1.381ab	0.394 b
Azaday	0.789 b	0.390 b	1.179 b	0.389 b

Means followed by the same letters within column are not significantly different at $p \leq 0.05$ according to Duncan multiple range test.

4.3.6 Concentration of Soil Heavy Metals (mg kg^{-1}) in all the Studied Locations for Broad Bean and Wheat Experiment

The findings in table 4.17 shows that the irrigation with wastewater affected significantly on concentration of Pb, Cu and Mn only. On the other hand the concentration of all of them were below the maximum available concentration mentioned by Bigdeli and Seilsepour, (2008) which were 3, 100, 100, 300 and 2000 mg kg^{-1} soil for Cd, Pb, Cu, Zn and Mn respectively.

The Cd content non significant effect, and in the studied soils was less than (3.453 mg.kg^{-1}) which was recorded by Mamand, (2008) in Erbil city.

The results of table (4.17) show significant effluence of lead content in soil of studied locations. The highest value (14.629 mg kg^{-1}) was in Azady location, and the lowest value (10.370 mg kg^{-1}) recorded at Hamamok location. Pb content was lower than the average data (55.81 mg kg^{-1}) in soils that was reported by Jaf, (2008)

According to the table (4.17) copper value show significant differences only between Hamamok location which have the lowest value was (22.85 mg kg^{-1}) and Shawgerawa location which have the highest value was (49.66 mg kg^{-1}). Non significantly differences between locations {Kany qara 40.22 mg kg^{-1}, Alyawa 39.04 mg kg^{-1} and Azady 39.99 mg kg^{-1} }. Our result of Cu in Shawgerawa was more than (41.64 mg kg^{-1}) as reported by Jaf, (2008). But within the range of (50 mg kg^{-1}) as mentioned by Abdulbary, (2000)

Zn illustrated in table (4.17), Show not significantly levels ($p<0.05$), the highest value (86.236 mg kg^{-1}) was at Azady location and the lowest value (75.852 mg kg^{-1}) was at Hamamok location. Also Zn is close to (74.145 mg kg^{-1}) as recorded by Mamand, (2008) within Erbil city.

The content of Mn element in the studied locations was higher than (249.811 mg kg^{-1}) that reported by Mamand, (2008), and its close to (579 mg kg^{-1}) that recorded by Mohammed, et. al., (2013) within Erbil city. Our result only in Hamamok higher than Ali, (2007).

Table 4.17 *Concentration of Soil Heavy Metals (mg kg^{-1}) in all Studied Locations for Broad bean and Wheat Experiment*

Heavy Metals	Locations					(Bigdeli and Seilsepour, 2008) Soil
	Hamamok	Kany qara	Shawgerawa	Alyawa	Azady	
Cd	1.505 a	1.563 a	1.571 a	1.307 a	1.746 a	3
Pb	10.370 b	12.440ab	11.344 b	10.988 b	14.629 a	100
Cu	22.85 b	40.22ab	49.66 a	39.04ab	39.99ab	100
Zn	75.852 a	84.068 a	77.635 a	75.867 a	86.236 a	300
Mn	624.92 a	460.39 b	335.01 c	546.63ab	547.52ab	2000

Means followed by the same letters within row are not significantly different at $p \leq 0.05$ according to Duncan multiple range test.

4.3.7 Effect of Wastewater on Heavy Metals Concentration (mg kg^{-1}) in Broad Bean Pods

Table 4.18 indicated to significant effect of irrigation wastewater and control on Cd and Zn concentration of broad bean pods, their highest value (1.40 and 54.53) mg kg^{-1} were recorded from irrigation with Azady and Kany qara wastewater respectively, while their lowest value (1.22 and 26.91) mg kg^{-1} were obtained irrigation with wastewater of Alyawa

Our results of Cd in all locations, except for Alyawa that agree, with El-Okkiah, (2015). Cd content at all the studied locations was higher than safe limits (0.1 mg kg^{-1}) Bordean et al., (2015). The results of Zn disagree with Chaoua et al., (2018). According to Bordean et al., (2015) Zn content in broad bean pods at all the studied locations was lower than Safe limits (100 mg kg^{-1}). While the other heavy metals were not effected significantly by irrigation with wstewster. The concentration Cd, Pb and Zn were above save limit of 0.1, 0.2, and 10) mg kg^{-1} as mentioned by Bordean, et al., (2015) respectively

Table 4.18 *Effect of Wastewater on Heavy Metals Concentration (mg kg^{-1}) in Broad Bean Pods*

Heavy Metals	Locations					Safe limits of heavy metals
	Hamamok	Kany qara	Shawgerawa	Alyawa	Azady	
Cd	1.25ab	1.26ab	1.26ab	1.22 b	1.40 a	0.1 (Bordean et al., 2015) (faba bean)
Pb	18.33 a	21.93 a	21.00 a	19.53 a	18.04 a	0.2 (Bordean et al.,2015) (faba bean)
Cu	11.55 a	10.92 a	10.14 a	15.06 a	10.64 a	10 (Bordean et al.,2015)(faba bean)
Zn	33.60 b	54.53 a	30.76 b	26.91 b	30.31 b	100 (Bordean et al., 2015)(faba bean)
Mn	18.68 a	16.46 a	17.971 a	15.84 a	17.66 a	30-300 (Abdulbary,2000) (Plant)
Means followed by the same letters within row are not significantly different at $p \leq 0.05$ according to Duncan multiple range test.						

4.3.8 Bio-concentration Factor in Broad Bean Pods (BCF)

Table (4.19) shows that the BCF values for most of the studied heavy metals was <1 except for Pb which was >1. It means the accumulation of most of the studied heavy metals except Pb were highe, lower in pods in comparing with their accumulation in soil.

the accumulation of Pb in broad bean pods was greater than the soil Gupta et al., (2022).

Table 4.19 *Bio- Concentration Factor (BCF) of Broad Bean Pods Irrigated by Wastewater*.

Locations	Hamamok	Kany qara	Shawgerawa	Alyawa	Azady
Cd	0.836	0.810	0.803	0.934	0.802
Pb	1.768	1.763	1.851	1.777	1.233
Cu	0.505	0.271	0.204	0.385	0.266
Zn	0.442	0.648	0.396	0.354	0.351
Mn	0.029	0.053	0.053	0.028	0.032

4.4 Fourth Experiment: Cereal Crop -the Wheat

4.4.1 Effect of Wastewater on the Vegetative Characteristics of Wheat

4.4.1.1 Plant Height (cm)

According to table 4.20, The wheat plant height show significant differences in the study locations. The highest and lowest plant height were recorded in the Azady location (82.44 cm) and the Alyawa location (55.49 cm). Azady location superior to the other locations (Hamamok, Kany qara ,Shawgerawa, Alyawa) by increasing (24.36 ,5.34 ,8.05 and 48.57 %) respectively.

