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Contribution to the study of the influence of mallow extract (*Malva sylvestris* L.) on the culture of lettuce (*Lactuca sativa* L.)

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Dedication

In the name of Allah, the Most Gracious, the Most Merciful. At the outset, I praise Allah Almighty for guiding and enabling me to complete this humble work, and I ask for His continued guidance in all that is to come.

Now, to my dear parents, **Nafir Mohammed** and **Nafir Hanifa**, I love you both and I thank you for every effort, advice, and kind word you have bestowed upon me. May Allah preserve you for me and illuminate my path through you.

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Dedication

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List of abbreviations

BC: Before Christ

Cm: centimeter

°C: Celsius

m: meter

USDA: The United State Dept of Agriculture

PI: Plant Introduction

CGN: Centre for Genetic Resources, the Netherlands

U.K: United Kingdom

A.D: anno Domini

FW: fresh weight

pF: potential of free water

ANOVA: analysis of variance

P.M: Polysaccharide Mixture.

M.W: Molecular Weight

DSA: Directorates of Agricultural Services

PCA: principal component analysis

Introduction

Lettuce is a commonly consumed leafy vegetable that is widely cultivated for its high nutritional value and low-calorie content. However, the quality of lettuce cultivation can be affected by various biotic and abiotic stress factors, which can lead to reduced yield quantity and quality. One potential solution to address these issues is the use of natural plant extracts, such as mallow extract, which has been shown to have a range of beneficial effects on plant growth and development **(Kesseli and al., 1991).**

Mallow (*Malva sylvestris* L.) is a common plant species that belongs to the family *Malvaceae*. It is widely distributed in Europe, Asia and North America, it has been traditionally used in herbal medicine due to its anti-inflammatory, analgesic and anti-allergic properties. Recent studies have also demonstrated that mallow extract has a range of beneficial effects on plant growth, including improving seed germination, enhancing root development and increasing plant resistance to various biotic and abiotic stress factors **(Davis, 2010)**.

Given these potential benefits, researchers have become increasingly interested in exploring the use of mallow extract in lettuce cultivation. However, to date, there has been limited research conducted on this topic, and more studies are needed to fully understand the potential effects of mallow extract on lettuce growth and development **(Fattahi, Souri, and Khazaei, 2019).**

This paper aims to provide scientific support on the influence of mallow extract on lettuce cultivation, with a focus on its effects on plant growth, yield and quality. Finally, this work will discuss the potential implications of these findings for lettuce cultivation and highlight areas for future research and to offer a less expensive and effective solution to farmers especially for those interested in market gardening as a first step in this field.

To achieve this objective our work has been divided into three parts: the first part bibliography study which elucidates a disruption of the tow species studied (lettuce and mallow) and the importance of each of them the second part focuses on the description of the experimental device and the methods followed in our study and the third part is interested in the exposure of the results obtained from this short duration of work on the ground.

Part1

Bibliography synthesis

Chapiter I: General description of lettuce cultivation

1.1 History

Ancient Egypt is known as the place where *L. sativa* was first cultivated with evidence of its cultivation appearing as early as 2680 BC. The Egyptians cultivated the plant for the production of seed oil. It is thought that the Egyptians selectively bred it into a plant grown for its edible leaves. The lettuce was seen as a sacred plant of the reproduction God Min and it was carried during his festivals and placed near his images. The plant was thought to help the God perform the sexual act untiringly **(Hart, 2005)**. Its use in religious ceremonies resulted in the creation of many images in tombs and wall paintings. The cultivated variety appears to have been about 30 inches (76 cm) tall and resembled a large version of the modern romaine lettuce. These lettuces developed by the Egyptians were further introduced in the Greece and then in Roma. The plant was further introduced in Americas by Christopher Columbus in the late 15th century **(Subbarao and Koike, 2007)**. Many medieval authors described *L. sativa* and its uses especially as a medicinal herb. These included Hildegard of Bingen (1098 and 1179) and Joachim Camerarius (1586) who described three basic modern lettuces including head lettuce, loose-leaf lettuce and romaine or cos lettuce **(Bennett and Hollister, 2001)**. Between the late 16th century and the early 18th century, many varieties were developed in Europe.

1.2 Origin and Domestication

Prior to domestication by humans, lettuce grew wild. It is still not exactly clear which species were involved in the evolution that led to modern-day lettuce. However, it is certain that *L. serriola* is one of or the only direct ancestor(s) **(Lindqvist, 1960; de Vries, 1990, 1997; Kesseli and al., 1991)**. The chromosomes of *L. sativa* and *L. serriola* are very similar morphologically **(Feráková, 1977)** and they cross freely with each other. The two taxa are considered by some as subspecies of the same species. It is most likely that changes in *L. serriola* caused by mutations led to the appearance of forms that were favoured by humans, particularly forms without spines on stems and leaves and with large seeds. They were then selected for use and further modified to fit human needs. These early forms would have been suitable for animal consumption and for oil from the seeds for domestic use. Several primitive forms still exist and are used for these purposes in Egypt today **(Harlan, 1986 and Ryder, 1999).** Most of this grow and develop rapidly and have non-reflexed involucres to prevent seed loss, large seeds, and high oil content in the seeds 35%

(Boukema and al., 1990). One of these landraces, known as USDA (United State Dept of Agriculture) Plant Introduction (PI) 251245 from Egypt, is used for seed oil The existence of these primitive forms in the Middle East provides strong support for the idea that lettuce probably originated in the eastern Mediterranean basin. From Egypt, cultivated lettuce spread to Greece and Rome and throughout the Mediterranean region **(Lindqvist, 1960)**. Around the Mediterranean basin, the romaine type of lettuce, also known as cos type (which may suggest its early use on Kos Island near Turkey), predominated and still is the most common lettuce type today. They most closely resemble the stem lettuces and thus probably have evolved from the stem types. The first written records of lettuce cultivation are credited to Herodotus who mentioned that about 550 B.C. a cos-like lettuce was eaten at the Persian Court **(De Vries, 1997)**. The cos lettuces are distributed close to the likely centre of origin and have considerable variation in leaf shape and length, flat and erect stature, open and closed heads, texture, and colour. It 77 is likely that leaf or cutting lettuces, butterhead, Latin types, and Batavia-type crisphead were all selected from this rich source of variability **(Ryder, 1999).**

Later, lettuce-growing areas further expanded from the Mediterranean region to the rest of Europe. The first indication of lettuce cultivation in Northwestern Europe is found in the herbal of Schöffer (1485) who described four lettuce types **(De Vries, 1997)**. Pieter made a painting in 1553 that shows a butterhead lettuce. The oldest cultivars in the largest lettuce germplasm collection in Europe (CGN, the Netherlands) are two French cultivars: 'Passion Blonde a Graine Blanche' from 1755 and 'Palatine' from 1771 **(Boukema and al., 1990)**. Peter Martyr reported its presence on Isabela Island in 1494 **(Ryder, 1997)**, just two years after Columbus's first voyage. In the next 400 years following its introduction, an assortment of leaf types was grown in America, including the loosely packed, softheaded crisp lettuce, known as Batavia types. At the beginning of the 20th century, most popular lettuces were butterhead types. In the early part of the century, however, the Batavia type of crisphead lettuce began to predominate, because it could be grown on irrigated large farms in the western USA and could maintain good quality for 10-12 days for the shipment to the rest of the country. In 1940, the researchers Whitaker crossed a Batavia cultivar 'Imperial' with an heirloom variety 'Brittle Ice' and developed the first true iceberg lettuce, 'Great Lakes', which is a compact firmheaded crisphead lettuce. Soon the iceberg type gained popularity and became dominant in the United States. Iceberg lettuce was introduced back to Europe and has become the most important lettuce type in the U.K. and the Scandinavian 78 Beiquan Mou Lettuce countries. The iceberg type has also become popular in Spain, Germany, Australia, and Japan, among others, and is now a major item in these countries. Cultivated lettuce was introduced into China between 600 and 900 A.D **(De Vries, 1997)**. The Chinese selected lettuce for the bulky succulent non-bitter stem and long narrow leaves for consumption of the stem mainly as a cooked vegetable. Domestication of the wild types of lettuce has resulted in the loss of prickles from leaves and stems, less latex and tissue bitterness, reduced suckering, slow bolting except for stem lettuce, an increase in seed size and non-reflexed involucres to prevent seed shattering. Human selection and later breeding efforts have also led to changes in size, shape, colour, texture and taste of leaves and plants, heading habits, resistance to diseases and insects and adaptation to different geographic areas and environments **(Beiquan ,2005).**

1.3 Scientific classification of lettuce

Lactuca sativa (Lettuce) is the most important crop in the group of leafy vegetables. It belongs to the family of *Asteraceae* which comprises between 23,000 and 30,000 species and is thought to be the largest family of plants **(Bayer and Starr, 1998).**

The botanical systematic of the lettuce was given by carl von linné (Bailey,1976) as follows:

- ✓ Kingdom: *Plantae*
- ✓ Phylum: *Magnoliophyta*
- ✓ Class: *Magnoliopsida*
- ✓ Order: *Asterales*
- ✓ Family: *Asteraceae*
- ✓ Genus: *Lactuca*
- ✓ Species: *Lactuca sativa.*

A survey of lettuce cultivars and classification of types was provided by (**Rodenburg 1960).** More comprehensive overviews of taxonomic and phenotypic analyses of lettuce cultivars were later presented **(DeVries and Van Raamsdonk, 1994; DeVries, 1997 and Mou, 2008)**. The crop comprises seven main groups of cultivars usually described as morphotypes. They are classified as butterhead lettuce *(var. capitata L. nidus tenerrima Helm) (Kopfsalat, Laitue pommé)*, crisphead lettuce *(var. capitata L. nidus jäggeri Helm) (Iceberg type, Eissalat, Batavia)*, cos lettuce *(var. longifolia Lam., var. romana Hort. in Bailey) (Römischer Salat, Laitue romaine)*, cutting lettuce *(var. acephala Alef., syn. var. secalina Alef., syn. var. crispa L.) (Gathering lettuce, Loose-leaf, Picking lettuce, Schnittsalat, Laitue à couper), stalk (Asparagus)* lettuce *(var. angustana Irish* *ex Bremer, syn. var. asparagina Bailey, syn. L. angustana Hort. in Vilm.) (Stem lettuce, Stengelsalat, Laitue-tige)*, Latin lettuce (without scientific name) **(Lebeda and al., 2007)**.

Figure 1. Different varieties of lettuce (www.pixabay.com, 2023).

According **Walley and al. (2017)** we distinguish 6 groups to which particular cultural aptitudes may correspond:

Lettuce that does not form a head

1/ Celtuce or asparagus lettuce: the plant forms a fleshy stalk whose pith is eaten after cooking and peeling **(Walley and al., 2017)**

2/ Cutting lettuce: develops a very full rosette of loose leaves. In the past, they were harvested by the handful, from dense seedlings in repeated passages. Today, they are harvested in crops to be sold as whole plants. Light in weight, it does not hold up well on the shelf (wilting due to evaporation).

Lettuces forming an apple

1/ Romaine lettuce: giving an oblong head, voluminous but less tight than in the following types. There are winter and summer types.

2/ Leaf lettuce or Batavia: apples with a flattened tendency, (leaves wider than long) and can be voluminous.

3/ butterhead lettuce: globular apples, more or less soft leaves. They are the most widespread, because they are best adapted to the oceanic climate.

4/ Fat lettuce: thick leaves forming a small apple, not very covered. Very good resistance to heat and to bolting.

*The renewal of varieties is currently very fast, partly due to a sustained search for genotypes resistant to the different (new) races of lettuce mildew (Bremia lactucae), to the Nasonovia ribis-nigri aphid, etc...

1.4. Morphological description of the lettuce

The lettuce is an annual plant of long days with short cycle, consumed (in Europe) in the the young state before the rise in seeds. It develops a rosette of whole leaves, capable or not, depending on the type, of forming an apple. After the formation of the apple, the stem undergoes an elongation and the apex evolves into a floral stem, **(Izdihar, 2022) (Figure 2).**

1.4.1 roots

The root system is pivotal (25 -30 cm) thick and hairy. In the plant, presence of white latex and, depending on the cultivar, of anthocyanins whose synthesis is favored by unfavorable cultivation conditions, especially low temperatures **(Izdihar, 2022) (Figure 2).**

1.4.2 Leaves

Lettuces offer an astonishing diversity, with smooth or blistered leaves, tender or crisp. The leaves can be erect, spread out, wavy, curled or deeply cut according to the varieties. Their color also varies: green, red or bicolored, the red color is due to a pigment, the anthocyane **(lafitte, 1985) (Figure 2).**

1.4.3 Flowers

The flowers of the lettuce plant are small and yellow in color. They are arranged in clusters at the tips of long, thin stalks that emerge from the center of the plant. The flowers are usually not very showy and are often overlooked. **(Izdihar, 2022) (Figure 2).**

1.4.4 Seeds

one counts 600 to 1000 seeds to the gram. The seed keeps for 3 to 4 years at a temperature of 10°C and a relative Humidity of 30%, but it remains very sensitive toexcess of moisture. The seeds have an inaptitude to germinate (dormancy) during 2 to 6 months after harvest. In principle, a cold storage with a high hygrometry during a few days is enough to lift the dormancy. It is admitted that the best seeds are those of 2 years old and that a lettuce that a lettuce goes to seed all the less quickly that its germination was fast **(Izdihar, 2022) (Figure 2).**

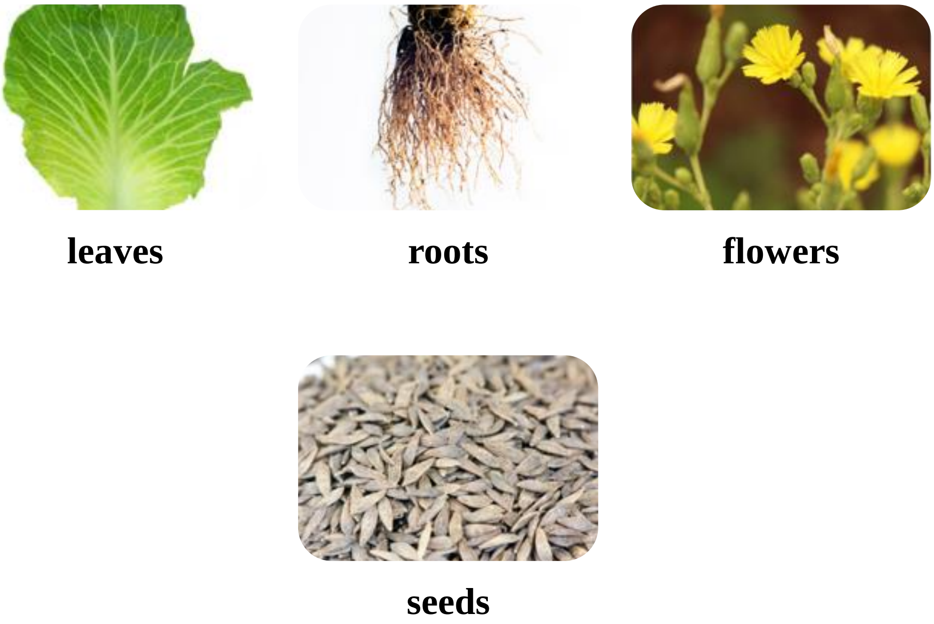

Figure2. Morphological description of the lettuce (www.canva.com, 2023).

