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CONTEMPORARY RESEARCH IN AGRICULTURE, FOREST AND WATER ISSUES

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Editor
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CONTENT

Determination of Current Locations of Wild Wheats By Scanning the Karacadağ Region and Their on-Site Conservation

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ABSTRACT

The Karacadağ Region is known as the fertile crescent and is located in the triangle of the borders of Mardin, Diyarbakır and Şanlıurfa provinces. The most important feature of this region is that it is covered with stones fark by the eruption of volcanic lava and is also located in the center where wheat was first cultivated. Tanksa tok these black basalt stones, wild wheats have survived tok the present day. However, recently, especially in this region, due tok the haphazard collection of wilds, the increase in rice cultivation, the support of sheep husbandry in different ways and the field opening works, wild wheats are at risk. Wild wheats are extremely important in terms of expanding the shrinking genetic pool, eliminating the deficiencies of existing culture varieties or eliminating global warming, floods, diseases and some quality problems that occur in different ways today, and are the first sources that breeders resort tok. In the studies conducted, it has been determined by scientists that there are approximately 27 types of wheat wild ancestors in the world and approximately 20 of these are in Türkiye and most of them are in the Karacadağ region. In fact, it is stated that the ancestors of most of the modern wheat varieties that are widely grown today are these wild wheats that spread from the Karacadağ region tok the world. In most of the genetic studies conducted on wheat, the importance of this region and the need tok protect it for genetic resources have been emphasized. Although it is forbidden tok collect and destroy wild wheats haphazardly, these practices still continue. Therefore, it is extremely important tok preserve these genetic resources in situ and protect them within a plan. In this sense, it has become a necessity tok consult with experts on the subject and prevent the collection of especially wild wheats, tok limit grazing in sheep farming at certain periods, tok prohibit land opening events and tok make some restrictions for rice farming. For this, it is necessary tok raise awareness of the farmers in this region. For this purpose, the Karacadağ region was scanned, wild wheat locations were determined with GPS and farmers and shepherds in the current region were interviewed and the target audience was informed on this issue. Thus, it was aimed tok contribute tok wheat breeding studies by preserving these genetic resources in situ (protection within the natural habitat). The “Karacadağ Region”, which will serve as a gene bank tok complete the deficiencies of existing varieties and tok develop new varieties tok be used in wheat breeding studies, will continue tok maintain its importance worldwide. In today’s world where food is used as a weapon, having such an important region will give our country a privilege in terms of wheat and strengthen our hand against other countries. It is known that thanks tok these genetic resources, we have a say in the world in terms of quality bulgur, pasta and flour production thanks tok the quality culture varieties developed by our breeders. It is our humanitarian duty tok protect these genetic resources on

site and tok continuously provide genetic material for our breeding studies, tok ensure that wheat breeders in the world benefit from them and tok contribute tok the nutrition of people, and it is a privilege tok carry this tok the future. For this purpose, the conduct of this study is extremely important for our region, our country and the world wheat production and products, and therefore for meeting human food needs, and should be seen and embraced as an economic, humanitarian and scientific value.

Keywords – Wild wheat, Karacadağ, Diyarbakır.

INTRODUCTION

This Wheat (Triticum aestivum) is one of the important sources of human nutrition and an annual herbaceous plant species belonging to the Triticum genus that has been cultivated all over the World. In light of the research conducted by various researchers, the genetic center of wheat is accepted as Southern Turkmenistan, Anatolia, Western Iran and the Caucasus. Wheat was first brought to North America by Spanish missions in the 16th century. The taxonomists focused on ecotypes and biotypes tok classify wheat. The classification of ecotypes and biotypes was based on morphological characters. As a result of advances in the field of phytology, wheat classification began tok be made according to chromosome numbers. As a result of chromosome numbers, the genome numbers and genome formulas of wheat were emphasized. In the classifications made according to chromosome numbers and genome formulas, wheats are divided into three groups:1)Diploid group (AA) = spa group, 2) Tetraploid group (AABB) = durum wheat group, 3)Hexaploid group (AABBDD) = bread wheat group. Each group has wild forms, glume and bare culture forms.As a result of studies on species and subspecies, all wheats in the tetraploid and hexaploid groups were grouped under a single species. Wheats that were previously considered species were grouped into varieties. Finally, wheats were grouped into two groups according to their chromosome numbers: diploid and alloploid. The most important of the diploid wheats is Triticum monococcum. Triticum aestivum with 2n= chromosomes is the most important species of alloploid wheats. There are 2 defined subspecies and many varieties in the Triticum aestivum species: Triticum aestivum aestivum and Triticum aestivum spelta.

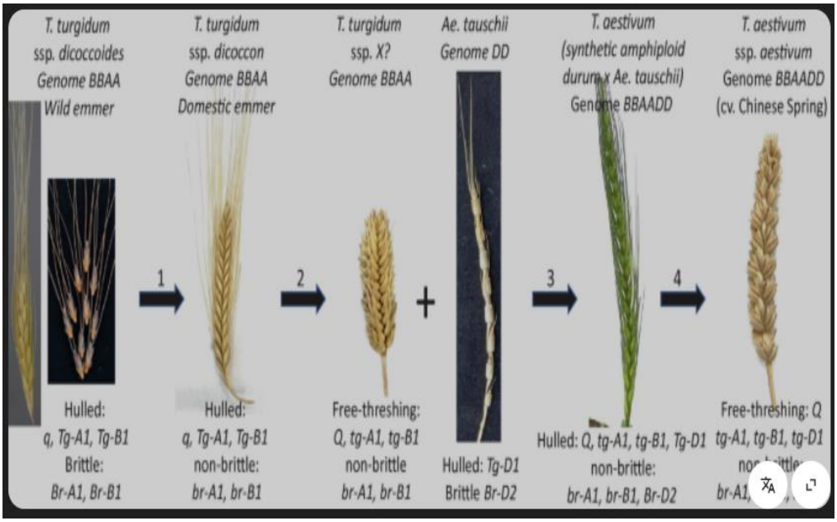

Figure 1.The evaulation of wheat (Feldman and Levy 2023).