Compared with well water irrigation, wastewater irrigation sustained better growth of the crop as is indicated by the higher values for plant high, which may be due to the availability of additional nutrients, like phosphate and potassium, etc. in the wastewater applied according to (table 3.2), these being readily available to the growing plants, could possibly result increased growth through enhanced cell division, expansion, and differentiation, the results in Kany qara, Shawgerawa and Azady locations agreed with Aziz et al., (1995). But disagreed in Alyawa location.

On the other hand, according to Kanwal et al., (2020) increasing in lead concentration, cause to decrease high of plant, This result agreed with our result in Alyawa location as shown in table (4.20) and (4.24).

Our result in Alyawa location was confirmed by El Rasafi et al., (2016; Repkina et al., 2023) as shown in table (4.24). The entire plant's height was lowered by copper stress. These reductions are in line with the drops in the starch, soluble sugar, and fat contents of the ore plants, which were brought on by decreased photosynthesis and CO^2 assimilation. However, the limitation of wheat development may be due to Cu-interference with cell division through the generation of chromosomal abnormalities and aberrant mitosis Moustakas et al., (1997).

4.4.1.2 Number of Tillers (tiller plant^{-1})

In the table 4.20, generally significant differences ($p<0.05$) were observed among the studied locations, the highest value was recorded at Shawgerawa location (136.44 tiller. plant^{-1}) and the lowest at Hamamok location (41.22 tiller plant^{-1}). According to table (3.2) increasing nitrogen cause significant increase in the number of effective tillers plant^{-1}. Our result in all the locations, agree with Rahman et al., (2014; Alghobar and Suresha, (2016).

4.4.1.3 Number of Leaves Tiller^{-1}

Table 4.20 clarifies significant differences among the studied locations in the number of leaves per tiller, which ranged from (3.70 to 4.11 leaf tiller^{-1}), the maximum leaf number was found at Alyawa location and the minimum leaf number was found at Hamamok location. Wastewater availability of additional nutrients, like phosphate and potassium, etc. cause increasing in the plant growth and provide higher values for leaf number, according to table (3.2) our result agree with Aziz et al., (1995).

4.4.1.4 Flag Leaf Area (cm²)

In table 4.20, the studied locations affected significantly on the flag leaf area .The lowest flag leaf area was (19.47 cm²) which observed at Hamamok location and the highest flag leaf area was recorded at Kany qara location (41.99 cm²), also the Kany qara superior to the other studied locations Hamamok, Shawgerawa, Alyawa and Azady locations by increasing (115.67, 44.59 ,75.25 and 52.19) % respectively. According to table (3.2) increasing nitrogen content in wastewater cause significant increase in the expansion of flag leaf area in all locations, by increasing cell number and cell expansion, our results in all locations were confirmed by Ali, (2021). While the results disagree with AL-Hassnawi and Al-Burki, (2022).

4.4.1.5 Number of Days From Seeding to 50% Flowering

According to table 4.20, there were significant differences among the locations in the number of days which required for flowering, the highest number of days was (104 days) at Hamamok and Azady locations and the lowest days was (101 days) at Alyawa location. But the required flowering days in Kany qara and Shawgerawa locations was (103 day).

Increasing nitrogen in wastewater of locations as shown in table (3.2) cause to decrease the number of days from seeding to flowering, Similar results have been mentioned by Ali, (2021) in studied locations, except Azady location. Also our result in all the locations, except for Azady was in acceptance with Naik, (2015) who stated that flowering be early in plants receiving nitrogen, compared to those receiving no nitrogen.

4.4.1.6 Grain Filling Period (day)

Results of statistical analysis which presented in table 4.20, the number of days from flowering to physiological maturity revealed that the variations among studied locations were significantly, the longest period was (46 days) at Shawgerawa location and the lowest period was (38 days) at Alyawa location, while the period at Kany qara and Azady locations was (45 days), But at Hamamok was (44 days).

Wastewater contain nutrients especially nitrogen, as shown in table (3.2), then increasing N in the studied locations increase the days of grain filling period, in Kany qara, Shawgerawa and Azady. These results are in agreement with those obtained by Ali, (2021). But disagreed in Alyawa location.

4.4.1.7 Number of Days From Seeding to 50%Physiological Maturity

The result of table 4.20 show significant differences in the days of plant maturity period, ranged from (139 to 149) days. The maximum days was in Shawgerawa and Azady locations and the minimum days was found in Alyawa location. But in Hamamok and Kany qara locations the maturity period was (148 days). Our result in Shawgerawa and Azady locations in acceptance with results Ali, (2021), while disagreed in Kany qara and Alyawa locations.

Table 4.20 *Effect of Wastewater on the Vegetative Growth Characteristics of Wheat*

Location	Plant height (cm)	No. of tillers/ m	No. of Leaves / tiller	Flag leaf Area Cm^2	No. of days from seeding to 50% flowering (days).	No. of days from flowering to 50% physiological maturity (filling period).	No. of days from seeding to 50% physiological maturity
Hamamok	66.29 b	41.22 c	3.70 b	19.47 c	104 a	44 c	148 b
Kany qara	78.26 a	109.44 ab	4.03 a	41.99 a	103 b	45 b	148 b
Shawgerawa	76.30 a	136.44 a	3.82 ab	29.04 b	103 b	46 a	149 a
Alyawa	55.49 c	74.44 bc	4.11 a	23.96 b c	101 c	38 d	139 c
Azady	82.44 a	114.99 ab	3.93 ab	27.59 b c	104 a	45 b	149 a

Means followed by the same letters within column are not significantly different at $p \leq 0.05$ according to Duncan multiple range test.

4.4.2- Effect of Wastewater on Some Stomata Characteristics on Upper & Lower Leaf Surface of Wheat Plant

Table (4.21) referes to the significant influence of wastewater on the number of stomata mm^{-2} for both lower and upper part of leaves. The highest value in the upper surface was (3.6 $stomata.mm^{-2}$) in both locations of Hamamok and Shawgerawa, while the minimum value (2.467$stomata.mm^{-2}$) was recorded at Azady location

No. of stomata on lower leaf surface were differed significantly between Shawgerawa location and the other studied locations which has the highest value (3.2 $stomata.mm^{-2}$) while the lowest value was recorded at Kany qara location (2.067 $stomata.mm^{-2}$).

Our results of the some locations, agreed with Holguin et al., (2022) who concluded that barley plants irrigated with wastewater had lower stomata density than the plants irrigated with ground water, while disagreed with Samarah et al., (2020).