1.5 The development cycle of lettuce

The development cycle of lettuce lasts about 45 days and takes place over a single year, with three distinct phases **(Sellam, 2020) (Figure 3)**.

1.5.1 Germination and emergence phase

The germination and emergence phases are the first stage in the life cycle of lettuce. It begins with the absorption of water by the seed, which triggers the process of germination.

During this phase, the seed swells and breaks open, allowing the embryonic plant to emerge. The first sign of emergence is the appearance of a small root, which grows downward into the soil in search of water and nutrients. This is followed by the emergence of the shoot, which grows upward towards the surface of the soil. The shoot then develops the cotyledons, which are the first leaves of the lettuce plant. **(Sellam, 2020).**

The germination and emergence phases are a critical stage in the growth of lettuce. The seed requires adequate moisture, oxygen and temperature to germinate and emerge successfully. Proper soil preparation and irrigation are essential to ensure the seed has access to the necessary nutrients and moisture.

Once the seedling emerges, it is important to provide it with adequate light and nutrients to promote healthy growth. As the seedling grows, it will enter the vegetative phase, where it will continue to develop leaves and stems before entering the reproductive phase.

Seed germination is rapid (2 to 3 days) **(Sellam, 2020).**

1.5.2 The vegetative phase

The vegetative phase is the second stage in the life cycle of lettuce, following the germination and emergence phase. During this phase, the lettuce plant grows leaves and stems and develops its root system, preparing for the reproductive phase.

The vegetative phase is characterized by the growth of the plant's above-ground structures. The leaves continue to grow and the stem elongates, allowing the plant to reach for sunlight. The roots also grow and branch out, providing the plant with water and nutrients from the soil. During the vegetative phase, the plant requires adequate nutrients, water, and light to promote healthy growth. Fertilization and irrigation are crucial to ensure the plant has access to the necessary nutrients and moisture. Additionally, the temperature and humidity of the growing environment should be carefully controlled to optimize growth. The length of the vegetative phase varies depending on factors such as temperature, light, and genetics. Generally, lettuce plants remain in the vegetative phase for several weeks before transitioning to the reproductive phase. Proper management of the vegetative phase is essential to ensure the plant is healthy and prepared for the reproductive phase, where it will produce flowers and seeds.

Forming a more or less closed apple, is the stage used for consumption and for marketing **(Sellam, 2020).**

1.5.3 The reproductive phase

*After the vegetative phase, the stem elongates and the flowering stem develops into a corymb. The plants are then 1 m to 1.5 m tall and bear numerous flower heads of 10 to 15 florets. All florets are ligulate and exhibit nearly synchronous development **(Pitrat and Foury, 2004, Zorrig, 2010; Valade, 2012).**

*The "seed" is formed of two parts, the seed body, hard, oblong, dark brown (black seeds) or creamy white (white seeds), and the beak bearing an aigrette or pappus that is removed during threshing. The bolting is more or less fast according to the climatic conditions and the genotypes.

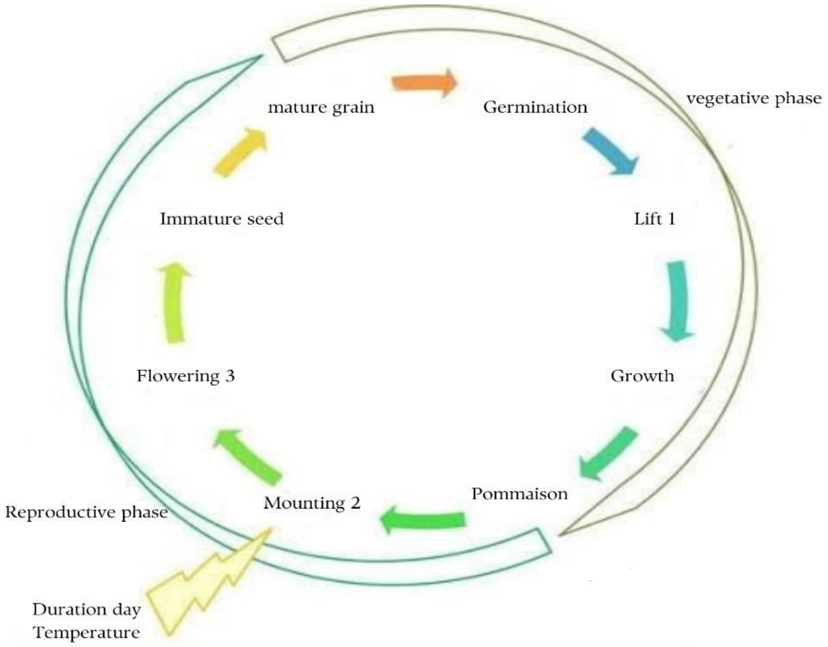

Figure 3. The development cycle of lettuce **(Huang et al., 2003**).

1.6 Climate condition and requirements of the crop

1.6.1. Climate condition

Lettuce is a very popular vegetable all over the world with a production of more than 21 million tons grown each year. Unfortunately, there are several difficulties with lettuce; it is sensitive to photoperiod and temperature. Excessive temperatures coupled with long photoperiods can lead to lose heads and wilting **(Thicoïpé, 1997)** or early bolting of lettuce

a-Temperature

Lettuce is a crop adapted to cool climates, with optimal growing temperatures ranging from 7°C at night to 24°C during the day **(Elattir and al., 2003 and Jenni, 2010)**. According to **Elmhirst (2006)**, germination temperature should be between 15°C and 18°C.

b-Illumination

The vegetative growth is all the more rapid as the days are long (13 hours of luminosity per day and more) and the optimum temperature at 20°C); but it is also possible under weak lighting and low temperatures according to the cultivars **(Verolet, 2001).**

c- Sunshine the optimums during the culture depend on the stage of development, the intensity of the illumination and the variety **(Elmhirst, 2006).**

d-Humidity

Too much humidity, especially when it is cool, favors the condensation of steam on the leaves and the appearance of diseases such as Botrytis grey mould **(Elmhirst, 2006).**

1.6.2 Requirements of the crop

a- Soil requirement

Lettuce *(Lactuca sativa*) is sensitive to asphyxiation and is nevertheless adapted to a wide variety of soils (sandy loam to clay loam). Moreover, it prefers soils with a high organic matter content. The optimal pH is 6.7 to 7.2. An acidic soil (pH<6) or beating is very unfavorable to the production of lettuce **(Collin and Lizot, 2003).**

b- Water requirement

Lettuce *(Lactuca sativa*) is moderately sensitive to water stress; one or two irrigations of 25 to 30 mm can be implemented at the beginning of flowering and during the seed filling stage. Under cover, irrigation will be easier to manage with the drip technique **(Collin and Lizot, 2003).**

c- Requirement in fertilizing elements

According to **Nicot (2010),** fertilization can act at three levels. First, the minerals absorbed by the roots will be used directly in the cells of the plant tissues. Fertilization can act at a second level which is the natural defense system of the plant of certain toxic compounds for bio-aggressors, as well as the reinforcement of cell walls. Finally, fertilization has an effect on the architecture of the plant. A strong fertilization leads to a strong vegetative growth, which generates in parallel a more humid climate in the greenhouse which influences the development of the diseases.

1.7 Planting and growing lettuce

1.7.1 Soil preparation

is done in early May, just before planting, to ensure better growth and recovery of the lettuce. The soil is first worked with a rototiller. Then, depending on the condition of the terrain, a pass with a harrow (if the soil is dry and doesn't break up well) or a rotavator (not on wet soil) will help bury the manure.

1.7.2 Planting

Planting can also be done through direct seeding in open fields. The optimal time for seeding is from March 1 to 31 in the southern region and from mid-March to mid-April in the northern region, on well-drained and warmed soil. The seeds should be sown at a depth of 1-2mm, with a density of 12 to 15 seeds per linear meter, and a spacing of 50 to 60cm. Good seed-to-soil contact can be ensured by using a press wheel at the back of the precision seeder's sowing elements, and rolling may be done behind the seeding if necessary. At the 5/6 leaf stage, thinning should be done, aiming to keep one plant every 10-15cm **(Benmadani and Belouadah, 2018).**

1.7.3 The plantation

The planting can be done in open field or under shelter. To succeed in the seeding, sow in fresh potting soil under shelter, and cover with plastic film for the first few days. Optimal germination is obtained at a temperature of 15 to 20°C and should occur within 2 or 3 days. An essential precaution is to harden the plants quickly from the stage of 2/3 leaves by removing the plastic film and opening the shelters. Otherwise, the plants can become fragile, wilt or even die. Mulching during planting preserves soil structure, limits evaporation, and prevents weeds from growing. The planting is done when the young roots emerge from the pot, which corresponds approximately to the stage of 4/6 leaves of the lettuce. Then, 5 plants per meter are planted **(Collin and Lizot, 2003).**

1.7.4 Fertilization

Maintaining soil fertility through respect for rotations, appropriate additions of organic amendments, and quality soil management should ensure plant nutrition. A global reflection is necessary tointegrate soil richness (analysis), potential supply of fertilizing elements by organic amendments,and the possible effect of the cultural precedent. Lettuce’s nitrogen needs are quite low and can be covered by the residue from a demandingcrop. The nitrogen residue from previous crops is taken into account, to which a supplementis added. This supplement can be in the form of composted manure **(Collin and Lizot, 2003)** There are 2 types of mineral fertilizers:

-Base fertilizers: These are fertilizers containing potassium and phosphorus that should be incorporated into the soil at least 15 days before sowing.

-Top dressing or maintenance fertilizers: These are fertilizers containing nitrogen such as urea, ammonium sulfate and monobasic ammonium phosphate (MAP or DAP). The main pests and control methods for lettuce cultivation **(Collin and Lizot, 2003).**

1.7.5 Mulching and irrigation

A biodegradable mulch (1.40m wide), covered on the sides, is laid using a straw blower. The planting beds will have a width of 1.20m. Lettuce is moderately sensitive to water stress: one or two irrigations of 25 to 30 mm can be implemented at the beginning of flowering and during the seed filling stage **(Collin and Lizot, 2003).**

1.8 Importance

1.8.1 The most lettuce producing countries around the world

One of the statistics presented in 2013 indicates that the world produced 24.0 tons of lettuce, knowing that China produced 13.5 tons of it, or more than half of the global production. Noting that all of China's lettuce production is consumed locally and it is not classified among the plant exporters that Spain led with the United States of America as the largest lettuce exporters in the world. The lead among countries in production ranged from one year to the next, due to the spread of its cultivation in the world with its various varieties, such as root lettuce, which is much desired in Egypt and China, while the butter variety is preferred in Europe and the Roman type is the most preferred in the countries of the Mediterranean basin. Let China, the giant coming from the East, remain the most lettuce-producing country around the world **(Yasser, 2022).**

1.8.2 List of countries by lettuce production

Rumors were circulated among the ancient Egyptians and Romans that lettuce was related to sexual potency, and settlers in South America considered it linked to the treatment of smallpox. However, its popularity in preparing various salad dishes doubled its cultivation, leading to an increase in its production worldwide.

Below is a list of countries by lettuce production:

1. China, with an annual production of 13.5 tons.
2. The United States of America, with an annual production of 3.5 tons.
3. India: with a production of 1.1 tons annually.
4. Spain, with a production of 0.9 tons annually.
5. Italy, with a production of 0.8 tons annually **(Yasser, 2022).**

1.8.3 Lettuce cultivation in Algeria

According to FAO (2019) Algeria is the main producer of lettuce in the region, and countries like Tunisia, Libya, and Morocco import lettuce from Algeria. The total production of lettuce in Algeria during the year 2019 was about 149,000 tons. The most productive state was Tipaza with a total production of about 38,000 tons, followed by Boumerdes with a total production of about 20,000 tons, and Bejaia with a total production of about 17,000 tons **(FAO, 2019).** Lettuce is cultivated in several regions in Algeria, including the provinces of Oran, Tipaza, Algiers, and Tizi Ouzou. Lettuce is widely grown in the coastal areas of Algeria due to the humid and mild climate. Many agricultural companies in Algeria supply lettuce to local markets, including the wholesale market in the Algerian capital.