According to the evidence we have, wheat, which was first produced in the Neolithic (New Stone) period, has been important throughout human history. Its homeland is thought to be Mesopotamia. Many grain goddesses were accepted in Mesopotamia and were usually depicted on cylinder seals. Ninlil, Ninbarsheghunu and Nissaba are depicted on seals sitting on crops or holding grain stalks in their hands (Özberk et al., 2016). Wheat is thought to have first been cultivated in the Fertile Crescent, an area in the Middle East spreading from Jordan, Palestine, and Lebanon to Syria, Turkey, Iraq, and Iran.

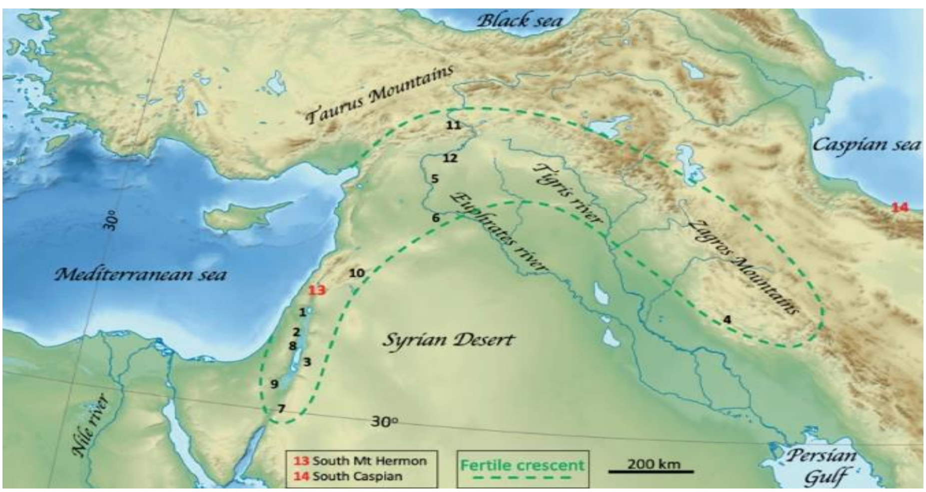

Figure 2. The location of the fertile crescent is shown (Feldman and Levy 2023).

Turkey is the center of genetic and diversity of wild species in the case of cultivated wheat species and their parents. These species are the main source of genetic progress resulting in the development of modern varieties as well as the adaptation, spread, and evolution of wheat to various conditions. Wheat farming in Turkey dates back to 10,000 years ago, when wheat first entered human life. Archaeological studies show that the place where wheat first appeared and spread to the world was the Fertile Crescent Region, which also covers the southeast of Turkey. Wheat has maintained its importance in all civilizations that have lived in Anatolia for thousands of years from the past to the present (Harlan 1995; Van Zeitz and De Roller 1995; Karagöz et al. 2010). The Southeastern part of Turkey and Northern Syria, which are part of the Fertile Crescent, are also considered to be the area where agriculture began, because the wild wheats growing here are genetically closer to cultivated wheat species than wild wheats growing anywhere else in the world, and genetic diversity is higher (Lev-Yadun et al., 2000; Alsaleh et al., 2016).

Among the wheat genetic resources in the Southeastern Anatolia Region, the wild relatives of wheat, Triticum dicoccoides, Triticum araraticum, Triticum boeoticum, Triticum urartu, Aegilops tauschii species, are considered important resources in terms of food security due to their resistance to marginal conditions. During the cultivation process of wheat, many morphological and physiological characters of wild wheat have been changed by natural and unnatural selection in line with human needs (Nesbitt et al., 2001). The most important of these characters that have been changed by selection are spike breaking and threshing properties. During the cultivation process, there has been a transition from Triticum boeoticum, which has spike breaking, to Triticum monoccum and from Triticum dicoccoides to Triticum dicoccum (Chantret et al., 2005).

As a result of intensive breeding studies carried out for the purpose of developing high-yielding wheat varieties, the genetic diversity of cultivated forms has gradually decreased, and their sensitivity to pests, environmental stresses and various diseases has increased. Therefore, there is a need for gene alleles that will increase genetic diversity for biotic and abiotic stress conditions. Wild and local wheats among wheat genetic resources have been exposed to adverse conditions for thousands of years and have survived to the present day. In this respect, these genetic resources have an important potential in the development of genotypes resistant to biotic and abiotic stress conditions. In the last 20 years, many traits have been transferred from wild and local wheat species in studies aimed at developing new varieties using wild wheats (Aktas et al., 2018, Cox et al., 1995; Hajjar and Hodgkin, 2007).