Zn stress factors for decreasing in stomatal conductance, has direct negative impact on membrane structure and permeability as well as on the destruction of guard cells Repkina et al., (2023). Soil salinity significantly affected the plant water status and reduced the photosynthetic rate and plant growth in wheat. The depressed photosynthetic carbon assimilation was mainly caused by stomata closure and lower photosynthetic electron transport Sun et al., (2016).

While the length and width of stomata were not effected significantly by wastewater.

Table 4.21 *Effect of Wastewater on Some Stomata Characteristics on Upper & Lower Leaf Surface of Wheat Plant*

Locations	Stomata Number ($stomata.mm^{-2}$)		Stomata Length (μm)		Stomata Width (μm)	
	Upper leaf surface	Lower leaf surface	Upper leaf surface	Lower leaf surface	Upper leaf surface	Lower leaf surface
Hamamok	3.600 a	2.533 b	71.611 a	76.398 a	39.219 a	44.736 a
Kany qara	2.533 b	2.067 b	75.119 a	77.260 a	44.359 a	45.304 a
Shawgerawa	3.600 a	3.200 a	67.106 a	68.970 a	43.574 a	42.466 a
Alyawa	3.000 ab	2.533 b	70.479 a	75.819 a	42.724 a	38.624 a
Azady	2.467 b	2.600 b	75.787 a	74.585 a	46.693 a	43.021 a
Means followed by the same letters within column are not significantly different at $p \leq 0.05$ according to Duncan multiple range test						

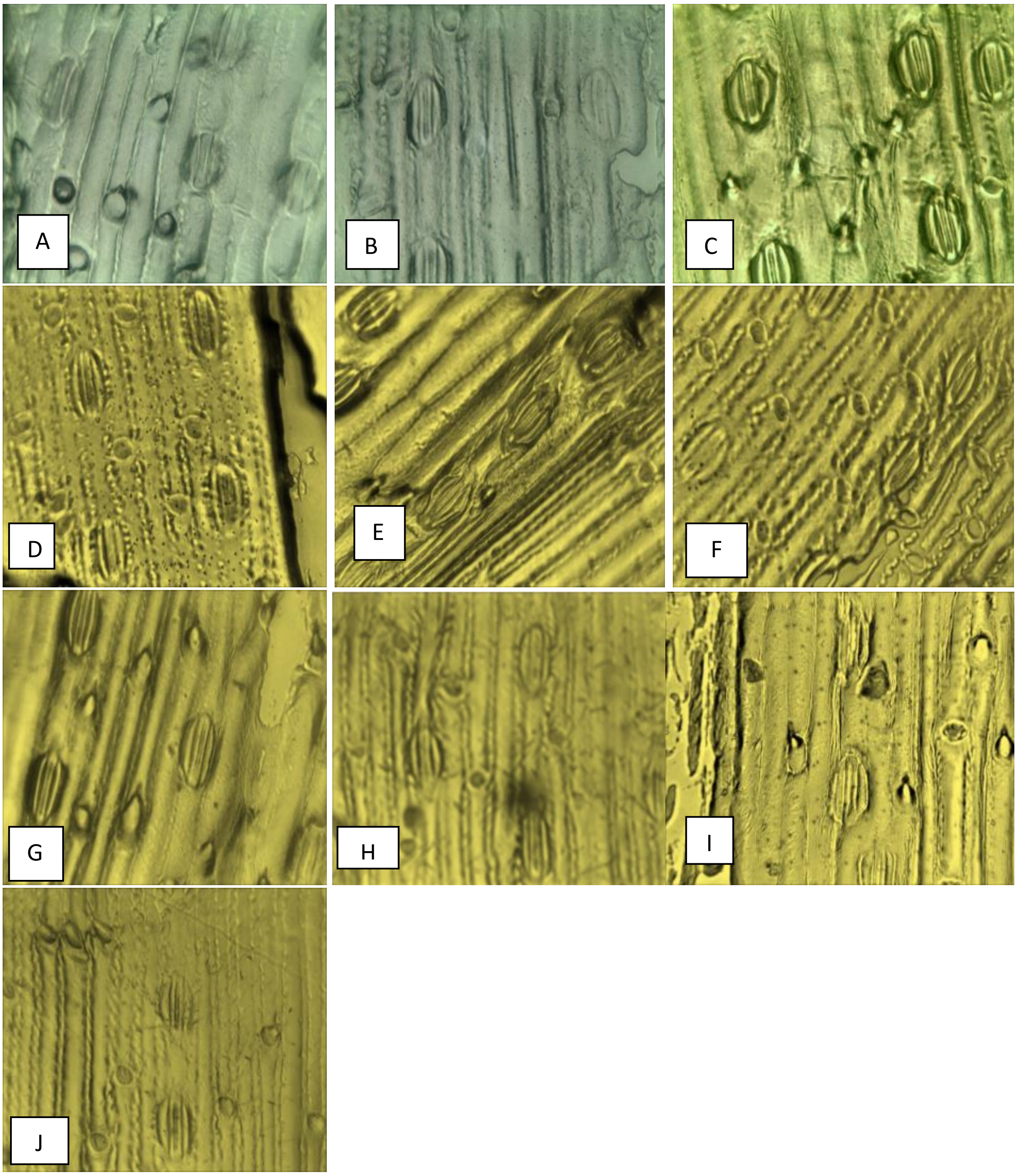


Figure (4.4) Stomata of adaxial(upper) and abaxial (lower)of wheat leaves surface of 40x, A. upper surface in Hamamok, B. lower surface in Hamamok, C. upper surface in Kany qara, D. lower surface in Kany qara, E. upper surface in Shawgerawa, F. lower surface in Shawgerawa, G. upper surface in Alyawa, H. lower surface in Alyawa, I. upper surface in Azady, J. lower surface in Azady.

4.4.3 Effect of Sewage Water on Photosynthetic Pigments in the Wheat

Leaves

According to table 4.22, Chlorophyll a did not differ significantly in the studied locations Hamamok (1.662 mg g^{-1}), Kany qara (1.668 mg g^{-1}), Shawgerawa (1.698 mg g^{-1}) Alyawa (1.592 mg g^{-1}), Azady (1.644 mg g^{-1}). Table 4.22 show content significant differences among the studied locations in the content of chlorophyll b, the highest was recorded at Shawgerawa and Kany qara locations by (1.302 and 1.277) mg g^{-1} respectively, and the lowest content were found at Azady and Alyawa locations by (0.653 and 0.672) mg g^{-1} respectively.

Increasing nitrogen rate in wastewater according to table (3.2), it is the most important mineral element in the process of chlorophyll biosynthesis, may be caused to increase chlorophyll b in Kany qara and Shawgerawa locations. These results agreed with Jerbi et al., (2020) in Alyawa and Azady locations, metal-induced stress especially lead according to table (4.24), Pb in plant adversely affected the plant pigment system. This may be a factor to decline in chlorophyll b, these results agreed with Saleh et al., (2020; Kanwal et al., 2020). Also our results in Alyawa and Azady locations agreed with Hajihashemi et al., (2020).