1.9 The components of lettuce

The lettuce is a good source of high dietary fiber (1.1 g/100 g, FW), vitamin A (166 lg/ 100 g, FW), folate or vitamin B9 (73 lg/100 g, FW), vitamin C (4 mg/100 g, FW), vitamin K (24 lg/100 g), and phenolic compounds. Since lettuce is very low in calories (10 kcal [60 kJ]/100 g, FW), it is often prescribed for weight loss programs **(Niederwieser, 2001).** Consumption of lettuce is reported to improve health benefits such as its higher dietary fiber content that aids in digestion. The higher b-carotene and lutein content in lettuce is associated with reducing risk of cancers, cataracts and heart disease and stroke **(USDA, 2004)**. Phenolic compounds in plants are responsible for antioxidant scavenging properties. Carotenoids possess antioxidant capacity and vitamin C, the water-soluble antioxidant, also shows antioxidant properties **(Lopez and al., 2014).** Some types of lettuce are sources of vitamin A, niacin, riboflavin, thiamine, Ca, Fe, K, Mn, Se and b-carotene **(Bunning and al., 2010).**

Chapiter II: General description of common mallow

2.1 Common mallow history

Malva sylvestris is a genus of about 25–30 species of herbaceous annual, biennial and perennial plants in the family of *Malvaceae* (of which it is the type genus), one of several closely related genera in the family to bear the common English name mallow. The genus is widespread throughout the temperate, subtropical and tropical regions of Africa, Asia and Europe **(Davis, 2010).** The word "mallow" is derived from Old English "malwe", which was imported from Latin "malva", which originated in Ancient Greek (malakhē) meaning "yellow" or Hebrew (malúakh) meaning "salty"**(Davis, 2010)**. A number of species, previously considered to belong to Lavatera, have been moved to Malva. The leaves are alternate, palmately lobed. The flowers are from 0.5–5 cm diameter, with five pink or white petals. The color mauve was in 1859 named after the French name for this plant.

This plant is one of the earliest cited in recorded literature. Horace mentions it in reference to his own diet, which he describes as very simple: "Me pascunt olivae, me cichorea, me malvae" ("As for me, olives, endives and mallows provide sustenance"). Lord Monboddo describes his translation of an ancient epigram that demonstrates *malva* was planted upon the graves of the ancients, stemming from the belief that the dead could feed on such perfect plants. Mallow, which grows wild in the middle east, is widely used as a source of nourishment in wartime and periods of austerity **(Taylor, 2009).**

2.2 Botanical classification of *Malva*

- ✓ **Kingdom:** *Plantae* (Plants)
- ✓ **Subkingdom:** *Tracheobionta* (Vascular plants)
- ✓ **Super division:** *Spermatophyta* (Seed plants)
- ✓ **Division:** *Magnoliophyta* (Flowering plants)
- ✓ **Class:** *Magnoliopsida* (Dicotyledons)
- ✓ **Subclass:** *Dilleniidae*
- ✓ **Order:** *Malvales*
- ✓ **Family:** *Malvaceae* (Mallow family)
- ✓ **Genus:** *Malva* (mallow)
- ✓ **Species:** *Malva sylvestris* (common mallow) **(Krebs, 1994).**

2.3 Botanical description

Malva sylvestris L. is a biennial herbaceous plant with fleshy taproot, as may be perennial by underground buds, belonging to the family *Malvaceaes* **(Flores, 2011)**, it has characteristics that are summarized in table 01**:** and figure 4.

Table 01: The botanical appearance of the different parts of *Malva sylvestris* L **(Flores, 2011).**

The part of The plant	Botanical aspect	
The root	The main root is fusiform, white in color, and rich in mucilage, while the others are discrete rootlets	
The stem	Round and hairy, most often ropy and woody at the base, can reach from 2 to 70 cm long	
The leaves	Large, dark green and purple at the base, long-stalked, with 3 to 7 palmately veined lobes, each rounded with a toothed edge	
The flowers	Purple pink, carried by short pedicels and grouped in bouquet of two or more. The calicule is formed of three short, lanceolate pieces followed by a calyx with five sepals, pubescent, welded with triangular divisions, then comes the corolla with five purple-pink petals veined with three darker branched stripes and purple	
The fruit	At maturity the fruit is incompletely enveloped by the slightly accentuated calyx and the fruiting stalks remain erect	

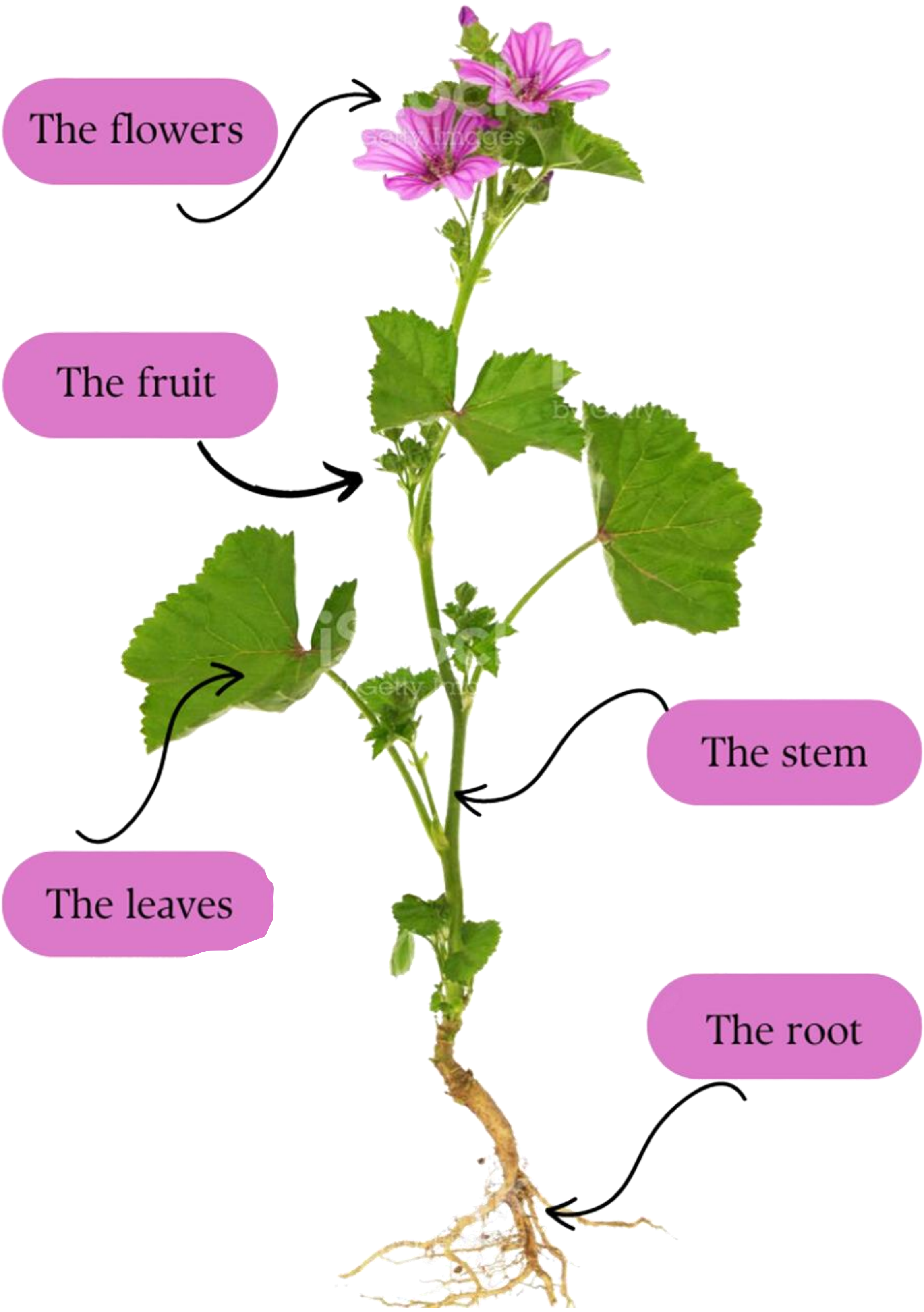

Figure 4. A picture showing all parts of the mallow plant (www.istockphoto.com, 2023).

2.4 International vernacular names

English: Blue Mallow, High Mallow

Arabic: خبازة برية:

French: Mauve des bois, Grande Mauve, mauve sauvage, fromageon

German: Malvenblüten, Malven blätter, Mauretanische Malve

Italian: Malva selvatica

Spanish: Malva común

Greek: Μολόχα

Turkish: Ebegümeci

Russian: Мальва лесная (maljva lesnaya): **(Zeghmar S., Ghoul K., 2019)**.

2.5 The main chemical constituents of *malva sylvestris*

malva contains many constants, some of which are mentioned in the following table.:

Table 02: Main chemical constituents of *Malva sylvestris* (Ghédira and Goetz, 2016) .

Flowers	
Chemical families	Chemical constituents
Mucilage (3.8- 7.3%)	Neutral and acidic polysaccharides of P.M. between 1.3 and 1.6. 106. By hydrolysis, provide galactose, rhamnose and glucuronic and galacturonic acids.
Anthocyanosides and anthocyanidols	Malvidin, malvine, delphinidin
Flavonoids	Genistein, myricetin, apigenin derivatives, querceti and kaempferol.
Other	Tannins and coumarins.
Leaves	
Chemical families	Chemical constituents
Mucilage (6,0- 7,2%)	Acidic polysaccharides with MW between 11,000 and 106 providing by hydrolysis of glucose, rhamnose, arabinose and galacturonic acid.

Flavonoids	Gossypin (gossypetin 3-sulfate-8-O-β-D-glucoside), hypolaetin 3′-sulfate, hypolaetin 4′-methyl ether 8-O- β - D - glucuronopyranoside, hypolétine 8-O- β - D - glucuronopyranoside and isoscutellarein 8-O- β - D - glucuronopyranoside
Phenolic derivatives (386,5 mg/g)	4-hydroxybenzoic, 4-methoxybenzoic, 4- hydroxydihydro-cinnamic, ferulic and Tyrosol.
Organic acids	Acides Oxalique, Malonique, Fumarique Succinique, Benzoïque, Glutarique, Phenylacetique
Other	Coumarins, Tannins, Malvones

2.6 Use of Common Mallow

Malva sylvestris, commonly known as common mallow, is a plant that has a variety of uses. Here are some of them:

2.6.1 Medical use

Malva sylvestris has been used in traditional medicine to treat a variety of ailments, including respiratory problems, digestive issues, and skin conditions. The plant contains mucilage, which has a soothing effect on the throat and can help alleviate coughs and sore throats. It is also said to have anti-inflammatory properties and can be applied topically to help relieve skin irritation **(Brady and Weil, 2010)**.

2.6.2 Culinary use

The leaves and young shoots of *Malva sylvestris* are edible and can be used in salads, soups, stews, and other dishes. They have a mild flavor and are rich in vitamins and minerals **(Brady, and Weil, 2010)**.

2.6.3 Herbal tea

The flowers and leaves of *Malva sylvestris* can be brewed into a tea that is said to have a soothing effect on the digestive system and can help relieve constipation **(Brady, and Weil, 2010)**.

2.6.4 Dye

The plant can be used to produce a yellow dye that was traditionally used to dye textiles **(Brady, and Weil, 2010)**.

2.6.5 Animal feed

Malva sylvestris can be used as a source of food for livestock and can be added to their diet to provide additional nutrients **(Brady and Weil, 2010)**.

2.6.6 agriculture use

Malva sylvestris, including has several potential uses in agriculture **(Brady and Weil, 2010)**.

a-Soil improvement

Malva sylvestris is a nitrogen-fixing plant, meaning that it has the ability to convert atmospheric nitrogen into a form that can be used by plants. As a result, it can help improve soil fertility and reduce the need for synthetic fertilizers **(Brady and Weil, 2010)**. The nature and properties of soils. Prentice Hall **(Pujol and al., 2017).**

Overall, the use of common mallow water extract as a natural plant growth regulator and bio-stimulant appears promising. However, more research is needed to fully understand its mechanisms of action and to optimize its use in different plant species and growth conditions **(Durgesh, Vijay and Raffaella, 2019).**

b-Weed control

Although *Malva sylvestris* is often considered a weed itself, it can also be used as a natural method of weed control. By planting *Malva neglecta* in areas where other unwanted plants are present, it can outcompete them for nutrients and light, eventually choking them out **(Holm, and al 1991).**

c-Livestock feed

As mentioned previously, *Malva sylvestris* can be used as a source of food for livestock. Its high nutrient content and palatability make it an attractive option for farmers looking to supplement their animals' diets **(Mekoya, Oosting and al., 2007).**

d-Companion planting

Malva sylvestris can be planted alongside other crops as a companion plant. It has been shown to improve the growth and yield of certain crops, including tomatoes and peppers **(Bonanomi, and al., 2010).**

-Pollinator habitat

The flowers of *Malva sylvestris* are attractive to bees and other pollinators, making it a valuable addition to any agroecosystem **(Biesmeijer and al., 2006).**

Part 2

Experimental part

Chapiter I: Material and methods

1.1 Presentation of the workplace

The experiment was conducted at the experimental agricultural site at the University of August 20, 1955 in Skikda, located in the municipality of Al-Hadaik, which is 3 km from the center of the state. The experimental site is located at the following geographical coordinates: 36° 49′ 32.16″ N, 6° 53′ 17.88″ E **(Figure 5).**

The climate of the experimental site is characterized by its mild temperatures and moderate rainfall, with relatively consistent weather patterns throughout the year.