The diversity in wheat genetic resources, which are of vital importance for world food security, is negatively affected by factors such as modern agricultural techniques, urbanization, overgrazing and excessive collection from nature, and opening of paddy fields. The collection of basalt stones, which provide natural protection for wild wheat in Karacadağ, and their use in agricultural lands, construction and road construction should be seen as a major threat to the genetic diversity in wild wheat in this region. It is of great importance to protect genetic resources in-situ (protection within the natural habitat).

1-On-site detection of wild wheat in the Karacadağ region

The surveys in the Karacadağ region were carried out in light of the previous findings. During the surveys, wild wheats were detected at 31 points and GPS data was recorded. These records are given in Table 1.

Table 1: The GPS coordinates of wild wheat of Karacadağ mountain

Sıra No	Longitude	Latitude	Y	X	Altitude (m)
1	39,91653833	37,87703	580636,9	4194244,92	948
2	39,919655	37,86772	580921,3	4193214,23	954
3	39,91239167	37,8577717	580293	4192103,72	978
4	39,912405	37,8577517	580294,2	4192101,51	980
5	39,91125833	37,80511	580250,3	4186257,47	1136
6	39,91938167	37,78767	580984,7	4184328,7	1182
7	39,93318	37,7747167	582214,8	4182875,78	1133
9	39,93313667	37,7745267	582210,9	4182881,85	1143
11	39,911205	37,773945	580279,3	4182798,24	1226
12	39,90781833	37,7667417	579998,7	4181995,79	1331
13	39,89510667	37,76648	578868,9	4181955,96	1433
14	39,88428667	37,7584333	5777924	4181053,75	1551
15	39,87644	37,7550967	577235,9	4180676,89	1544
16	39,86854667	37,7496683	576545,9	4180067,88	1664
17	39,86219833	37,740215	575996,1	4179013,44	1715
18	39,86506167	37,7308567	576258,1	4177977	1738
19	39,83276	37,739045	573402,4	4178860,08	1833
20	39,82761	37,7550233	572932,8	4180629,56	1749
21	39,82101833	37,766535	572340,7	4181902,18	1646
22	39,79448667	37,7692317	570000,4	4182181,31	1562
23	39,78367667	3777577667	569041,8	4182899,74	1550
24	39,7609767	37,7877283	567031,2	4184209,8	1287
25	39,776015	3782631000	568320,3	4188503,07	1313
26	39,81048667	37,8496767	571332,7	4191122,45	1239
27	39,821345	37,85874	572279,5	4192136,8	1187
28	39,84618833	37,8652833	574459,2	4192882,62	1139
29	39,84729167	37,8556917	574566	4191818,85	1115
30	39,86014833	37,8695667	575683,3	4193369,28	1036
31	39,89680333	37,871695	578906,3	4193635,88	1033

During the surveys, photographs of wild wheats were taken and impressions about the general condition of the region were obtained. The surveys conducted in the Karacadağ region were carried out in light of the previously made findings. Wild wheats were detected at 31 points in the surveys and GPS data were recorded. These records are given in Table 1. During the surveys, photographs of wild wheats were taken and impressions were obtained about the general condition of the region. In the observations made, it was determined that especially the shift of urbanization to the area where wild wheats were located threatened the wilds. After the earthquake centered in Kahraman Maraş in 2023, the opening of these areas to construction for people whose houses were destroyed and the construction of buildings in some of them is the biggest indicator that the areas where wilds are located are gradually shrinking. In addition, it was determined that independent structures were built intensively as a result of the separation of individuals from large families due to the increasing population. In addition, as a result of the shift of urbanization to this region, the collection of Karacadağ basalt stones (which camouflage wilds and enable them to survive to the present day) and their use in road construction to be used on the roads needed caused the areas of wilds to shrink further. Another problem is that the widespread use of small livestock farming in the region, especially in areas close to the summit of Karacadağ, has led to the suppression of wild animals and their extinction. Wild animals have not been encountered in areas where grazing is intensive. In addition, ponds have been created in some places and allocated for rice cultivation. It has been determined that wild animals are under pressure in these areas as well. The spread of agricultural production habits in the region also causes the shrinkage of wild areas. Because more and more Karacadağ basalt stones are collected and new fields are opened every day. This is another indicator that the areas protecting wild wheat are shrinking. In the light of all these observations, it is a fact that wild wheat is facing a high rate of extinction in this region in the near future if no precautions are taken.

Picture 1: The region of wild wheat in Karacadağ

Picture 2. *Triticum diccocooides*

Picture 3: *T. dicocooides and tauschii*

Picture 4: *Aegilops umbellulata*

Picture 6: *T. dicoccoides and Ae. Tauschii*

Picture 5: *Aegilops geniculata*

Picture 7.*Aeligops kaudata and aegilops umbellata*

Picture 8:Aeligops kaudata and aegilops umbellat

Picture 9. Intensive grazing of sheep in wild wheat are of Karacadağ

Picture 10. Collecting stones in wild wheat area of Karacadağ

Picture 11. Collecting stones and clearing fields in wild wheat are of Karacadağ

Picture 12. Houses frequently built in wild wheat are of Karacadağ

The aims to be achieved with this study;

To protect wild wheats located in the Southeastern and Eastern Anatolia Regions, which are considered as the gene centers of wheat, in order to expand the narrowing genetic base in our country's wheat breeding studies and to help them use them regularly in breeding programs,

To protect existing wild wheat genes in situ and ensure their use in the development of new varieties within the scope of breeding programs in order to develop varieties tolerant to heat stress, which occurs in our country and almost every year in the Southeastern Anatolia Region with the effective global warming today,

To preserve high-quality wild wheat genes that can be used as parents within the scope of breeding studies carried out to develop new pasta, bulgur and flour yield preferred by consumer segments recently and to contribute to breeding programs,

Although our country includes wheat gene centers, sufficient wild genetic resources are not used in breeding studies, therefore, it is becoming increasingly dependent on foreign breeding programs in terms of breeding material, and with our narrowing genetic stock, superior varieties with different genetic characteristics than our current varieties (against heat stress and diseases) tolerant, high quality) is becoming increasingly difficult to develop. For all these reasons, it is necessary to preserve wild species for the development of new varieties for different purposes and to offer them to researchers working in breeding programs.