Total Chlorophyll in the wheat leaves significantly differed in the studied locations. According to table 4.22, the highest Chlorophyll content recorded at Shawgerawa location (3.00 mg.g^{-1}), and the lowest Chlorophyll content was (2.263 mg.g^{-1}) at Alyawa location. Kany qara and Shawgerawa locations have higher nutrient (N, P and K) as shown in table (3.2), than other locations, uptake of wastewater enhancement of chlorophyll content in wheat, the results accepted by Dash, (2012). Our result in Alyawa and Azady locations as shown in table (4.24) agreed with Saleh et al., (2020) who stated Pb stress causes to decrease in chlorophyll content .Also total chlorophyll consist of the summation of chlorophyll a and chlorophyll b, there for increasing chl a and b in Kany qara and Shawgerawa locations causes increasing total chlorophyll in these locations. On the other hand decreasing chl. a and b in Alyawa and Azady causes a decreasing in the total chlorophyll content in these locations. Holguin et al., (2022) suggests that the biosynthesis of chlorophyll molecules depends partially on the assimilation of P. Our results in Azady and Alyawa locations agreed with Hajihashemi et al., (2020; Pathrol and Bafna, 2013).

Total chlorophyll content decreases under heavy-metal stress by Cd, Cu and Pb (Shakya et al., (2008; Shahid et al., 2015). Cu has shown that to inhibit the enzymes responsible for producing chlorophyll by activating oxidative damage and altering cell-membrane characteristics through lipid peroxidation Shakya et al., (2008). Wheat plants' hydration status was dramatically impacted by soil salinity, which also decreased plant growth and photosynthetic rate. Stomatal closure and reduced photosynthetic electron transport were the primary contributors to the reduced photosynthetic carbon assimilation Sun et al., (2016). The interaction of Cd or Zn with the functional -SH group of chlorophyll producing enzymes during the several steps of chlorophyll manufacture may also be responsible for the decrease in chlorophyll content in leaves Sharma et al., (2010). The significant decline of the chlorophyll content in wheat plants grown in Cu-contaminated soil in relation to the decrease in the chlorophyll a and b ratio is an indication of the poor condition of those plants and the lack of adaptive adjustment in pigment concentrations to high Cu levels Moustakaset al., (1997). Carotene content differed significantly in the studied locations, the highest Carotene (0.720 $mg.g^{-1}$) recorded at Shawgerawa location , which superior to the other locations Hamamok, Kany qara, Alyawa and Azady by increasing (0.028, 0.007, 0.066, 0.005 unit), respectively.

Increase macro element especially phosphorus and potassium in soils irrigated with wastewater as shown in table (3.4), may be a factor for increasing carotene content in Kany qara, Shawgerawa and Azady locations, the results agree with Zeid and Abou El Ghate, (2007). In Alyawa have the highest level of Cd, as compared with other locations according to table (4.24). Cadmium stress decreased the content of carotenoid content, the result agree with Hussain, et al., (2022). Also the results agree with Hajihashemi et al., (2020; Kanwal et al., 2020). Increasing Zn accumulation by plants seems to be the one of the main reasons for physiological process inhibition under Zn stress carotene decline this mentioned by Repkina et al., (2023) that agreed with our result at Alyawa location according to table (4.24). Cu and Pb have a negative effect on Carotenoid content Giannakoula,, et al., (2021). Also Cd accumulation in soil and in plant parts have significant and negative relationships with carotenoid content Sharma et al., (2010).

Table 4.22 *Effect of Wastewater on Photosynthetic Pigments in the Wheat Leaves*

Locations	Chlorophyll a	Chlorophyll b	Total chlorophyll	Total Carotenoids
	$mg.g^{-1}$			
Hamamok	1.662 a	0.843 b	2.504 b	0.692 ab
Kany qara	1.668 a	1.277 a	2.945 a	0.713 ab
Shawgerawa	1.698 a	1.302 a	3.000 a	0.720 a
Alyawa	1.592 a	0.672 b	2.263 b	0.654 b
Azady	1.644 a	0.653 b	2.296 b	0.715 ab

Means followed by the same letters within column are not significantly different at $p \leq 0.05$ according to Duncan multiple range test.

4.4.4 Effect of Wastewater on the Wheat Grain Yield and its Components

4.4.4.1 Number of Spikes m^2

According to table 4.23, the number of spikes was influenced significantly in the studied locations, the highest number was (624.00 spike m^{-2}) at Azady location and the minimum number (98.67 spike m^{-2}) was recorded at Alyawa location.

Compared with well water irrigation, wastewater irrigation sustained better growth of the crop as is indicated by the higher values for spike number, which may be due to the availability of additional nutrients, like phosphate, potassium, etc. in the wastewater applied (Table 3.2). The results of Kany qara, Shawgerawa and Azady locations agrees with Aziz et al., (1995). Spikes number significantly enhanced due to P fertilization and organic amendment Ding et al., (2020). According to table (3.2), our results in all locations except Alyawa in agreement with Rahman et al., (2014). And disagree with Samarah et al., (2020) who studied on barley. Zn excess concentrations can impede growth by limiting cell division by lengthening mitotic phases and the entire mitotic cycle, as well as by impairing cell elongation by reducing the flexibility of cell walls or the turgor of cells Repkina et al., (2023).

4.4.4.2 Length of Spike (cm)

Result of table 4.23 shows the existence of significant effect of wastewater on the length of spike in the studied locations. The highest length of spike was recorded no significant differences between the locations Kany qara, Shawgerawa and Azady were (11.83, 11.43 and 11.35 cm) respectively, and the lowest length (9.58 cm) was in Hamamok. Wastewater irrigation provide better growth of the crop as is indicated by the higher values for spike length, may be due to the availability of additional nutrients, like phosphate and potassium, etc. in the wastewater applied (Table 3.2). These are readily available to the growing plants, our results in all the locations agrees with Aziz et al., (1995).

According to table (3.2) our results in all the locations was confirmed by Ali et al., (2021; Mojid et al., 2016).

4.4.4.3 Grain Weight Spike (g)

As shown in Table 4.23 there were significant differences among locations to the weight of spike, the highest weight was (2.207 g) at Kany qara and the lowest weight was (0.159 g) at Alyawa.

In general the results are similar with those recorded by increasing N, P, and K in wastewater irrigation (table 3.2) cause increase the yield of spike, our results in Kany qara, Shawgerawa and Azady locations agrees with Oscarson, P., (2000) but Alyawa disagree with this study results. High value of Cu in Alyawa as shown in table (4.24), may be a factor for decreasing the grain yield of spikes according to Alhammad et al., (2023). Our results in all locations agrees with Mojid et al., (2016) except for Alyawa.