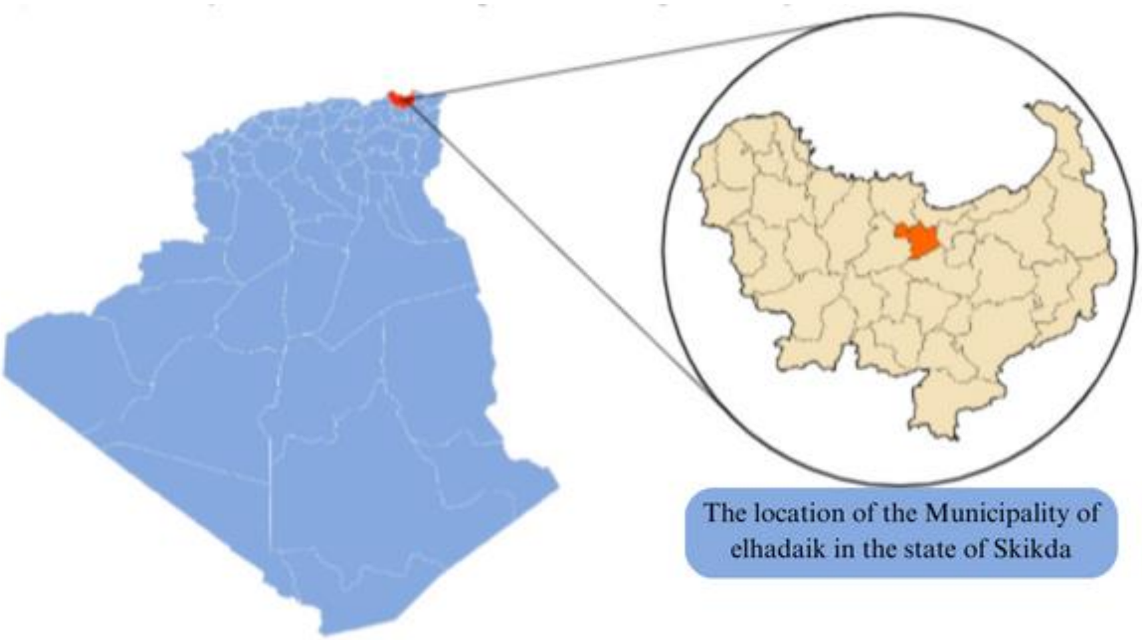

Figure 5. Geographical location map of the study **(www.maps.google.fr , 2023).**

1.1.2 The climate

The climate of El hadaik Mediterranean, Hot summer climate, the city's yearly temperature is 19.02ºC and it is -0.98% lower than Algeria's averages. El hadaik typically receives about 41.87 millimeters (1.65 inches) of precipitation and has 91.28 rainy days (25.01% of the time) annually **(www.climatsetvoyages.com, 2023).**

1.1.3 The soil

the edaphic characteristics of our study plot are regrouped in **(Table 3).**

Table 03. Chemical and physical characteristics of study plot.

Analyze	Values
PH	**7.55**
CE (mmhos/cm)	**1.348**
Organic material (٪)	**2.72**
Clay (%)	**27.3**
Silt (%)	**10.33**
Coarse sand (%)	**54.57**
Fine sand (%)	**7.81**

1.2 Plant material

Butterhead lettuce, is a type of lettuce that is known for its tender, buttery leaves and mild, sweet flavor. Here are some of the characteristics. Generally, in the winter and spring period

(Walley and al., 2017).

-It is a variety very appreciated by the farmers

-It is a seasonal crop where the harvest will take place. Generally, is the winter and spring period.

Butterhead lettuce has a round, compact head with leaves that are soft, slightly crinkly, and pale green in color. The leaves of butterhead lettuce are very soft Butterhead lettuce has a mild, sweet flavor that is slightly nutty and buttery. Butterhead lettuce is low in calories and high in vitamins A and C, making it a healthy choice for salads and other dishes. Butterhead lettuce prefers cooler growing conditions and is often grown in the spring and fall. It is also sensitive to heat and can bolt (produce flowers and seeds) in hot weather.

Sowing date: the date of sowing of the Butterhead lettuce is varied according to the climatic conditions (the temperature essentially) therefore we can sow all the time but the essential to the temperature between 10 and 20 °c.

Sowing depth: the seeds are typically sown at a depth of about 1/4 to 1/2 inch (6 to 12 mm) in well-prepared, moist soil.

Sowing density: As a general guideline, Butterhead lettuce is typically sown at a density of 10 to 15 seeds per linear foot of row or 8 to 12 seeds per square foot when using a broadcast or wide row planting method. This can result in a final plant population of approximately 8 to 12 plants per square foot after thinning or transplanting.

1.3 Methodology

1.3.1 Preparation of the study plot

Lettuce requires rich, moisture-retaining soil free of stones, so we cleaned the field of the previous plant debris before plowing and tilling the soil to prepare it for planting the crop

It is necessary to create favorable and identical growing conditions between each plant to

plant in order to succeed in cultivation. Thus, a poorly controlled soil structural condition at the beginning cannot be corrected by fertilization or irrigation. The following figures (Figures 6 and 7) show the state of the experimental plot before and after preparation with manual tools.

Figure 6. Plowing, first step before transplanting lettuce.

Figure 7. Trace the blocks before transplantation.

1.3.2 Amendment

After preparing soil we spread the peat **(Figure 8).** The latter has the following physicochemical characteristics: **(Table 4).**

Table 04. Characteristics of peat.

Characteristic	Values
Dry matter in the raw product, approx. %	35
Organic matter in the raw product, approx. %	32
Water retention capacity at pF=1, approx. %	775
Dry bulk density, approx. g/l	80
Conductivity, ms /m	20
PH (water)	5

Figure 8. Mix the manure well into the soil to homogenize.

1.3.3 Transplanting seedlings

The seedlings were planted on March 26, th 2023, with a distance of 20 cm between each seedling and 40 cm between each row, with a density of 10 seedlings in 2 meters **(Figure 9).**

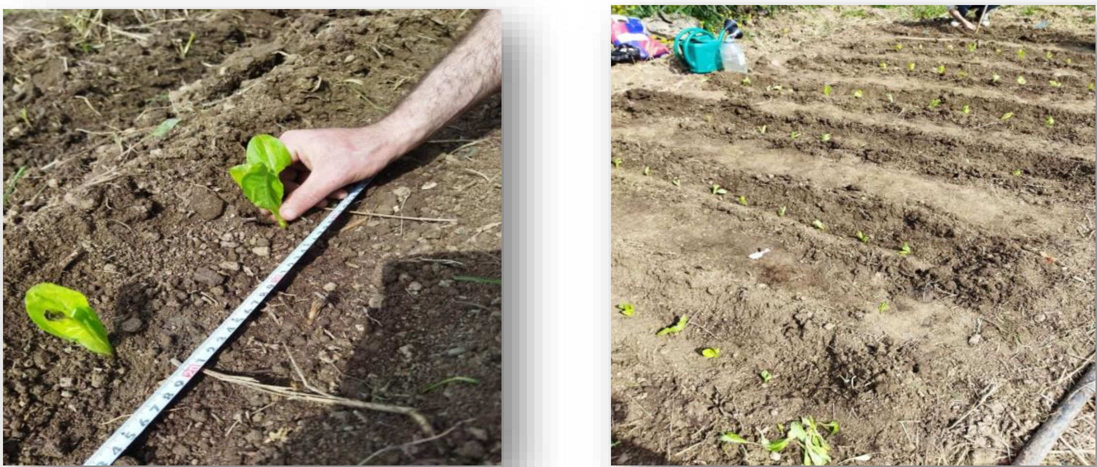

Figure 9. Lettuce plantation.

1.3.4 Irrigation

The irrigation water used in our experiment is that of the water of the department Agronomy (skikda) **(Figure 10)** and mallow extract.


Figure 10. irrigation of lettuce.

1.3.5 Preparation of the mallow extract

The preparation of the Mallow solution is the most important initial part, it is necessary to follow the steps well to avoid all risks of errors, the use of water with a neutral pH is essential for the experiment. The mallow extract used as irrigation water for our work is obtained after macerating 1 kg of leaves in 10 liters of tap water for one week away from light eroding a cold place mixing daily the solution **(Bartheleny and Fick, 2014).** After this period the mixture was filtered to obtain an aqueous solution **(Figure 11)** We make sure to keep the solution in a cool place that is not exposed to sunlight in order to avoid any possible reaction that may occur and change the composition of the solution.


Figure 11. Preparation of the mallow extract.

We brought a plastic container, avoiding iron barrels that oxidize very quickly in contact with the liquid, which may change its chemical composition. We put fresh mallow leaves in a container, then we add 5L of water. After that, we let it dissolve in water for three days, stirring the mixture from time. to time to ensure complete dissolution of the plant leaves.

***Concentrations:**

For the concentrations used in our experiment, we used three different concentrations:

The first is 100% concentrated: (1g\10ml)

After obtaining the mallow leaves solution, we use it directly without any addition or modification to its components.

The second is 50%: (1g\20ml)

We get it after diluting the first solution, by adding 5 liters of water to 5 liters of mallow leaves solution, taking into account the use of the same water used in the preparation of the mallow extract in the process of dilution.

The third is 0%:

We use only water without any additives.

1.3.6 Experimental set-up of the trial

We prepared a piece of land with an area of 3 square meters. This area was cleared of weeds and aerated by turning the soil. Then we divided it into three parts (three valleys), separating them according to the irrigation material from right to left. The first is irrigated with ordinary tap water (1). The second is irrigated with a diluted aqueous extract of the mallow plant at 50% (2). The last one is irrigated with an aqueous extract of the mallow plant (3) **(Figure 12).**

(1). Test 1**, (2).** Test 2**, (3).** Test 3

Figure 12. The divide of lettuce rows.

1.3.7 Parameters studied

During this study, we monitored the evolution of the plant in terms of length and height. Measurements were taken twice a week throughout the study period (during the vegetative cycle of the crop). Then, after harvesting, we measured the length and width of the roots and the weight of each plant **(Figure 13 and 14).**

Figure 13. Measures of growth.

At the end of the experiment, have calculated the daily growth rate by the following formula:

Daily growth rate = last measurement – previous measurement / the number of days.

Figure 14. Harvesting of lettuce plant.

1.4 Statistical analysis

We performed a principal component analysis to reorganize the data set contemning correlated variables into groups in order to highlights the existence of a significant difference between treatments. This analysis was supported for the ANOVA in order to detect the existence of significance for all the parameters studied using the reversion 3.5.3 software.

Chapiter II: Results and discussion

1.Length development

The **table 5** gives as the average weekly measurements of the repetitions of the three tests performed as well as the stand deviation (ð) and the coefficient of variant (cv) The obtained results show the length (cm) in terms of time (days) shown in the chart below **(Figure16).**

Table 5. Results of length development of lettuce.

Date	Test1		Test2		Test3	
	average±ð	cv%	average±ð	cv%	average±ð	cv%
09/04/2023	7,9±1,07	13,63%	7,34±1,40	19,16%	7,11±0,85	8,35%
13/04/2023	9,51±1,04	11,02%	8,04±1,40	17,49%	7,43±0,84	8,84%
16/04/2023	9,75±0,82	8,42%	8,44±1,23	14,67%	8,83±0,75	11,73%
19/04/2023	10,33±0,98	9,51%	8,94±1,36	15,21%	9,43±0,55	17,03%
23/04/2023	11,08±0,73	6,64%	9,8±0,92	9,46%	10,08±1,06	9,43%
26/04/2023	12,68±1,06	8,36%	11,9±1,31	11,08%	11,66±0,75	15,49%
30/04/2023	16,16±0,68	4,22%	13,9±1,42	10,27%	13,5±1,67	8,06%
02/05/2023	20,08±0,58	2,91%	18,7±1,20	6,46%	15,66±1,08	14,50%

On the first day, all the tests were initiated with watering solutions. We observed a similar start for all three experiments, with a slight advantage for Test 1, which received a 100% solution.

From the starting day, (13/04/2023), Test 1 continued to outperform both Test 2 and Test 3, demonstrating the superiority of the 100% solution. However, Test 2 and Test 3 progressed at the same rate. This can be attributed to precipitation that occurred on the same day, diluting the concentration of the solution used for irrigating Test 2. In contrast, Test 1 remained unaffected and maintained its original pace due to the higher concentration of the solution.

Following that, we observed moderate development in all three experiments. Test 1 consistently showed superior growth, while Test 2 and Test 3 exhibited similar progress. This continued to be influenced by precipitation and changes in concentrations.

By the day (26-04-2023), we clearly noticed a rapid and significant growth in height across all three Tests, coinciding with the cessation of precipitation **(Appendix 1)**. From where we record an accelerated rate of growth of test 1 and 2 and a slowing down of even stoppage of growth of test 3 **(Figure 15)**. which was irrigated solely with water. This can be attributed to the concentrations returning to their original state after the precipitation had stopped. These results can be justified by the analysis of the ANOVA **(Appendix 2)**, which has provided us with a highly significant difference among the three tests. The superiority consistently lies in favor of Test 1 at a significance level of **α ≥5%** this can also be confirmed by the low coefficient of variation and less than 15% for all the measurement taken **(Table 5)**.

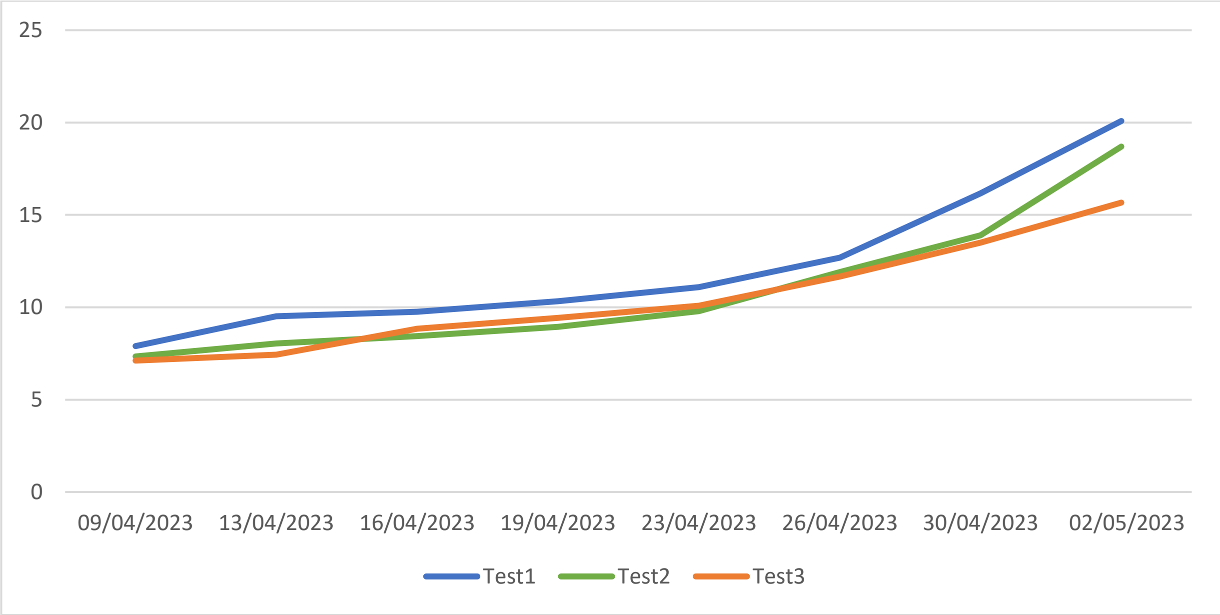

Figure 15. Lettuce leaf length growth chart.