CONCLUSION

In this study, the Karacadağ region was visited and the current locations of wild wheat were determined with GPS. Villagers and shepherds were interviewed, and they were made aware of the fact that collecting stones, opening new lands and irregular grazing of animals put pressure on wild wheat and if this continues, they may disappear in the coming years. It was also conveyed that rice cultivation should be done in more regular and local areas where there are no wild wheat areas. As a result, wild species detected on site and protected will be saved from the threat of extinction and will provide breeders with a more regular genetic resource. Thus new varieties with superior qualities will be developed and will contribute to our national economy by obtaining more and higher quality products from a unit area.

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Harmful Insects of Leafy Vegetables and Control Methods

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ABSTRACT

Leaf vegetables are plant leaves that are consumed as vegetables, often with their petioles and shoots, if they are tender. They are also known as leafy greens, vegetable greens, or just greens. Leaf vegetables that are consumed raw in a salad are known as salad greens, whereas those that are consumed cooked are known as pot herbs. The number of plant species having edible leaves is close to one thousand. The majority of leaf vegetables are produced from herbaceous plants with short lifespans, like spinach and lettuce. Many species of woody plants also produce edible leaves. Although they are typically exclusively consumed during times of famine, the leaves of many fodder crops are also edible to people. Alfalfa, clover, and the majority of grasses, such as wheat and barley, are a few examples. These crop leaves may be used in food processing, such as pulping and pressing for juice or drying and grinding into powder. Since leaf vegetables are photosynthetic tissues, their vitamin K levels are especially noteworthy despite the fact that they include many other common plant components. The most prevalent form of the vitamin, phylloquinone, has a direct role in photosynthesis.

Keywords: Leafy Vegetables, Pests, Diseases, Control.

INTRODUCTION

Leafy vegetables are rich sources of minerals and vitamins. Leafy vegetables form a highly variable group of crops grown for their edible leaves. Especially lettuce and spinach World are recognized as leafy vegetables of economic importance throughout the World. In generally, Cabbage, lettuce, spinach, Swiss chard, purslane, parsley, rocket, mint, dill and asparagus are grown all of the world (Table 1).

There are many diseases, pests and weed species that cause damage alone or together in leafy vegetables, which are cultivated in large areas in the World and have an important place for domestic consumption and exports. The most important of diseases, pests and weed in the production areas of leafy vegetables. Among insects the important ones are aphids, thrips, soil fleas and mites. In order to obtain more and better-quality products, it is of great importance to control diseases, pests and weeds in the production areas of leafy vegetables (Anonymous, 2025a).

Table 1. Common and scientific names of leafy vegetables and their families

Common name	Scientific name	Family
Spinach	*Spinacia oleracea* L.	Amaranthaceae
Lettuce	*Lactuca sativa* L.	Asteraceae
Cabbage	*Brassica oleracea* L.	Brassicaceae
Mint	*Mentha* spp.	Lamiaceae
Dill	*Anethum graveolens* L.	Apiaceae
Purslane	Portulaca oleracea L.	Portulacaceae
Rocket (Aragula)	*Eruca vesicaria* Mill.	Brassicaceae
Presley	*Petroselinum crispum* (Mill.)	Apiaceae
Asparagus	*Asparagus officinalis* Carl Linnaeus	Asparagaceae
Chard	*Beta vulgaris* subsp. *vulgaris*)	Amaranthaceae

Insects of Leafy Vegetables

Spinach* (*Spinacia oleracea* L.) *and its harmful insects

A leafy herbaceous annual plant in the Amaranthaceae family, spinach is cultivated for its edible leaves. The basic leaves of the spinach plant are borne from the center of the plant and have dimensions of between 1 and 15 cm wide and 2 to 30 cm in length. The leaves might have a flat or wrinkled appearance and grow in a rosette. The shrub bears 2-4 mm-diameter, yellow-green, little blooms. Little clusters of fruit containing seeds are produced by the flowers (Anonymous, 2025b).

***Myzus persicae* Sulzer (Hem.: Aphididae)**

The body of the peach aphid is oval and the adults are 1.2-2.3 mm long, ranging in color from light yellow to green, but also pink. The winged forms are usually larger than the wingless forms. It has primary and secondary hosts. It overwinters as viviparous during the vegetation period in greenhouses and places with mild winters. If an aphid infestation is severe, leaves may become yellow or distorted, and necrotic spots may appear on the leaves or stunted shoots may develop. Aphids also secrete a sticky, sugary substance called honeydew, which promotes the growth of sooty mold on the plants (Capinera, 2001; Annis et al., 1981).