4.4.4.4 Seed Index:

Weight of 1000 grain in the studied locations show significant differences in table 4.23, the highest weight recorded at Kany qara location was (55.13g) and the minimum weight was (34.8g) at Alyawa location.

Effects of wastewater significantly increased 1000 grain weight, because sewage water contains nutrients required by the plants according to table (3.2). The results of Kany qara, Shawgerawa and Azady locations agreed with Gandomkar, (2018). High value of Cu in Alyawa, as shown in table (4.24), may be a factor for decreasing 1000-grain weight in comparison to the control treatment according to Alhammad et al., (2023). the results of all locations agreed with Pradhan et al., (2001; Mousavi and Shahsavari, 2014; Akbar et al., 2021), except for Alyawa location.

4.4.4.5 Grain Yield (ton ha^{-1}):

The results of table 4.23 show significant effect on grain yield at the studied locations, the highest yield value (11.448 ton ha^{-1}) was recorded at Kany qara location and the lowest yield (0.157 ton ha^{-1}) was recorded at Alyawa location

wastewater irrigation and alternate irrigation have added to nitrogen contribution, and thus, increased the N. content cause to increase grain yield. Our results in Kany qara, Shawgerawa and Azady locations agrees with Salakinkop and Hunsha, (2014) who stated about 75 % nitrogen present in sewage is utilized by plants. Also our results in Kany qara, Shawgerawa and Azady agrees with Pradhan et al., (2001; Mojid et al., 2016; Holguin et al., 2022)

Several researchers reported accumulation N, P, and K in the soil with wastewater and cause to increase grain yield and biological yield of the crops Esmailiyan et al., (2008). Grain yield significantly enhanced due to P fertilization and organic amendment contain in wastewater for irrigation Ding et al., (2020). The grain yield of winter wheat determined by the spike number Chen et al., (2019).

Hussain and A1-Saati, (1999) reported yield of maize showed a significant increase with wastewater irrigation.

According to table (4.24), cadmium may impact physiochemical and biological processes in plants, disrupting vegetative growth and development and resulting in reduced grain yields and grain quality in the Alyawa location. Hussain, et al., (2022). Salt stress induced various physiological and metabolic modifications and eventually decreased plant growth in wheat, which results in decreased grain yield Sun et al, (2016). The result of Alyawa location only agrees with Farahat et al., (2017).

4.4.4.6 Straw Yield (ton ha^{-1})

According to table 4.23, the straw yield among the studied locations differed significantly, the highest straw yield was (10.694 ton ha^{-1}) at Azady location and the lowest yield was (3.365 ton ha^{-1}) at Hamamok location.

wastewater has nutrient potential which it's important for plant growth, as straw yield is higher than control, in all the locations agrees with Saha, et al., (2010). Also straw yield related with grain yield and biological yield. Our results in all the locations were in acceptance with Ding et al., (2020).

4.4.4.7 Biological Yield (ton ha^{-1})

Biological yield differed significantly in the studied locations as shown in table 4.23, which the highest biological yield was recorded in Azady location was (21.407 ton ha^{-1}) but the lowest biological yield with non- significant differences recorded between Alyawa and Hamamok were (4.977 and 5.3533) ton ha^{-1} respectively,

Ali, (2021) revealed the role of increasing the rate of nitrogen fertilization cause increasing the biological yield of wheat crops.

Our results in all the locations agrees with Alizadeh et al., (2001; Mojidi et al., 2016; Akbar et al., 2021) except Alyawa.

4.4.4.8 Harvest Index %

Harvest index reached significant level ($p<0.05$) in the studied locations, as shown in table 4.23, Kany qara location have the highest percent (63.22%), and the minimum percent recorded at Alyawa location (3.16%).

Effects of wastewater treatment significantly increased harvest index, because sewage water contains organic matter and nutrients required by the plants according to table (3.2). The results of all locations disagree with Mojid et al., (2016). According to table (3.4) and (3.2) our results in all the locations were acceptance with Asif et al., (2012; Arif et al., 2017), except for Alyawa.

Table 4.23 *Effect of Wastewater on Grain Yield of a Wheat and its Components*

Location	No. of Spikes/ m^2	Length of spike (cm)	Grain wight per spike (g)	Seed index (g)	grain yield (ton.ha^{-1})	Straw Yield (ton.ha^{-1})	Biological yield (ton.ha^{-1})	Harvest index %
Hamamok	182.33 b	9.58 c	1.089 c	48.23 c	1.988 c	3.365 d	5.3533 c	37.14 c
Kany qara	518.67 a	11.83 a	2.207 a	55.13 a	11.448 a	6.659 bc	18.107ab	63.22 a
Shawgerawa	534.33 a	11.43 a	1.298 c	48.9 bc	6.935 b	8.268 ab	15.203 b	45.62 bc
Alyawa	98.67 b	10.22 b	0.159 d	34.8 d	0.157 c	4.820 cd	4.977 c	3.16 d
Azady	624.00 a	11.35 a	1.717 b	50.96 b	10.713 a	10.694 a	21.407 a	50.04 b

Means followed by the same letters within column are not significantly different at $p \leq 0.05$ according to Duncan multiple range test.

4.4.5 Effect of Wastewater to the Heavy Metals Concentration (mg kg^{-1}) in Wheat Grains

The results in table (4.24) reveals the elements' concentrations in wheat grain (Cd, Pb, Cu, Zn, Mn). The concentrations of heavy metals in wheat grain vary from metal to other in studied locations. According to Duncan's test Cd content in wheat grain in studied locations show non- significant differences ,

The results in table 4.24 revealed that the concentration of Pb element in wheat grains differed significantly in studied locations, which ranged between (13.983 - 24.393) mg kg^{-1}. The highest value was found at Alyawa location and the lowest value was found at Kany qara location, and the differences between locations Hamamok, Kany qara, Shawgerawa, and Azady did not reache a significantly level. The content of Pb in all locations higher than (0.35 mg kg^{-1}) which recorded by Hassan et al., (2013). The grain content of Pb at all locations higher than the safe limits (0.4 mg kg^{-1}) that stated by Chinese standards Huang et al., (2008). The relatively high content of Pb in Hamamok (control location) have been the result of uptake from polluted soil that located on main road with traffic density. Additionally, the foliar uptake of atmospheric heavy metals from vehicle emissions which has been identified as another path way of heavy metal pollution in vegetable crops Mamand, (2008).