2.Width development

The obtained results show the width (cm) in terms of time (days) shown in the chart below **(Figure 16).**

The **Table 6** groups the average values of repetitions and the tests carried out for the width parameter of the lettuce plans as well as the stand deviation and the coefficient of variant.

Table 6. Results of width development of lettuce.

Date	Test1		Test2		Test3	
	average±ð	cv%	average±ð	cv%	average±ð	cv%
09/04/2023	10,35±1,84	17,78%	9,52±1,82	19,17%	8,35± 1,68	20,17%
13/04/2023	11±2	18,18%	11,6±2,59	22,37%	10,56±1,42	13,49%
16/04/2023	12,72±2,64	20,81%	13±2,21	17,05%	11,68±1,14	12,08%
19/04/2023	14,42±2,28	15,80%	13,8±2,26	16,41%	12,67±0,83	6,5%
23/04/2023	16,42±2,45	14,95%	15,78±1,84	11,68%	14,38±1,26	8,77%
26/04/2023	17,75±0,96	5,42%	17,8±1,62	9,12%	16,12±1,66	10,31%
30/04/2023	20,78±1,34	6,49%	20±2,29	11,45%	18,75±2,39	12,74%
02/05/2023	21,28±0,99	4,66%	21,07±1,48	7,04%	19,31±2,20	11,40%

On the first day of the watering process (09/04/2023), we note that preference was given to Test 1 with a concentration of 100 percent, after which preference was given to the diluent Test 2, while Test 3, watered with tap water, maintained the same level under each of 1 and 2, after which we noticed a continuous fluctuation in preference until the end of the treatment between Test 1 and 2 with an apparent difference between Test 1 and 2 and Test 3 .Indeed the coefficient of variation remains below 20% , even though the analysis of the ANOVA did not reveal a significant difference between the treatments at a significance level of **$\alpha \geq 5\%$ (Appendix 2).**

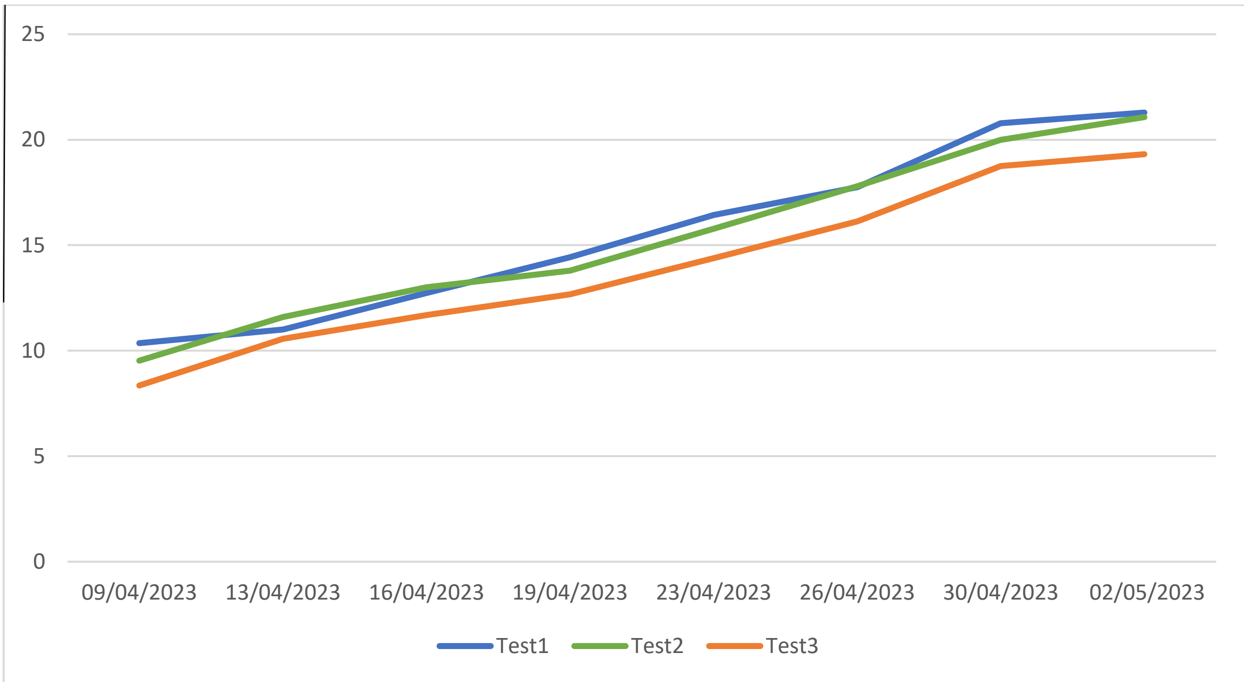

Figure 16. Lettuce width growth chart.

3.Length growth rate

We obtained the results shown below **(Figure 17 and Table 7)** by subtracting the newly obtained length after measurement from the old length for each lettuce head from each line until the final length.

Table 7. Results of length growth rate of lettuce leaves.

Date	Test1		Test2		Test3	
	average±ð	cv%	average±ð	cv%	average±ð	cv%
09/04/2023	0,38±0,07	20,32%	0,23±0,08	36,28%	0,07±0,42	57,38%
13/04/2023	0,47±0,21	46,09%	0,29±0,14	49,64%	0,21±0,72	33,27%
16/04/2023	0,25±0,09	36,01%	0,23±0,14	63,23%	0,19±0,81	40,83%
19/04/2023	0,45±0,19	43,93%	0,48±0,20	42,73%	0,59±0,29	49,54%
23/04/2023	0,38±0,15	39,85%	0,42±0,19	44,79%	0,45±0,27	60,95%
26/04/2023	0,88±0,20	23,45%	0,53±0,18	35,06%	0,43±0,28	65,15%
30/04/2023	1,33±0,13	10,43%	1,56±0,39	25,11%	0,67±0,44	65,55%

Starting from the first watering day, there was a superiority of "Test 1"(100%), followed by "Test 2" (with 50%), and finally "Test 3" (water). However, from 13/04/2023, there was a decline in the growth rate for both "Test 3" and "Test 2" due to the occurring shedding, which resulted in a decrease in the concentration of the solutions. The growth rate remained unstable during the following days due to the continued shedding.

On the other hand, starting from 26/04/2023, we noticed some noticeable changes that make both "Test 1" and "Test 2" better than "Test 3," with a slight advantage for "Test 2." This change is likely attributed to the cessation of shedding and the stabilization of the concentration of the solutions.

Based on the available information, it appears that "Test 1" and "Test 2" were more effective in achieving the desired results compared to "Test 3," especially after the cessation of shedding and the stabilization of the concentration of the solutions and these results are confirmed statistically by the ANOVA **(Appendix 2)** which provided us with highly significant difference between the three experiments.

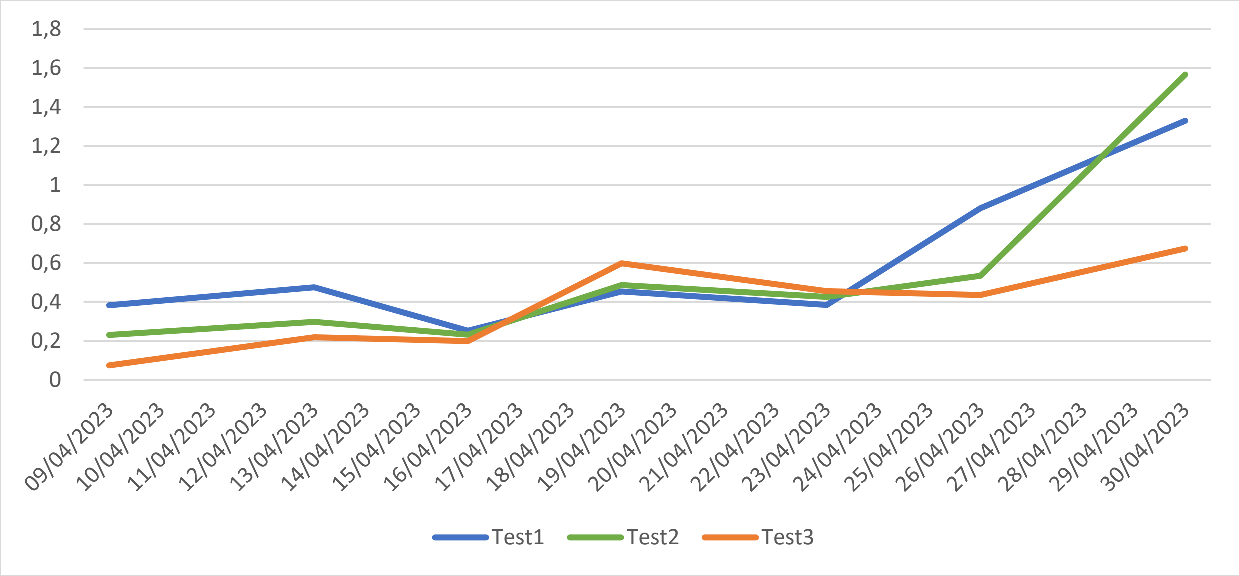

Figure 17. Lettuce leaf length growth rate chart.

4.Width growth rate

We obtained the results shown below **(Figure 18 and Table 8)** by subtracting the newly obtained width after measurement from the old width for each lettuce head from each line until the final width.

Table 8. Results of width of lettuce leaves.

Date	Test1		Test2		Test3	
	average±ð	cv%	average±ð	cv%	average±ð	cv%
09/04/2023	0,31±0,13	45%	0,14±0,05	38,35%	0,07±0,28	47,93%
13/04/2023	0,46±0,18	40,31%	0,46±0,22	49,31%	0,21±0,32	67,86%
16/04/2023	0,63±0,19	31,34%	0,18±0,06	32,92%	0,19±0,25	76,70%
19/04/2023	0,47±0,22	46,76%	0,47±0,20	42,47%	0,59±0,23	58,19%
23/04/2023	0,51±0,20	38,92%	0,62±0,24	39,71%	0,45±0,36	69,83%
26/04/2023	0,50±0,22	45,42%	0,485±0,22	45,40%	0,43±0,29	50,03%
30/04/2023	0,46±0,15	32,94%	0,20±0,07	37,51%	0,67±0,19	74,03%

Initially, we noticed that "Test 1" had the superiority, followed by "Test 2" and water in the last. However, after the shedding, "Test 2" significantly decreased and remained equal to "Test 3" during the following days, unlike "Test 1," which maintained its leading position. This can be attributed to its resistance to rain due to the high concentration of the solution, and that’s statistically proved by analysis of the ANOVA which has provided us with a significant difference among the three tests. **(Appendix 2)**

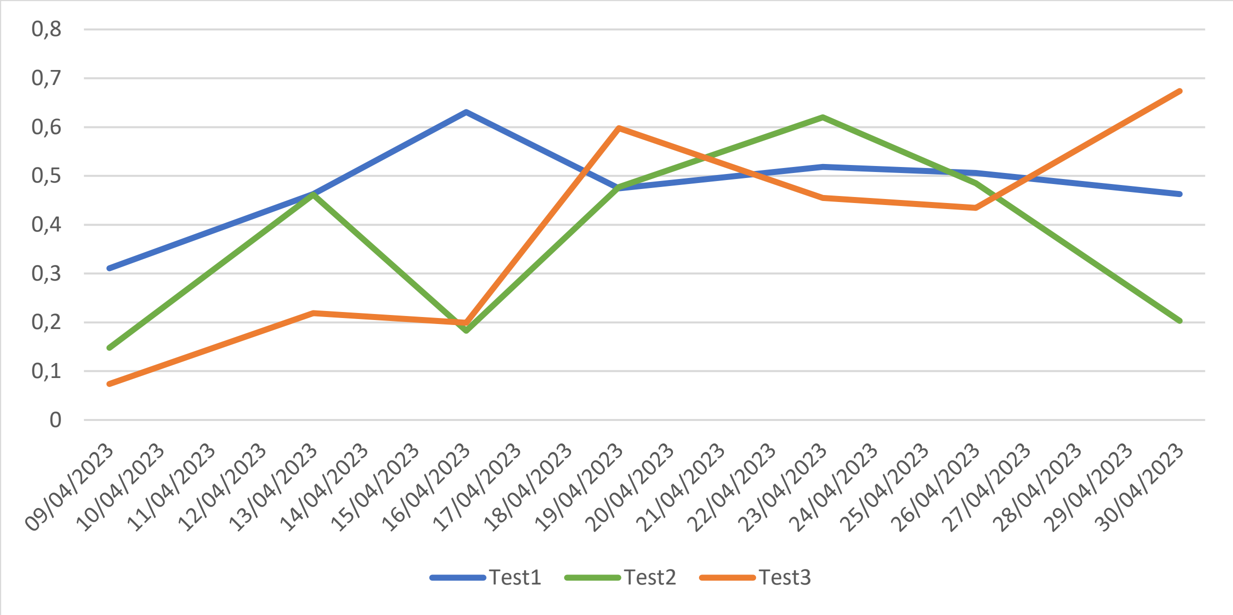

Figure 18. Lettuce leaf length growth rate chart

5.Final roots width (the clump of roots)

We obtained the following results by measuring the width of plant roots for each lettuce head individually after ensuring their maturity and reaching the flowering stage. The means obtained for the three tests are summarized in the **Table 9** and represented graphically by the histogram in **Figure 19**.