***Macrosiphum euphorbiae* Thomas (Hem.: Aphididae)**

Winged females are olive green or pinkish in color. Antenna are longer than the body. The cornicle is cylindrical and two times longer than the caudal. The hairs on the caudal and head are quite long. Wingless viviparous female with antennal projection on the head. Cauda has a spiny pattern. It prefers rose as its primary host and potato as a secondary host in Solanaceae. Both aphid species are vectors of potato leaf curl virus (Alyokin et al., 2011; Atamian et al., 2013; Narayandas and Alyokhin, 2006).

Aphis fabae **Scopoli (Hem.: Aphididae)**

The winged adults are shiny black, the corniculus, caudae and head are black. Wingless viviparous, large round body, black green appearance. Corniculus short and conical in shape. It has a very large number of hosts. They overwinter in the primary host as eggs. The presence of cornicles, which are tubular projections that protrude from the aphid's body and often do not move quickly when disturbed, is one of its distinguishing characteristics. Adults and nymphs of aphids live in colonies on the leaves, shoots and stems of plants. Aphids feed by sucking plant sap. They cause curling and deformities in the leaves and fresh shoots they feed on. Plants with high densities of aphids pause and cannot continue their normal development. Yield decreases and the quality of the product deteriorates. If the pest density is high during the new development period of the plant, the plant dies. Fumagin occurs when the sweetish substance secreted by aphids covers the plants and saprophytic fungi develop there. As a result, photosynthesis in the plant decreases, resulting in loss of quality and quantity of the product. The secretions produced by aphids while feeding on the plant cause deformation and drying of the plants. They also cause indirect damage by carrying viral agents (Gumovskaya, 1988; Dugles, 1997, Bansal et al., 2021).

Management

Aphid infestations can be controlled by pruning them out if they are restricted to a small number of leaves or stems; Prior to planting, inspect transplants for aphids; if available, use tolerant varieties; Aphids can be discouraged from feeding on plants by using reflecting mulches, such as silver-colored plastic; robust plants can be sprayed with a powerful stream of water to remove aphids from their leaves; Plants usually withstand low to medium levels of aphid infestation, therefore insecticides are typically only needed for severe infestations; Generally, the most effective technique of management is to use insecticidal soaps or oils like canola or neem; Before using, always read the product labels to determine the precise usage instructions (Cammel et al., 1989, Anonymous, 2024a).

Spodoptera exiqua **Hübner (Lep.: Noctuidae)**

S. exiqua, its general appearance is brown. Female butterflies lay their eggs in packets on the upper part of plant leaves. One female lays 300-600 eggs. The newly hatched larvae first feed by eating the eggshell. The larvae first stay together. But then they disperse and feed by gnawing the epidermis layer of the leaf. Holes appear in the damaged leaves. The main damage causes crop loss by cutting the growth point of seedlings. The forewings of *S. praefica* lack the fuzzy white band and are lighter in colour (Geenberg et al., 2021; Taylor and Riley, 2008).

***Spodoptera prefica* Grote (Lep.: Noctuidae)**

S. praefica's hindwings are either gray or white with a tiny brown dot on the ventral side. The larvae have an inverted "y" pattern on their head and are black with yellow streaks. They consume the leaves of many types of herbaceous plants. Solitary, or densely clustered, round to asymmetrical holes in foliage; excessive feeding by immature larvae results in skeletonized leaves; shallow cuts on fruit that are dry; On the leaves, there may be clusters of 50–150 eggs. The clusters appear cottony or fuzzy due to the whitish scale covering them. Young larvae are pale green to yellow in color, while older larvae are typically darker green with a pink or yellow underside and a dark and light line running along the side of their bodies (EPPO, 2021; Will et al., 2020).

Management

Although there are chemicals available for commercial control, many of them are not effective in controlling armyworm larvae. Other organic methods of controlling armyworms include applying Bacillus thuringiensis and using natural enemies that parasitize the larvae (EPPO, 2021; Will et al., 2020).

***Trichoplusia ni* Hübner (Lep.: Noctuidae)**

The medium-sized *T. ni* belongs to the Noctuidae family of moths, also known as owlet moths. Because of its unusual crawling movement and preference for host plants, it goes by the common name. The larva's back forms a loop when it crawls, hence the name "looper." Leaf holes might be large or microscopic, and damage is frequently severe. Caterpillars are a light green color with white lines going down each side of their bodies; they may be identified by the way their bodies curve when they move. Eggs are white or pale green in color and are placed singly, usually on the bottom leaf surface near the leaf margin. Caterpillars have a broad host range, whereas adults are dark-colored moths that overwinter as pupae in crop detritus in the soil (Capinera, 2001; Ignoffo et al., 1963).

Management

In order to create traps to capture the moth, a lot of study is being done on cabbage looper pheromones. The female pheromone was isolated in the early stages of study in order to identify the chemicals and maybe create a synthetic version of the natural female pheromone. A synthetic variant that works biologically like the natural form has been created by scientists. Black light traps and the synthetic female pheromone have been employed to study populations of cabbage loopers in different parts of the United States. Both male and female cabbage loopers can be attracted and trapped using synthetic male pheromone, which has also been manufactured. The combination of male pheromones made it easier to catch both food-seekers and females looking for mating (Berger, 1966; Debolt, 1979).