The findings in table 4.24 show the concentration of Cu in wheat grain differed significantly between all the studied locations , the highest value at Alyawa location by (18.080 mg kg^{-1}) and the lowest value was in Hamamok and Shawgerawa locations by (4.769 and 5.511) mg kg-1, respectively. The average value in all the locations was higher than (4.1 mg

kg^{-1}) Hassan et al., (2013). The concentration of Cu in all the studied locations higher than the (0.42 mg kg^{-1}) as reported by Hussain et al., (2011). According to Huanget al., (2008) the locations Kany qara, Alyawa and Azady were higher than safe limits (10 mg kg^{-1}), but in (Hamamok and Shawgerawa) were lower than the standard level.

Zn is the most studied element in wheat grains Hassan et al., (2013) and it is an essential element for plant nutrition, and it is require only minute amount Ahmed, (2017b). Zn concentration in wheat grain differed significantly in the studied locations ($p<0.05$) (table 4.24), the highest value (67.081 mg kg^{-1}) at Alyawa location and the lowest value (23.713mg kg^{-1}) at Shawgerawa location, the result of Shawgerawa location only was lower than (35.3) mg kg^{-1} Hassan et al., (2013). But Zn concentration in all the studied locations lower than (133 mg kg^{-1}) Jamali et al., (2009). The Content of Chinese tolerance limits for Zn in wheat grains were not exceeded; only Alyawa (67.081 mg kg^{-1}) indicated over the tolerance limit (50 mg kg^{-1}) in wheat grains Huang et al., (2008).

Manganese is an essential micronutrient in plant nutrition and has several functions and it plays an important role in reactions of enzymes. However, accumulation of excessive manganese (Mn) in leaves causes a reduction of photosynthetic rate, necrotic brown spotting on leaves, petioles and stems is a common symptom of Mn toxicity Ahmed, (2017b). Mn concentration in wheat grain was ranged between (14.458 - 33.012) mg kg^{-1} table (4.24), The highest value recorded in Azady location and the lowest value recorded in Kany qara location. Our results in all the studied locations higher than 4.9 mg kg^{-1} Hassan et al., (2013). Mn content in wheat grain in both locations Hamamok and Kany qara were lower than Safe limits (30-300 mg kg^{-1}) as stated by Abdulbary, (2000).

Table 4.24 *Effect of Wastewater on Heavy Metals Concentration (mg kg^{-1}) in Wheat Grains.*

Heavy Metals	Locations					Safe limits of heavy metals
	Hamamok	Kany qara	Shawgerawa	Alyawa	Azady	
Cd	1.120 a	1.168 a	1.256 a	1.279 a	1.228 a	0.1 (Huang et al., 2008) (wheat)
Pb	15.323 b	13.983 b	14.089 b	24.393 a	16.290 b	0.4 (Huang et al., 2008) (wheat)
Cu	4.769 c	11.014 b	5.511 c	18.080 a	13.851 b	10 (Huang et al., 2008) (wheat)
Zn	40.940 b	36.069 b c	23.713 c	67.081 a	36.843 b c	50 (Huang et al., 2008) (wheat)
Mn	25.765 a	14.458 b	31.434 a	31.439 a	33.012 a	30-300 (Abdlbary,2000) (Plant)
* Means followed by the same letters within row are not significantly different at $p \leq 0.05$ according to Duncan multiple range test.						

4.4.6 Bio-Concentration Factor in Wheat Grains (BCF)

The uptake factor from soil by plant is recognized as Bio-Concentration Factor (BCF).
Table (4.25) show the BCF values of heavy metals in wheat grains irrigated by wastewater. Cadmium show at all studied locations <1, this indicated that the accumulation of Cadmium in the wheat grains at all the studied locations was lower than the accumulation in soil**.**
The BCF of Pb at all locations has suprassed value of one at studied locations, this revealing that the accumulation of Pb in wheat grains was greatre than the acuumulation in soil Gupta et al., (2022). While BCF of copper, zinc and manganese in all the studied locations <1, this mean that the accumulation of copper, zinc and manganese in the wheat grains in all the studied locations was lower than the accumulation in soil**.**

Table 4.25 *Bio-Concentration Factor (BFC) of Wheat Grains Irrigated by Wastewater*

Locations	Hamamok	Kany qara	Shawgerawa	Alyawa	Azady
Cd	0.744	0.747	0.799	0.978	0.703
Pb	1.477	1.124	1.241	2.219	1.113
Cu	0.208	0.273	0.110	0.463	0.346
Zn	0.539	0.429	0.305	0.884	0.427
Mn	0.041	0.031	0.093	0.057	0.060

5. Conclusion

Based on the obtained results from the present investigation, the following main conclusions have been drawn

1- The response of the studied plants are differing results at measuring physiological and growth parameters in selected plants chard, celery, broad bean and wheat.

2- Wastewater increased plant growth. The using of waste water for irrigation may be an abundant resource of nutrients and essential elements for plant's growth. In fact, waste water has high concentration of organic matter and nutrients as compared to fresh water. Therefore, the nutrient accumulation occurring in the soil and facilitates accessing these nutrients by the plants.

3- Wastewater irrigation demonstrates the effectiveness to increase the yield of chard ,celery, broad bean also wheat in most of studied locations.

4- Extreme health risks are predicted, Cd and Pb contents in the studied plants at all locations, were higher than the permissible limit, while Cu and Zn were higher than the permissible limit in some locations. Also the Mn contents was lower than permissible limit in all the locations.

5- The values of Bio-concentration factor for plants (chard, celery, broad bean and wheat) showed accumulation of toxic metals such as Pb in all the locations and Cd in some locations, while the metals Cu, Zn and Mn were excluded in all the locations.

6. Recommendation

1- It is still too early to recommend the use of wastewater as an alternative option for fresh water irrigation for plants.

2- Conducting experiments on other plants especially in arid and sub-arid regions and choosing the plants that collect the least heavy metals in their edible parts.

3 - Using wastewater for forest trees production, to be a method for soil cleaning from heavy metals.

4- Choosing the research sites that are far from transportation routes, to avoid the influence of car exhausts, and to ensure the accuracy of the search results.

5-More researchs are required for examining the long-term effects from wastewater application on pathogens and human health in the future.

6-Utilizing treated wastewater in the irrigation process for avoiding the health risk

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الملخص

أجريت هذه الدراسة في قضاء كويسنجق ، في خمسة مواقع زراعية حول المدينة حيث شملت موقع حماموك (مياه آبار) كموقع كنترول وأربعة مواقع تعتمد في سقيها على مياه الصرف الصحي (كاني قره ، شوگيراوه، علياوه ، آزادي) خلال فصل الشتاء. ٢٠٢١-٢٠٢٢ لدراسة تأثير الري بمياه الصرف الصحي على بعض خصائص النمو الخضري ومكونات المحصول والخصائص الفسيولوجية لنباتات السلق والكرفس والباقلاء والقمح.