Table 9. Results of final roots width.

	Test1		Test2		Test3	
	average±ð	cv%	average±ð	cv%	average±ð	cv%
weight	75,02±14,50	19,33%	85,09±32,17	37,81%	76,58±24,47	31,95%

As shown in the graph, there is almost no significant difference in terms of root width, except that we noticed a considerable superiority of Test 2 over Test 1 and a close similarity in width with Test 3. This means that the root width of Test 1 was the smallest among the three experiments. Additionally, the analysis of ANOVA revealed a significant difference which gives preference to Test 3 at a significance level of alpha ≥ 5% **(Appendix 2).**

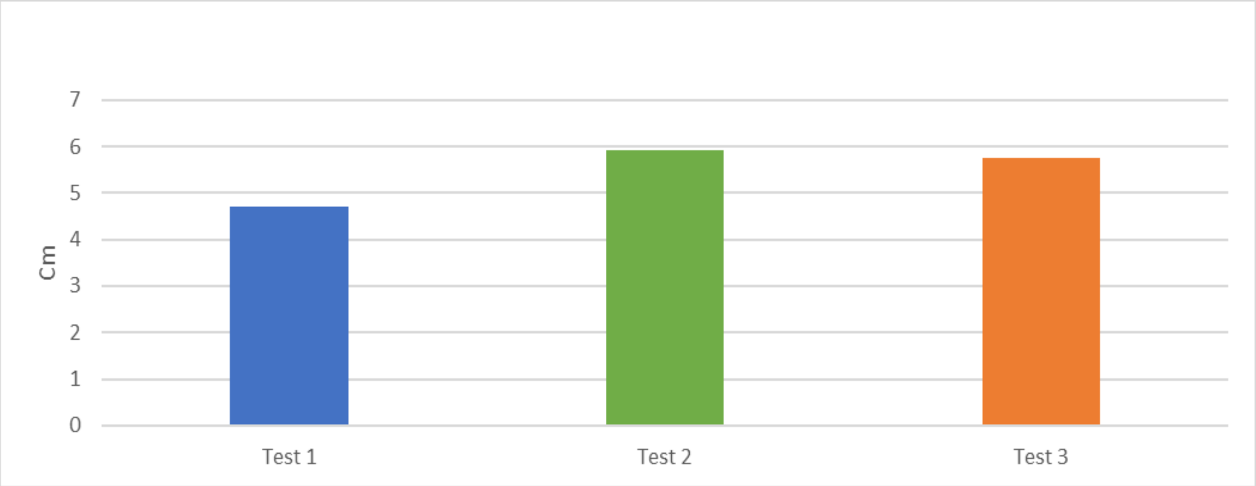

Figure 19. Comparative histogram of roots width parameter results.

6.Final roots length (clump roots)

We obtained the following results **(Figure 21 and Table 10)** by measuring the length of plant roots for each lettuce head individually after ensuring their maturity and reaching the flowering stage.

Table 10. Results of final roots length.

Parametres	Test1		Test2		Test3	
	average±ð	cv%	average±ð	cv%	average±ð	cv%
Final Length of roots	10,42±2,47	23,72%	8,5±1,29	15,18%	8,8±1,50	16,96%

As shown in the graph, there is almost no significant difference in root length. However, we observed a considerable superiority of Test 1 over both Test 2 and Test 3, which aligns with its achievement of good results in terms of shoot length. These results are statistically justified by the correlation circle **(Figure 20)** between the variables, which gives preference to Test 1 at a significance level of alpha ≥ 5% **(Appendix 2).**

Figure 20. Comparative histogram of roots length parameter results.

7.Final weight of lettuce heads

Contrary to the morphological growth of lettuce, the weight of the lettuce heads showed that the superiority was given to Test 2 (50%) **(Table 11 and Figure 21)**. There is a significant difference between Test 1, Test 2, and Test 3, this is attributed to the plant's composition, where most of its structure consists of leaves. Although Test 2 did not yield positive results in terms of length and width like Test 1, it indicates that its internal composition is dense. This led to positive results in terms of weight and significantly larger plant mass, nearly double that of Test 1 and Test 3, al thought the ANOVA gives no significative difference between the tests at the level alpha ≥ 5% **(Appendix 2).**

Table 11. Results of weight development.

Parametres	Test1		Test2		Test3	
	average±ð	cv%	average±ð	cv%	average±ð	cv%
final weight of luttce heads	4,71±0,75	16,03%	5,92±0,97	16,46%	5,75±1,06	18,59%

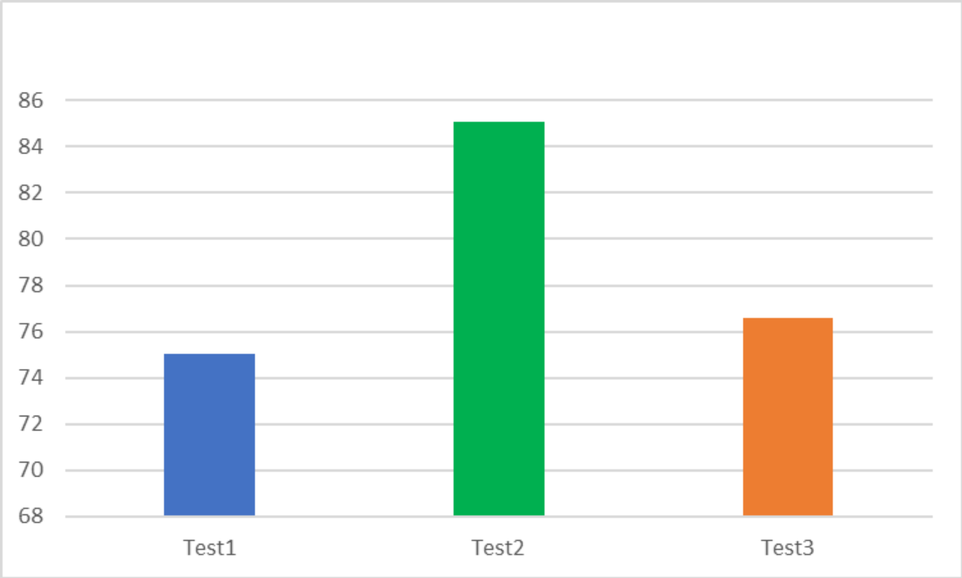

Figure 21. Comparative histogram of final weight parameter results.

8.Yield per hectare

From the lettuce weights in grams, we calculated the yield in kilograms per hectare. The results obtained are grouped in the **Table 12.**

	average	yield (kg)
Test 1	75,02571429	9,378213
Test 2	85,09714286	10,637142
Test 3	76,58625	9,573281

Table 12. The yield per hectare.

Regarding the yield per hectare, as the **Figure 22** shows that we obtained somewhat negative results compared to the usual yield at the level of Skikda state about (40 quintals per hectare according to statistics provided by (DSA 2023). Specifically, we achieved 9.37 quintals per hectare for Test 1, 9.57 kilograms per hectare for Test 3, and finally 10.63 quintals per hectare for Test 2, which is the best among the three experiments. The reason behind these insufficient results can be attributed to the late planting time, which did not start from the seeds, and this is not recommended, not to mention the prolonged exposure to sunlight, which accelerated the flowering process.

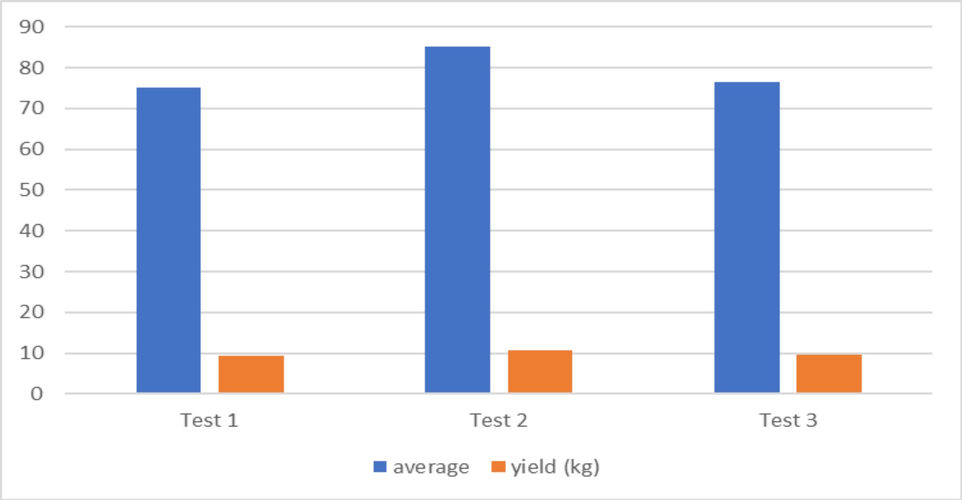

Figure 22. Comparative histogram of yield parameter results.

The PCA (principal component analysis) found that the two main components contributed equally to the representation of all the parameters studied **(Appendix 3)**. The inertia percentage values were 55.49% and 44.51% for axis 1 and axis 2 respectively.

According to the table of coordination **(Appendix 3)** we notice that all the variables have strongly contributed in the disruption of the tests of our work, with the exception of the parameters of the roots (length and width).

A simple observation of the correlation circle **(Figure 23),** we notice that the discriminating variables of axis 1 are:

- Final average length
- Final average width
- Final average growth rate of length
- Final average growth rate of width

While the discriminant variables of axis 2 are:

- Average length of roots
- Average width of roots
- Average weight

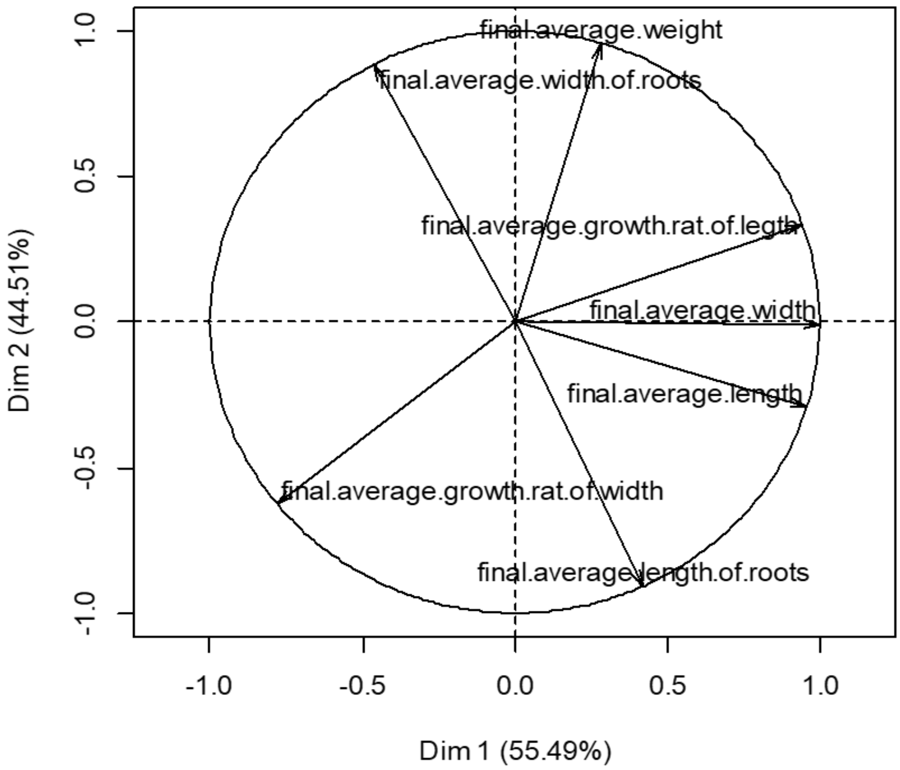

Figure 23. correlation circle.

The distribution of individuals shows a good dispersion **(Figure 24)** where certain parameters exhibit superiority in Test 2, such as final average weight, final average growth rate, and final average width.

For Test 1, its specific parameters, in which it achieved significant superiority in terms of length, are as follows: final average length and final average length of roots.

To conclude, Test 3 represents only one parameter (final average grow rate of width), for which the ANOVA analysis does not show a significant difference. However, it does not mean that Test 3 should be excluded or disregarded.

So, the best test is the one represented by the highest values of the parameters, which is Test 2, and these parameters show a significant difference.

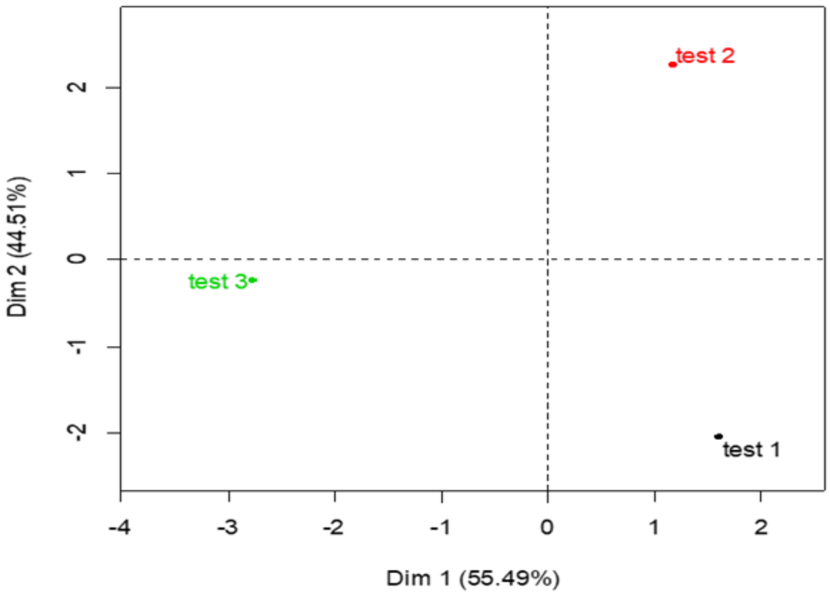

Figure 24. Projection of the tests on the factorial plane 1-2.