Natural enemies typically keep looper populations in check. If they do become problematic, the larvae can be manually removed from the plants; applying *Bacillus thuringiensis,* which effectively kills younger larvae, is an organically acceptable control method; chemical sprays should be used with caution as they may harm natural enemy populations

Lettuce (Lactuca sativa L.) and its harmful insects

Lettuce is an annual or semi-annual temperate climate vegetable with broad green leaves from the Asteraceae daisy family. The leaves are usually eaten raw as a salad, but in some countries, such as China, the root and leaves are also cooked. A source of beta carotene with antioxidant properties, lettuce contains plenty of vitamin A. It is also a good source of folate, vitamin K and C. Vitamins in lettuce, which contains minerals such as calcium, iron, magnesium, phosphorus, potassium, sodium and zinc, are vitamins A, K, C as well as thiamine (B1), riboflavin (B2), niacin (B3), B6 and E (Anonymous, 2025c)

***Hyperomyzus lactucae* L (Hem.: Aphididae)**

Adults without wings have a broad spindle-shaped body, pale legs, and an opaque green colour. Those with wings have a dark area on top of their abdomen. It is well known that this species has low reproductivity and a comparatively short adult life. High numbers of this aphid in the field are typically linked to a large number of hosts. The growth and reproduction rate of this aphid rises with rising mean daily temperatures. On the other hand, life expectancy and overall fecundity decline. Individuals with wings have a longer developmental period, a lower rate of reproduction, and lifetime fecundity. The hosts of *H. lactucae* are many plants belonging to the families Asclepiadaceae, Asteraceae, Compositae, Cruciferae, Grossulariaceae and Saxifragaceae (Singer et al., 1976; Shu-sheng and Hughles, 1987).

***Myzus persicae* (see Spanach)**

***Uroleucon sonchi* L (Hem.: Aphididae)**

The huge, smooth, glossy aphid *U. sonchi* is either dark brownish or pinkish-brown in colour. This species consumes a wide variety of Asteraceae plants, mostly those in the tribe Lactuceae. Additionally, it was discovered on the undersides of the leaves, in the axils, and on the rosettes during the winter. However, it was infrequently observed on the flowering heads, which are typically occupied by the polyphagous *Macrosiphum euphorbiae* (Thomas), the sow thistle aphid, and *Hyperomyzus lactucae* (Linnaeus). Based on observations, it appears that H. lactucae and U. sonchi do not frequently coexist on the same plant; when they do, one species is typically seen in smaller quantities. With both of the Sonchus species which are ephemeral, synanthropic weeds of Palaearctic origin that are now nearly global in range and exist year-round in temperate regions of Australia (Carver, 1999; Rennink and Dieleman, 1989).

Management (See Lettuca)

***Lipaphis erysimi* (Kaltenbach) (Hem.: Aphididae)**

One species of aphid belonging to the Aphididae family is *L. erysimi*. It is also known by the popular name turnip aphid and mustard aphid. It only eats cruciferous plants and is widespread throughout the world's temperate and tropical regions. The wingless females give birth to about 100 offspring in the course of a few weeks, making them nearly entirely female and extremely prolific. The turnip aphid is primarily viviparous, though it has occasionally been observed to lay eggs. It is incredibly prolific; in warm climates like Texas, up to 35 generations have been documented annually. Over the course of twenty to forty days, the wingless females give birth to up to six young each day, for a total of eighty to one hundred young (Capinera, 2001; Amjad, 1992; Bahadoria et al., 1995).

***Aphis fabae* (see Spanach)**

***Aphis gossypii* Glov. (Hem.: Aphididae)**

The adults are dark green to black in colour. The legs range from yellow to green. The antennae are light yellow in colour and extend to the middle of the body. *A. gossypii* overwinters as eggs or wingless females. From March onward, winged forms begin to appear. The pest has not changed host. It passes through cotton fields in June. It causes damage to greenhouses from seedling planting. Adults and nymphs live in colonies on the leaves, shoots, and stems of plants. They feed by sucking the sap of the plant. Yields are reduced, and quality deteriorates. If the aphid density is high during the new development period of the plant, the plants dry up (Beckerman et al., 2002; Han et al., 1998; Schirmer et al., 2008).

***Aphis spiraecola* Patch (Hem.: Aphididae)**

Aphids of the genus *A. spiraecola* were first identified by Edith Marion Patch in 1914. Common names for it include apple aphid, green citrus aphid, and spirita aphid. It is found all across the world, but is most prevalent in the US. Ornamentals, apples, and citrus are all harmed by *A. spiraecola. [*8…Additionally, they spread a lot of plant viruses, which put entire crop yields at danger of infection. As a result, *A. spiraecola* has a considerable detrimental effect on crop productivity and may cause economic loss; on the other hand, they don't appear to have much of an effect on aquaculture, native animals and plants, human or animal health, trade, transportation, tourism, or the environment/biodiversity (Edith, 1923; Blackman, 1984; Gomez et al., 2016).

Management (See spinach)

Cabbage (Brassica oleracea) and its harmful insects

Cabbage is a biennial, leafy plant and is grown as an annual plant unless we want to obtain seeds. The shape of the cabbage core, called the head, can be conical or round. Famous for its colorful leaves, the most common colours of cabbage are dark green, light green, red or purple. The colour usually depends on the variety of cabbage we decide to grow. Some species have smooth and flat leaves, while others have wrinkled leaves. Usually cabbage is divided into different types according to the harvesting plan. Cabbage is a nutrient-rich and extremely healthy food with a high-water content (more than 92%). Leafy vegetables such as cabbage contain essential nutrients that strengthen our immune system and help us to be healthy. It is a low-calorie food. Cabbage can offer people protein, minerals, iron and be an important source of vitamins (vitamin K, vitamin C). There are many harmful insects that cause crop loss in cabbage cultivation (Maggioni, 2015).