أظهرت النتائج للنبات السلق أن الري بالمياه الصرف الصحي أدى إلى انخفاض في ارتفاع النبات وعدد الأوراق في جميع المواقع باستثناء آزادي، ولكنه أدى إلى زيادة وزن المجموع الخضري الطازج والجاف في جميع المواقع، وزيادة معنوية في عدد الثغور في بعض المواقع. كما أدى الري بالمياه العادمة إلى انخفاض محتوى الكلوروفيل ب والكلوروفيل والكاروتين في جميع المواقع. كما كانت المعادن الثقيلة الكادميوم (Cd) والرصاص (Pb) أعلى من المستوى القياسي في جميع المواقع المدروسة مع موقع السيطرة، كما كان موقع (علياوة) أعلى من النحاس (Cu) وموقع (كاني قرة) يحتوي على الزنك (Zn) أعلى من المستوى القياسي.

أظهرت نتائج النبات الكرفس أن الري بالمياه صرد الصحي أدى إلى زيادة معنوية في ارتفاع النبات وعدد الأوراق فقط في كاني قره، وزيادة وزن المجموع الخضري الطازج والجاف في كاني قره وشگيراوه، وزيادة معنوية في عدد الثغور فقط في كاني قره، وزيادة معنوية في الكلوروفيل أ و إجمالي الكلوروفيل في جميع المواقع باستثناء آزادي. كما كانت المعادن الثقيلة والكادميوم (Cd) والرصاص (Pb) أعلى من المستوى القياسي في جميع المواقع المدروسة بما في ذلك موقع الكنترول، في حين كانت معادن النحاس (Cu) والزنك (Zn) والمنجنيز (Mn) أقل من المستوى القياسي في جميع المواقع المدروسة، مع موقع الكنترول.

أظهرت نتائج نبات باقلي (فول) ان الري بالمياه الصرف الصحي انخفاضاً معنوياً في ارتفاع النبات في جميع المواقع، كما أدى إلى زيادة عدد الأوراق، مساحة الورقة (سم²)، عدد قرون نبات-١، عدد بذور نبات-١، وزن القرنة الطازجة والجافة في النبات. كاني قره وأزادي. كما أدى إلى زيادة أيام التزهير في كاني قره وشوگيراوه. أيام الاستحقاق في جميع المواقع باستثناء شوگيراوه.. تقليل فترة الملء في كاني قره و شوگيراوه. كما أدى الري بمياه الصرف الصحي إلى زيادة كبيرة في ارتفاع الجراب الأول في شوگيراوه وأزادي. كما زاد عدد القرون الأولى وعدد البذور والوزن الجاف للقرن الأول فقط في موقع آزادي. أظهر عدد وطول وعرض الثغور ارتفاعاً معنوياً في بعض المواقع، كما زاد الكلوروفيل أ والكلوروفيل الكلي والكاروتين في كاني قره و شوگيراوه، أما الكلوروفيل (ب) فقد زاد فقط في ا شوگيراوه. كما أن نسبة معادن الكادميوم (Cd) والرصاص (Pb) والنحاس (Cu) في قرنة الفول عريضة أعلى من المستوى القياسي في جميع المواقع المدروسة بما في ذلك موقع السيطرة، في حين كانت معادن الزنك ((Znوالمنجنيز (Mn) أقل من المستوى القياسي في جميع المواقع المدروسة. المواقع المدروسة بما في ذلك موقع الكنترول.

أظهرت نتائج محصول القمح أن الري بالمياه صرف الصحي أدى إلى زيادة ارتفاع النبات في جميع المواقع ماعدا منطقة علياوة، لكن عدد الفروع وعدد الأوراق ومساحة ورقة العلم زاد معنوياً في جميع المواقع، وانخفضت أيام التزهير في جميع المواقع ماعدا آزادي لها نفس أيام الملء، وكانت فترة النضج أعلى في جميع المواقع باستثناء علياوة وكانت أيام النضج أعلى في شوگيراوه وأزادي، وأقل في علياوة ونفس الشيء في كاني قره.

أظهرت أعداد الثغور انخفاضاً معنوياً، ولكن ارتفع معدل الكلوروفيل ب، والكلوروفيل الكلي في كاني قره وشوگيراوه، كما زاد محتوى الكاروتين في جميع المواقع ماعدا منطقة علياوة. أظهرت أعداد السنابل ووزن السنابل ودليل البذور وحاصل الحبوب والحاصل البيولوجي ودليل الحصاد زيادة معنوية في جميع المواقع باستثناء علياوة، بينما زاد طول السنابل وإنتاج القش في جميع المواقع. كما أن حبوب القمح تحتوي على معادن ثقيلة Cd و Pb أعلى من المستوى القياسي في جميع المواقع

بما في ذلك موقع السيطرة، وكان معدن النحاس أعلى من المستوى القياسي في مواقع كاني قره وعلياوة وأزادي، وكان محتوى الزنك أعلى من المستوى القياسي فقط في علياوة، بينما كان معدن المنغنيز (Mn) أقل من المستوى القياسي في موقعي حماموك وكاني قره بينما كان ضمن المستوى القياسي في مواقع شوگيراوه وعلياوة وأزادي.

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جمهورية العراق الفيدرال
حكومة إقليم كوردستان
وزارة التعليم العالي و البحث العلمي
جامعة كويه

دراسة تأثيرالري بمياه الصرف الصحي في نمو وحاصل وتركيز المعادن الثقيلة لبعض النباتات في مدينة كويسنجق

رسالة مقدمة الى فاكلتي العلوم والصحة في جامعة كويه
وهي جزء من متطلبات نيل شهادة الماجستير
في بايولوجي .(MSC)

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حاصلة على
شهادة بكالوريوس علوم الزراعية / جامعة كويه
٢٠١٢

باشراف
ا.م..د. ارول انور محسن

٢٠٢٣

پوخته

ئەم توێژینەوەیە لە چەند کێڵگەیەکی کراوە لە شاری کۆیە ئەنجامدراوە، کە پێکدێن لە پێنج شوێن لە دەوروبەری شاری کۆیە، یەک شوێن لە (ئاوی بیر- حەمامۆک) و چوار شوێنی تر پێکدێن لە ئاوی ئاوەڕۆ وەك (کانی قەرە، شەوگێراواعەلیاوە و ئازادی) لە وەرزی زستانی (٢٠٢١-٢٠٢٢) بۆ لێکۆڵینەوە لە کاریگەری ئاودێری ئاوی پیس لەسەر هەندێک تایبەتمەندی گەشەی ڕووەکی و پێکهاتەی بەرهەم و تایبەتمەندییە فیزیۆلۆژییەکانی چەند ڕوەكێك وەك سلق، کەرەوز، پاقلە و گەنم