Finally, we note that the hierarchical classification **(Figure 25)** provides us with a dispersion of the three tests, each of them separated by a Euclidean distance. Test 1 and Test 2 are very close to each other, while Test 3, representing tap water, is further away.

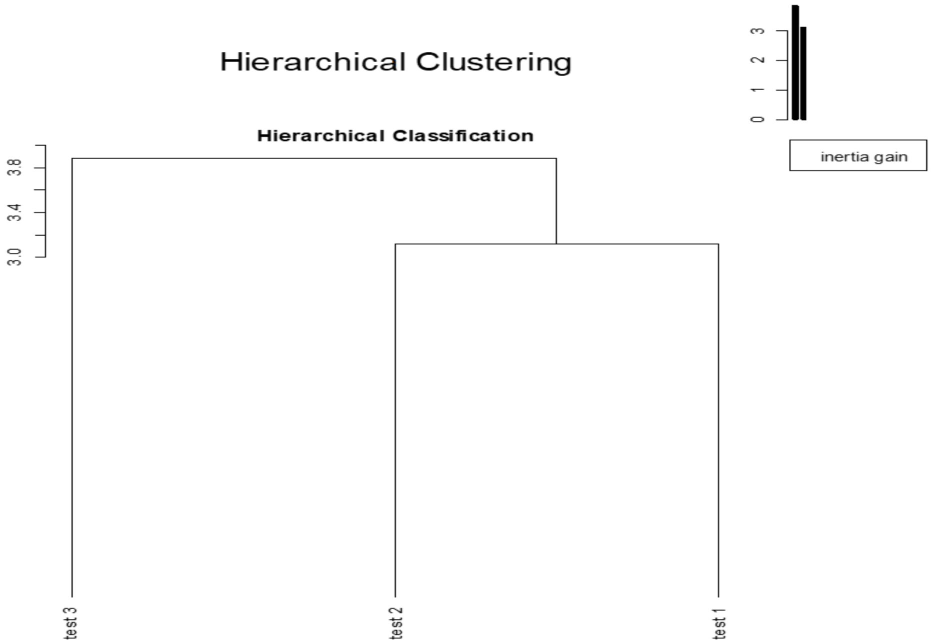

Figure 25. Dendrogram of the grouping of the tests carried our based on the parameters studied.

Conclusion

The choice of the crop and the rigorous monitoring of our experimentation have led to the achievement of clear and positive results, satisfying our main objective. The main purpose of this study is to improve the quality of lettuce irrigated with a plant-based organic fertilizer, specifically the *Malva sylvestris* (mallow) compost extract, at different concentrations (Concentrated mother solution and daughter solution diluted to half 50%).

The initial stages of the experiment showed promising results. The experiment Test 1, watered with a 100% solution, exhibited a slight advantage over Test 2 and Test 3. This indicates that the high concentration solution had a positive impact on the growth and development of the lettuce plants.

Furthermore, after the cessation of precipitation, significant and rapid growth in height was observed in all three experiments. This suggests that the plants responded positively to the favorable environmental conditions, leading to accelerated growth.

Moreover, the experiment Test 2, despite not performing as well as Test 1 in terms of length and width, demonstrated a dense internal composition. This resulted in a higher weight and significantly larger plant mass compared to Test 1 and Test 3. This finding highlights the potential for optimizing plant growth by considering internal characteristics in addition to external morphological measurements.

However, there were also negative aspects observed in the experiment. The occurrence of precipitation on the first day led to a dilution in the concentration of the solution used for irrigating Test 2. As a result, the growth rate of Test 2 declined. This indicates that fluctuations in solution concentration due to external factors can negatively impact plant development.

Additionally, we observed negative aspects, including the impact of precipitation on solution concentration and the consistent superiority of Test 1 over the other experiments.

In summary, the best test is the one represented by the highest values of the parameters, which is Test 2, and these parameters show a significant difference. These findings highlight the importance of carefully managing solution concentrations and considering both external and internal plant characteristics to optimize lettuce growth, and in order for the treatment to be effective, it should be carried out starting from the lettuce sowing stage. Therefore, the difference should be more pronounced, especially in terms of reducing the duration between sowing and germination and before transplantation.

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APPENDIX

Appendix

Appendix 1. Detailed results of the studied parameters.

date	test1/L1	test1/L2	test1/L3	test1/L5	test1/L7	test1/L9	average	ð	cv
09/04/2023	7,00	6,50	9,00	8,50	7,40	9,00	7,90	1,08	13,63
13/04/2023	10,50	9,50	9,60	10,00	7,50	10,00	9,52	1,05	11,03
16/04/2023	11,00	9,50	10,00	9,50	8,50	10,00	9,75	0,82	8,43
19/04/2023	11,50	10,50	10,50	10,50	8,50	10,50	10,33	0,98	9,51
23/04/2023	12,50	11,00	10,50	10,50	11,00	11,00	11,08	0,74	6,64
26/04/2023	12,80	11,50	13,50	12,00	12,00	14,30	12,68	1,06	8,37
30/04/2023	15,50	15,50	17,00	16,00	16,00	17,00	16,17	0,68	4,23
Final Length 02/05/2023	20,00	19,50	20,00	20,50	19,50	21,00	20,08	0,58	2,91

date	test2/L2	test2/L4	test2/L6	test2/L8	test2/L9	average	ð	cv
09/04/2023	4,80	8,70	7,00	7,70	8,50	7,34	1,41	19,16
13/04/2023	6,00	9,00	7,00	8,70	9,50	8,04	1,41	17,49
16/04/2023	6,50	9,00	7,50	9,70	9,50	8,44	1,24	14,68
19/04/2023	6,50	9,20	8,70	10,50	9,80	8,94	1,36	15,22
23/04/2023	9,00	9,50	9,00	11,50	10,00	9,80	0,93	9,46
26/04/2023	9,50	12,50	12,00	12,00	13,50	11,90	1,32	11,08
30/04/2023	12,00	13,50	13,00	16,00	15,00	13,90	1,43	10,28
final length 02/05/2023	18,50	18,50	17,50	21,00	18,00	18,70	1,21	6,46

date	test3/L1	test3/L2	test3/L6	test3/L7	test3/L8	test3/L9	average	ð	CV
09/04/2023	6,70	8,40	6,60	6,50	8,00	6,50	7,12	0,85	8,35
13/04/2023	7,00	8,50	7,00	7,00	8,50	6,60	7,43	0,84	8,84
16/04/2023	9,00	9,50	8,50	7,50	9,00	9,50	8,83	0,75	11,73
19/04/2023	9,50	10,00	9,00	8,60	9,50	10,00	9,43	0,55	17,03
23/04/2023	9,50	12,00	9,00	9,50	10,00	10,50	10,08	1,07	9,44
26/04/2023	11,50	13,00	11,50	11,00	12,00	11,00	11,67	0,75	15,50
30/04/2023	12,00	16,00	14,00	11,50	13,00	14,50	13,50	1,67	8,07
final length 02/05/2023	16,50	17,00	14,00	15,00	16,00	15,50	15,67	1,08	14,50

date	test1/L1	test1/L2	test1/L3	test1/L5	test1/L6	test1/L7	test1/L9	average	ð	cv
09/04/2023	11,50	11,00	9,00	12,00	7,00	10,00	12,00	10,36	1,84	17,78
13/04/2023	12,00	11,00	10,00	12,00	7,00	12,00	13,00	11,00	2,00	18,18
16/04/2023	12,50	13,30	17,00	12,00	8,00	12,80	13,50	12,73	2,65	20,81
19/04/2023	15,00	15,50	17,50	14,00	10,00	14,00	15,00	14,43	2,28	15,81
23/04/2023	18,00	19,00	18,00	16,00	11,50	16,00	16,50	16,43	2,46	14,95
26/04/2023	18,00	19,00	18,50	17,30	16,00	18,00	17,50	17,76	0,96	5,43
30/04/2023	21,00	22,00	22,50	21,00	19,00	21,00	19,00	20,79	1,35	6,49
Final width 02/05/2023	21,00	22,00	22,50	21,50	20,00	22,00	20,00	21,29	0,99	4,67

date	test2/L2	test2/L4	test2/L5	test2/L6	test2/L7	test2/L8	test2/L9	averga	ð	cv
09/04/2023	10,00	9,70	11,00	5,50	10,00	10,50	10,00	9,53	1,83	19,18
13/04/2023	10,00	9,70	15,50	8,00	12,00	14,00	12,00	11,60	2,60	22,38
16/04/2023	11,00	12,00	16,50	10,00	13,00	14,50	14,00	13,00	2,22	17,06
19/04/2023	11,00	14,50	17,00	10,60	14,50	15,00	14,00	13,80	2,26	16,41
23/04/2023	13,50	16,00	19,00	14,00	15,50	17,00	15,50	15,79	1,85	11,69
26/04/2023	16,00	17,40	21,20	17,50	17,50	17,00	18,00	17,80	1,62	9,12
30/04/2023	16,50	21,00	24,00	20,50	20,00	19,00	19,00	20,00	2,29	11,46
02/05/2023	19,50	22,00	23,50	22,00	20,50	20,50	19,50	21,07	1,48	7,04

date	test3/L1	test3/L2	test3/L3	test3/L5	test3/L6	test3/L7	test3/L8	test3/L9	average	ð	CV
09/04/2023	9,00	10,80	7,00	7,50	9,50	6,50	10,00	6,50	8,35	1,68	20,17
13/04/2023	12,00	11,00	9,00	10,50	10,50	9,00	13,00	9,50	10,56	1,43	13,49
16/04/2023	12,50	13,00	9,00	10,50	12,00	12,50	13,00	11,00	11,69	1,41	12,09
19/04/2023	12,50	13,50	11,50	11,50	12,80	13,50	12,60	13,50	12,68	0,83	6,57
23/04/2023	16,00	15,50	13,40	12,00	15,00	14,00	14,50	14,70	14,39	1,26	8,77
26/04/2023	17,50	16,50	15,50	12,50	16,50	18,00	16,50	16,00	16,13	1,66	10,32
30/04/2023	21,50	20,00	19,00	14,00	20,50	20,00	17,00	18,00	18,75	2,39	12,75
02/05/2023	20,00	20,00	20,00	15,00	22,50	20,50	18,00	18,50	19,31	2,20	11,41

date	test1/L1	test1/L2	test1/L3	test1/L5	test1/L6	test1/L7	test1/L9	average	ð	cv
09/04/2023	0,16	0,30	0,15	0,38	0,25	0,25	0,25	0,38	0,08	20,32
13/04/2023	0,66	0,80	0,13	0,40	0,50	0,33	0,50	0,47	0,22	46,09
16/04/2023	0,17	0,25	0,16	0,33	0,33	0,37	0,16	0,25	0,09	36,02
19/04/2023	0,25	0,45	0,64	0,66	0,13	0,50	0,55	0,45	0,20	43,93
23/04/2023	0,60	0,16	0,30	0,50	0,50	0,33	0,30	0,38	0,15	39,86
26/04/2023	0,68	1,00	1,00	1,16	0,66	1,00	0,67	0,88	0,21	23,46
30/04/2023	1,50	1,33	1,33	1,50	1,16	1,16	1,33	1,33	0,14	10,44

date	test2/L2	test2/L4	test/L5	test2/L6	test2/L7	test2/L8	test2/L9	avergae	ð	cv
09/04/2023	0,30	0,15	0,36	0,15	0,15	0,25	0,25	0,23	0,08	36,29
13/04/2023	0,16	0,45	0,30	0,16	0,16	0,33	0,52	0,30	0,15	49,64
16/04/2023	0,00	0,33	0,33	0,40	0,16	0,30	0,10	0,23	0,15	63,23
19/04/2023	0,40	0,50	0,50	0,75	0,75	0,25	0,25	0,49	0,21	42,74
23/04/2023	0,16	0,50	0,50	0,50	0,50	0,16	0,66	0,43	0,19	44,79
26/04/2023	0,62	0,75	0,75	0,25	0,50	0,50	0,37	0,53	0,19	35,06
30/04/2023	2,16	1,66	1,83	1,50	1,16	1,66	1,00	1,57	0,39	25,12

date	test3/L1	test3/L2	test3/L3	test3/L5	test3/L6	test3/L7	test3/L8	test3/L9	average	ð	CV
09/04/2023	0,08	0,02	0,00	0,08	0,10	0,10	0,12	0,10	0,07	0,04	57,38
13/04/2023	0,22	0,33	0,33	0,20	0,15	0,16	0,16	0,20	0,22	0,07	33,27
16/04/2023	0,16	0,16	0,33	0,13	0,16	0,33	0,16	0,16	0,20	0,08	40,84
19/04/2023	1,00	0,50	0,88	0,15	0,60	0,25	0,60	0,80	0,60	0,30	49,54
23/04/2023	0,66	0,33	0,50	0,00	0,83	0,50	0,66	0,16	0,46	0,28	60,95
26/04/2023	0,13	0,75	0,37	0,37	0,62	0,12	0,25	0,87	0,43	0,28	65,15
30/04/2023	1,25	0,33	0,66	0,66	0,00	1,16	1,00	0,33	0,67	0,44	65,56

date	test1/L1	test1/L2	test1/L3	test1/L5	test1/L6	test1/L7	test1/L9	average	ð	cv
09/04/2023	0,13	0,50	0,25	0,30	0,25	0,50	0,25	0,31	0,14	45,00
13/04/2023	0,40	0,76	0,33	0,66	0,33	0,26	0,50	0,46	0,19	40,32
16/04/2023	0,63	0,73	1,00	0,66	0,50	0,40	0,50	0,63	0,20	31,35
19/04/2023	0,46	0,87	0,12	0,50	0,50	0,50	0,37	0,47	0,22	46,77
23/04/2023	0,66	0,66	0,16	0,66	0,50	0,66	0,33	0,52	0,20	38,93
26/04/2023	0,30	0,30	0,75	0,32	0,75	0,75	0,37	0,51	0,23	45,42
30/04/2023	0,50	0,50	0,50	0,75	0,33	0,33	0,33	0,46	0,15	32,95