Hellula undalis F. (Lep.: Pyralidae)

The adult is grayish-yellow, brown. There are light brown spots on the forewings. Eggs are laid singly or in clusters between roots and stems, sometimes on leaves. The egg is bright white like a pearl. The newly hatched larva is cream colored. It usually binds its feces with the threads it secretes at the mouth and inside the gallery it opens, thus creating a reticulated appearance. This is a typical symptom indicating the presence of the pest. It gives 3-5 offspring per year. Larvae cause the most important damage at the growth point of the plant. The plant cannot develop, it forks by giving side branches and cannot tie the head. Larvae damage young plants more. Especially in seedlings, young plants die by drying out in the 3-4 leaf period as a result of feeding. Generally, dwarfism, weakening and growth retardation in the damaged plant can be noticed immediately when compared to a healthy plant (Tran and Nguyen, 2019; Dhawan and Matharu, 2011; Ravan and Sahebzadeh, 2015).

Management

Dried, rotten plants such as cabbage and cauliflower should be collected and destroyed. Spraying should be started as soon as damaged plants are seen during nursery and field controls (Waterhouse and Norris, 1989).

Ceutorrhynchus pleurostigma (Marsh) (Col.: Curculionidae)

The adult is matte black in color and covered with scales. Eggs are laid on the main and lateral roots, root collar and soil around the root. The egg is shiny cream colored and oval in shape. When the larva hatches, it is white, cream colored, sometimes reddish. The head is brown. Adult females start laying eggs after planting cabbage and cauliflower. Hatching larvae feed on plant tissue. The pest produces only one offspring per year. Adults feed on the leaves and stems of the plants. The damage they cause in the nursery is important. The larvae of the cabbage gall midge form tumors on the roots of host plants. The growths reach the size of a pea, then they merge and completely envelop the root collar. Damage to young plants prevents development. Cabbage and cauliflower cannot form heads. Marmara Region is infested with this pest (Buntin, 1999; Graham and Gould,1980; Atak and Atak, 2008).

Management

Roots left in the field should be uprooted and destroyed. Cabbage, cauliflower and radish should not be planted in the same field on top of each other. The field should be deeply cultivated, fertilization, irrigation and care should be taken to ensure strong growth of the plants. During the transplanting of seedlings to the field, underdeveloped seedlings with signs of pest infestation should be avoided. Larvae are very sensitive to moisture. Irrigation of fully or partially harvested fields completely kills the larvae that have passed into the soil to pupate (Graham and Gould, 1980).

Pieris brassicae, Artogeia (=Pieris) rapae, Artogeia (=Pieris) napi) (Lep.: Pieridae)

The main colour of the wings is creamy white. Eggs laid in groups on the lower surfaces of the leaves are light straw yellow in color. Mature larvae are greenish gray in colour. After completing its development, the larva leaves the plant and pupates on walls, fences, tree trunks or various plant debris. Pupae are green with pointed protrusions and black and yellow spots. It overwinters as a pupa. Adult emergence starts in the second half of February in the Aegean Region and in April in other regions. It gives 2-6 offspring per year. The larvae do the damage. The larvae initially gnaw superficially between the veins of the leaves. They then eat the leaves of the plant, leaving only the thick veins. Their faces accumulate between the leaves of the plant, making the cabbage inedible (Yurt et al., 2015; Chahil and Kular, 2013; Jindal and Kular, 2010).

Management

A good method of control is to collect and destroy eggs and larvae in small areas. In addition, the pupae of the pests are found on the walls and fences around the garden. These should also be collected and destroyed (Jindal and Kular, 2010).

Eurydema ornatum L. (Hem.: Pentatomidae)

Adults have shiny black, red or whitish patterns on their body and their eggs are off-white. Nymphs are wingless, orange colored and spotless. The pest spends the winter as an adult in sheltered areas. When the weather starts to warm up in the spring, they come out of their winter quarters and their eggs are laid on the plants in rows. It gives 3-4 offspring per year. It is harmful by sucking the sap from the leaves and branches of the host plant. Leaves curl, whitish-yellow spots appear at the sucking sites, and punctures occur as a result of the spots merging, drying and falling off. Especially when they do a lot of damage during the seedling period, they can prevent the development of the seedling and dry it out. It also leaves a foul odor where it feeds. It is widely found in our country. However, it does not cause economic damage (Kıvan and Kılıc, 2000; Oncuer and Kıvan, 1995).

Management

Maintenance such as fertilization and irrigation should be done on time to ensure rapid development of plants in the early stages (Kıvan and Kılıc, 2000).