ئەنجامی پێوانەکانی لێکۆڵینەوە بۆ ڕوەکی سلق دەریخست کە ئاودێری ئاوی پیس کەمبوونەوەی بەرچاوی هەیە لە بەرزی ڕووەک و ژمارەی گەڵاکان لە هەموو شوێنەکان جگە لە ئازادی، بەڵام بووەتە هۆی زیادبوونی بەرچاوی کێشی لقە تازە و وشکەکان لە هەموو شوێنەکان، ژمارەی ستۆماتا بە شێوەیەکی بەرچاو زیاد دەکات لە هەندێک شوێن، وە کاریگەری نەبوو لەسەردرێژی و پانیی ستۆماتاو وەهەروەها کاریگەری نەبووەلەسەر کلۆرۆفیل ئەی، بەڵام بووە هۆی کەم بوونی کلۆرۆفیل بی و کلۆرۆفیلی گشتی و کارۆتین

کادمیۆم و قوڕقوشم زیاترن لە ئاستی ستاندارد لە هەموو شوێنەکان، زینك لە کانی قەرە و مسیش لە عەلیاوا زیاترن لە ئاستی ستاندارد

ئەنجامی پێوانەکانی لێکۆڵینەوە بۆ ڕوەکی کەرەوز دەریدەخەن کە ئاودێری ئاوی پیس بووەتە هۆی زیادبوونی بەرچاوی بەرزی ڕووەک، ژمارەی گەڵاکان لە کانی قەرا، هەروەها زیادکردنی کێشی لقە تازە و وشکەکان لە کانی قەرە و شەوگەراوە، و بە شێوەیەکی بەرچاو ژمارەی ستۆماتا تەنها لە کانی قەرا زیاد دەکات، و وە کاریگەری نەبولەسەر درێژی و پانی لە ستۆماتا، وهەروەها زیادبوونی کلۆرۆفیل ئەی و کلۆرۆفیلی گشتی لە هەموو شوێنەکان جگە لە ئازادی، وە کاریگەری نەبولەسەر کلۆرۆفیل بی و کارۆتین لەگەڵ توخمەکانی کادمیۆم، مس، قورقوشم و زینك وە هەروەها مەنگەنیز کەمتر بوو لە ستاندارد، بەڵام ڕێژەی کۆبوونەوەی قوڕقوشم زیاتر بوو لە (یەك) لە هەموو شوێنەکان وە کادمیۆم تەنها لە عەلیاواز

وە هەروەها بۆ پاقلە ئەنجامەکان دەریانخست کە بەرزی ڕوەك کەمی کردووە، بەڵام لە کانی قەرە و ئازادی بووە هۆی زیادبوونی ژمارەی گەڵا و پۆد و تۆوەکان و ڕووبەری گەڵا لەگەڵ بەرهەمەکانیان، وە جیاوازی ڕۆژانی گوڵ کردن و ماوەی پڕکردنەوە لە کانی قەرە و شەوگەرەوا، بڵام ڕۆژانی پێگەیشتن لە هەموو شوێنەکانە جگە لە شەوگێراوا

ژمارە و درێژی و پانی ستۆماتاکان لە هەندێک شوێن زیادبوونی بەرچاویان نیشان دا

کلۆرۆفیلی گشتیو کلۆرۆفیل ئەی و کارۆتین لە کانی قەرا و شەوگێراوە زیاد دەکات، بەڵام کلۆرۆفیل بی تەنها لە شەوگێراوە زیاد دەکات

کادمیۆم و قوڕقوشم زیاترن لە ئاستی ستاندارد لە هەموو شوێنەکان، وە مس لە عەلیاوا و حەمامۆك، ، بەڵام ڕێژەی کۆبوونەوەی قوڕقوشم زیاتر بوو لە (یەك) لە هەموو شوێنەکان

لە ئەنجامدا بۆ ڕووەکی گەنم جیاوازیەکی بەرچاو هەبوو لە بەرزی ڕوەك لە هەموو شوێنەکان جگە لە عەلیاوا، بەڵام ژمارەی لق وە ژمارەو ڕوبەری گەڵا، لە هەموو شوێنەکان بە شێوەیەکی بەرچاو زیادی کردبوو، وە ژمارەی گوڵکردن کەمی کردبوو جگە لە ئازادی وە هەروەها ماوەی پڕبوون زیادی کردبوو جگە لە عەلیاوا ، وە پێگەیشتن لە شەوگێراواو ئازادی زیادی کردبوو، وە ژمارەی ستۆماتا کەمی کردبو بەڵام وە کاریگەری نەبولەسەر درێژی و پانی لە ستۆماتا و کلۆرۆفیل ئەی، وە کلۆرۆفیل بی و کلۆرۆفیلی گشتی زیادی کردبوو لە کانی قەرەو شەوگێراوا، ووە کارۆتین زیادی کردبوو لە هەموو شوێنەکان

جگە لە عەلیاوا، ژمارەو بەرهەمی گوڵ و ژمارەی ١٠٠٠ دنك و بەرهەمی گشتی زیادی كردبوو لە هەموو شوێنەكان جگە لە عەلیاوا، بەڵام درێژی گوڵ بە شێوەیەكی گشتی زیادی كردبوو

كادمیۆم و قورقوشم زیاترن لە ئاستی ستاندارد لە هەموو شوێنەكان، وە مس لە هەموو شوێنەكان زیاترە جگە لە شەوگێراواوە هەروەها زینك تەنها لە عەلیاوا زیاتر بو، بەڵام ڕێژەی كۆبوونەوەی قورقوشم زیاتر بوو لە (یەك) لە هەموو شوێنەكان

وە هەروەها ڕێژەی میتاڵەكان لە خاك كەمترە لە ئاستی ستاندارد.

کۆماری فیدراڵی عیراق

حکومەتی هەرێمی کوردستان

وەزارەتی خوێندنی باڵاو توێژینەوەی زانستی

زانکۆی کۆیە

کاریگەری ئاودان بە ئاوی ئاوەڕۆ لەسەر گەشەو بەرهەم و خەستی توخمی قورس لە هەندێ ڕووەک لە شاری کۆیە

ماستەرنامەیەکە پێشکەشی

فاکەلتی زانست و تەندروستی کراوە لە زانکۆی کۆیە وەك بەشێك لە پێداویستی

بەدەستهێنانی بڕوانامە ی ماستەر لە زانستی بایۆلۆجی

لە لایە ن

ژاکاو مصطفی سعید

بەکالۆریوسی وەرگرتوە لەکشتوکاڵ

لە فاکەلتی زانست و تەندروستی/ زانکۆی کۆیە/ لە ساڵی ٢٠١٢

بە سەرپەرشتی

پ. ی. د.ئارول محسن ئەنوەر

٢٠٢٣