date	test2/L2	test2/L4	test2/L5	test2/L6	test2/L7	test2/L8	test2/L9	average	ð	cv
09/04/2023	0,14	0,12	0,13	0,27	0,11	0,16	0,11	0,15	0,06	38,35
13/04/2023	0,33	0,76	0,33	0,66	0,33	0,16	0,66	0,46	0,23	49,32
16/04/2023	0,20	0,30	0,16	0,20	0,11	0,16	0,15	0,18	0,06	32,92
19/04/2023	0,63	0,37	0,38	0,85	0,25	0,50	0,37	0,48	0,20	42,47
23/04/2023	0,83	0,46	0,50	0,86	0,66	0,20	0,83	0,62	0,25	39,72
26/04/2023	0,13	0,60	0,55	0,75	0,62	0,50	0,25	0,49	0,22	45,40
30/04/2023	0,25	0,33	0,16	0,25	0,16	0,11	0,16	0,20	0,08	37,51

date	test3/L1	test3/L2	test3/L3	test3/L5	test3/L6	test3/L7	test3/L8	test3/L9	average	ð	CV
09/04/2023	0,75	0,05	0,25	0,75	0,83	0,63	0,75	0,75	0,59	0,28	47,94
13/04/2023	0,16	0,33	0,66	0,20	0,50	1,16	0,30	0,50	0,48	0,32	67,86
16/04/2023	0,00	0,16	0,50	0,33	0,26	0,33	0,20	0,83	0,33	0,25	76,71
19/04/2023	0,87	0,50	0,50	0,12	0,50	0,16	0,33	0,30	0,41	0,24	58,20
23/04/2023	0,25	0,33	0,66	0,16	0,50	1,33	0,50	0,43	0,52	0,36	69,84
26/04/2023	0,50	0,87	0,87	0,37	1,00	0,50	0,13	0,50	0,59	0,30	50,03
30/04/2023	0,16	0,00	0,33	0,33	0,66	0,16	0,33	0,16	0,27	0,20	74,03

date	test1/L1	test1/L2	test1/L3	test1/L5	test/L6	test1/L7	test1/L9	average	ð	cv
Final Length of roots	10,50	9,00	10,50	15,50	10,00	7,50	10,00	10,43	2,47	23,72
final weight of roots	4,50	4,00	4,50	4,00	6,00	5,50	4,50	4,71	0,76	16,03
weight	76,05	82,35	92,51	83,54	67,92	75,70	47,11	75,03	14,51	19,34

date	test2/L2	test2/L4	test2/L5	test2/L6	test2/L7	test2/L8	test2/L9	average	ð	cv
Final Length of roots	9,50	9,00	7,00	8,50	7,00	10,50	8,00	8,50	1,29	15,19
final weight of roots	4,50	5,00	5,50	6,00	6,50	7,00	7,00	5,93	0,98	16,46
weight	77,70	66,63	156,81	76,42	69,41	82,13	66,58	85,10	32,18	37,81

date	R3/L1	R3/L2	R3/L3	R3/L5	R3/L6	R3/L7	R3/L8	R3/L9	average	ð	CV
Final Length of roots	11,00	7,50	9,00	7,50	7,50	11,00	8,00	9,50	8,88	1,51	16,97
final weight of roots	6,00	7,00	6,00	4,00	7,00	6,00	5,50	4,50	5,75	1,07	18,59
weight	82,49	69,72	86,14	40,12	69,72	118,78	93,28	52,44	76,59	24,47	31,95

Appendix 2. ANOVA results.

```
Response: final.length
          Sum Sq Df F value      Pr(>F)
tests     67.078  3  22.611 0.000008075 ***
Residuals 14.833 15
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

> with(fo, (tapply(final.length, list(tests), mean, na.rm=TRUE))) # means
     test 1 test 1/100%       test 2       test 3
   20.10000    20.00000     18.70000     15.66714

> with(fo, (tapply(final.length, list(tests), sd, na.rm=TRUE))) # std. deviations
     test 1 test 1/100%       test 2       test 3
  0.6519202           NA    1.2083046    0.9860141

> xtabs(~ tests, data=fo) # counts
tests
     test 1 test 1/100%       test 2       test 3
          5           1            7            7
```

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```
Response: final..width
          Sum Sq Df F value Pr(>F)
tests      7.452  2  2.1054 0.1508
Residuals 31.857 18

> with(Da, (tapply(final..width, list(tests), mean, na.rm=TRUE))) # means
  test 1   test 2   test 3
21.28571 21.07143 19.92857

> with(Da, (tapply(final..width, list(tests), sd, na.rm=TRUE))) # std. deviations
   test 1    test 2    test 3
0.9940298 1.4840421 1.4556949

> xtabs(~ tests, data=Da) # counts
tests
test 1 test 2 test 3
     7      7      7
```

```
Response: final..growth.rat.of.legth
          Sum Sq Df F value    Pr(>F)
tests     2.6546  2  10.498 0.0009514 ***
Residuals 2.2759 18
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

> with(Dat, (tapply(final..growth.rat.of.legth, list(tests), mean, na.rm=TRUE))) # means
   test 1    test 2    test 3
1.3300000 1.5671429 0.7228571

> with(Dat, (tapply(final..growth.rat.of.legth, list(tests), sd, na.rm=TRUE))) # std. deviations
   test 1    test 2    test 3
0.1388044 0.3936460 0.4528692

> xtabs(~ tests, data=Dat) # counts
tests
test 1 test 2 test 3
     7      7      7
```

```
Response: final..growth.rat.of.width
           Sum Sq Df F value  Pr(>F)
tests     0.24041  2  5.9237 0.01055 *
Residuals 0.36526 18
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

> with(Datas, (tapply(final..growth.rat.of.width, list(tests), mean, na.rm=TRUE))) # means
   test 1    test 2    test 3
0.4628571 0.2028571 0.3042857

> with(Datas, (tapply(final..growth.rat.of.width, list(tests), sd, na.rm=TRUE))) # std. deviations
    test 1     test 2     test 3
0.15250293 0.07609518 0.17840564

> xtabs(~ tests, data=Datas) # counts
tests
test 1 test 2 test 3
```

```
Anova Table (Type II tests)

Response: final..length.of.roots
          Sum Sq Df F value Pr(>F)
tests     13.907  2  2.2958 0.1279
Residuals 57.548 19

> with(Dataset, (tapply(final..length.of.roots, list(tests), mean, na.rm=TRUE))) # means
   test 1    test 2    test 3
10.428571  8.500000  9.332857

> with(Dataset, (tapply(final..length.of.roots, list(tests), sd, na.rm=TRUE))) # std. deviations
  test 1   test 2   test 3
2.473671 1.195229 1.343710

> xtabs(~ tests, data=Dataset) # counts
tests
test 1 test 2 test 3
     7      8      7
```

```
Response: final..width.of.roots
           Sum Sq Df F value  Pr(>F)
tests       6.881  2  4.0326 0.03572 *
Residuals 15.357 18
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

> with(t, (tapply(final..width.of.roots, list(tests), mean, na.rm=TRUE))) # means
  test 1   test 2   test 3
4.714286 5.928571 5.928571

> with(t, (tapply(final..width.of.roots, list(tests), sd, na.rm=TRUE))) # std. deviations
   test 1    test 2    test 3
0.7559289 0.9759001 1.0177005

> xtabs(~ tests, data=t) # counts
tests
test 1 test 2 test 3
     7      7      7
```

```
Response: final..weight
           Sum Sq Df F value Pr(>F)
tests       442.1  2  0.3422 0.7147
Residuals 11627.1 18

> with(set, (tapply(final..weight, list(tests), mean, na.rm=TRUE))) # means
  test 1   test 2   test 3
75.02571 85.09714 75.74286

> with(set, (tapply(final..weight, list(tests), sd, na.rm=TRUE))) # std. deviations
  test 1   test 2   test 3
14.50931 32.17544 26.30719

> xtabs(~ tests, data=set) # counts
tests
test 1 test 2 test 3
     7      7      7
```

Appendix 3. ACP results.

Eigenvalue and percentage of inertia of the studied parameters

```
> res$eig
       eigenvalue percentage of variance cumulative percentage of variance
comp 1    3.88415               55.48786                          55.48786
comp 2    3.11585               44.51214                         100.00000
```

Coordinates of the studied parameters

```
$cor
                                       Dim.1        Dim.2
final.average.length               0.9565375 -0.291609301
final.average.width                0.9999781 -0.006616618
final.average.growth.rat.of.legth  0.9421950  0.335065019
final.average.growth.rat.of.width -0.7806775 -0.624934087
final.average.length.of.roots      0.4178488 -0.908516575
final.average.width.of.roots      -0.4649493  0.885337309
final.average.weight               0.2850713  0.958506306
```

Correlation matrix

	final.average.growth.rat.of.legth	final.average.growth.rat.of.width	final.average.length	final.average.length.of.roots
final.average.growth.rat.of.legth	1.00000000	-0.9449440	0.803536795	0.08928295
final.average.growth.rat.of.width	-0.94494401	1.0000000	-0.564510740	0.24155780
final.average.length	0.80353679	-0.5645107	1.000000000	0.66461995
final.average.length.of.roots	0.08928295	0.2415578	0.664619952	1.00000000
final.average.weight	0.58975471	-0.8215520	-0.006827935	-0.75170215
final.average.width	0.93995739	-0.7765255	0.958446042	0.42385098
final.average.width.of.roots	-0.14142734	-0.1903020	-0.702914039	-0.99862213

	final.average.weight	final.average.width	final.average.width.of.roots
final.average.growth.rat.of.legth	0.589754715	0.9399574	-0.1414273
final.average.growth.rat.of.width	-0.821552039	-0.7765255	-0.1903020
final.average.length	-0.006827935	0.9584460	-0.7029140
final.average.length.of.roots	-0.751702149	0.4238510	-0.9986221
final.average.weight	1.000000000	0.2787230	0.7160577
final.average.width	0.278723017	1.0000000	-0.4707971
final.average.width.of.roots	0.716057680	-0.4707971	1.0000000

Summary

Our study, which lasted for a month on the experimental plot of Skikda University, aims to evaluate and compare the effect of biofertilizers obtained from the spontaneous plant Malva sylvestris (mallow) on the biometric parameters and yield per hectare of lettuce. The crop was grown under natural conditions (climate and soil). For this purpose, two different concentrations of mallow extract solution (50% and 100%) were compared with a third solution consisting of tap water (control), used for watering the lettuce plants.

In conclusion, the most effective test is Test 2, which showed significant differences for the majority of the parameters studied. These results confirm the importance of carefully managing solution concentrations and considering external and internal plant characteristics to optimize lettuce growth for effective treatment.

In the end, it is recommended to start the irrigation process from the lettuce sowing stage to highlight the influence of these solutions on germination and germination capacity as well.

Key words: Lettuce, Bio-fertilizers, biometric, Productivity, Parameters.

Résumé

Notre étude, qui a duré un mois sur la parcelle expérimentale de l'Université de Skikda, vais pour but d'évaluer et de comparer l'effet des biofertilisants obtenus de la plante spontanée *Malva sylvestris* (la Mauve), sur les paramètres biométriques et sur le rendement par hectare de la laitue. La culture a été cultivée dans des conditions naturelles (climat et sol). Pour cela, deux concentrations différentes de solution d’extrait de mauve (50 % et 100 %) ont été comparées avec une troisième solution constituée d’eau de robinet (temoin), utilisées pour l’arrosage des plants de laitue.

Le test 2, bien qu'il ne soit pas aussi performant que le test 1 en termes de longueur et de largeur, il a révélé un poids plus élevé par rapport au test 1 et au test 3. Il est clair que la dilution de la concentration des solutions due à des facteurs externes (précipitations) peut avoir un impact négatif sur le développement des plantes.

En conclusion, le test le plus performant est le test 2, qui a montré des différences significatives pour la majorité des paramètres étudiés. Ces résultats confirment l'importance de gérer soigneusement les concentrations de la solution et de tenir compte des caractéristiques externes et internes de la plante pour optimiser la croissance de la laitue afin d'obtenir un traitement efficace. A la fin, il est recommandé de commencer le processus d'irrigation dès le semis de la laitue, afin de mettre en évidence l'influence de ces solutions sur la germination.

Mots clés : Laitue, Bio-fertilisant, biométrique, Productivité, Paramètres.

ملخص

تهدف دراستنا التي استمرت لمدة شهر في الموقع التجريبي لجامعة 20 اوت 1955 في سكيكدة إلى تقييم ومقارنة تأثير السماد العضوي المستخرج من نبات نبات الخبيزة *Malva sylvestris* على المعايير البيومترية والإنتاجية لنبات الخس. انجزت هذه التجربة في تربة عادية معرضة لجميع الظروف الطبيعية. لهذا الغرض ، تم السقي بتركيزين مختلفين من السماد العضوي (50٪ و 100٪) ، و ماء الحنفية (محلول شاهد).

أظهر الاختبار 2 ، على الرغم من عدم أدائه جيدًا مثل الاختبار 1 من حيث الطول والعرض ، تركيبة داخلية كثيفة ، مما أدى إلى زيادة وزن النبات و اعطائنا نتائج افضل مقارنةً بالاختبار 1 والاختبار 3. من الواضح أن التخفيف في تركيز المحلول الناتج عن العوامل الخارجية (هطول الأمطار) اثر سلبًا على تطور النبات.

في الختام ، كان الاختبار الأفضل أداءً هو الاختبار 2 ، والذي أظهر اختلافات كبيرة في المعايير. تؤكد هذه النتائج على أهمية تحديد تركيز المحاليل بعناية لتحسين نمو الخس. لتحقيق العلاج الفعال ، يوصى ببدء عملية السقي ابتداءا من مرحلة بذر الخس ، لتحديد مدى تاثير هذه المحاليل على معيار انتاش البذور.

الكلمات المفتاحية: خس ، سماد حيوي ، مقاييس حيوية ، إنتاجية ، الاعدادات.