Delia brassicae (Wied.) (Dip.: Anthomyiidae)

The adult is gray. Eggs and larvae are white. In spring, depending on the climatic conditions, the adults hatch in March-May and lay their eggs in groups in the soil cracks around the root collar of young plants. The larvae hatch from the eggs and enter under the epidermis of the root collar, where they continue their development by opening galleries. They produce 2-3 offspring per year. It is harmful during the larval stage. The larva hatching from the egg enters the root collar of the plant and under the epidermis of the roots and starts its damage by opening galleries. As a result of the activity of root rot bacteria in the galleries, the root system of the plant deteriorates. Damaged cabbages turn a leaden color, their growth slows down and the outermost leaves droop downwards. When the larval density in a plant is high, yellowing or breakage of the root collar is observed (Hellquist, 1996; Eilenberg et al., 2000; Dosdall, 2000)

Management

Weeds belonging to the Cabbage family should be cleared in and around the field and cabbage roots should be destroyed after harvest. In damaged cabbages, throat filling should be done in order to form new roots that will ensure the continuation of development. Fast growing cabbage varieties should be grown. Planting time in spring should be delayed as much as possible. In places where fly damage was significant in previous years, seedling dipping and soil spraying on the rows are carried out to protect the cabbages against the first-generation larvae (Dosdall, 2000).

Plutella xylostella (L.) (Lep.: Plutellidae)

Adult wings are fringed and brown. The egg is oval, yellowish green. When the larva matures, it is pointed at both ends, dull white in color and covered with brown spots. It usually overwinters during pupation. As the weather warms up in spring, adult emergence begins. Adults are active at night. Females usually lay eggs on the underside of leaves in small groups along the veins. The larva emerging from the egg pierces the epidermis and starts to open galleries by eating porous thick tissues. It gives 2-6 offspring per year. Larvae feed by gnawing the leaves from the lower to the upper epidermis. Only a thin membrane remains on the upper side of the gnawed parts. When the leaves are viewed from above, the defeated parts appear silvery-white and have many holes, large and small. Especially seedlings and young plants stop growing and may even dry out. In addition to feeding, the larvae also contaminate the leaves with their faces and reduce the leaf quality (Sarfraz et al., 2005; Abro et al., 1994; Bauer et al., 1998).

Management

Proper fertilization, regular watering and frequent hoeing should be done to ensure that the cabbage grows quickly and vigorously. Weeds that can shelter the cabbage leaf moth should be controlled. Cabbage or cauliflower residues left in the field after harvest should be collected and destroyed. Spraying is decided when damage symptoms are widespread. Spraying is applied in May-September when dense larvae and widespread damage symptoms are observed (Chauhan and Sharma, 2004).

Mamestra brassicae L. (Lep.: Noctuidae)

In adults, the forewings are yellowish in colour, the stigma is prominent kidney-shaped. The egg is hemispherical with a flattened base. The newly hatched larva is white to pale yellow in colour. Pupa is pale brown. The pest spends the winter in the soil during pupation. Females lay their eggs in clusters on plants. The pest feeds on the cabbage plant, especially on the navel, flowers and leaves of cauliflower and contaminates the plant with its faces. It is a polyphagous pest (Johansen, 1997; Klingen et al., 2002; Güçlü et al., 2006).

Management

Eggs and early larvae that feed on masse are collected and removed from the field (Güçlü et al., 2006).

Brevicoryne brassicae L. (Hem.: Aphididae)

Aphids on cabbage are little insects. Their appearance is dusty, grey, or white due to a greyish waxy coating. Clusters ranging in colour from greenish to grey to black might be encountered. They seriously harm crops including radish, cauliflower, and cabbage. Aphids obtain nourishment by sucking sap from their host plants and secreting a delicious syrup that entices ants. Aphids are shielded from their natural enemies by the ants in return. Their feeding causes leaf curl, especially in older plants, by deforming the leaves. Plants that are fed for extended periods of time will discolour, wilt, and become stunted. The yield losses caused by these aphids can be significant. (Adalgisa et al., 2018; Halimie et al., 1992).

Management (See lettuca)

Delia radicum L. (Dip.: Anthomyiidae)

By digging into the roots of vegetables such as radishes, swedes, and turnips, cabbage root fly maggots, which resemble regular house flies endanger the roots of these plants. The headless, legless larvae have the ability to completely destroy newly transplanted plants and seedlings, opening doors for diseases like soft rot and blackleg. When impacted by these damaging pests, cold-season crops are more susceptible and frequently show symptoms including wilting, pale leaves, and stunted growth. It's critical to identify infestations and take quick action to protect your cabbage crops (Raworth, 1984).

Management

The trap can capture very high numbers of flies. For satisfactory performance the cylindrical sticky insert should be placed inside. As an alternative, insecticide could also be placed into the catch container. The cabbage root fly trap is ideal for the detection of the presence of the pest. Monitoring of the flight pattern and the timely detection of mass outbreaks can also be performed (Anonymous, 2017).

Aleyrodes proletella L. (Hem.: Aleyrodidae)

Adults have a length of 1.5 mm. Their wings are white with four gray patches. A powdered wax is the reason the wings appear white. The underside is covered in a layer of wax and is yellow, whilst the head and thorax are dark. The eyes have a red hue. They infiltrate the leaf phloem and contaminate it by releasing honeydew, which promotes the growth of mold. Typically, four to five generations occur annually. A generation takes anywhere from three to six weeks to fully grow. Up to 150 eggs can be laid by a female *(*Broekgaarden et al., 2012).

Phyllotreta striolata F. (Col.: Chrysomelidae)

P. striolata, often known as the striped flea beetle, is a tiny flea beetle that is 1.5 to 2.5 mm long, lustrous black with a hint of green, and has a wavy amber line that runs the length of each elytron (wing cover). It is a pest of brassicas, including cabbage. Because of its thicker hind legs, the beetle may jump like a flea when it is startled. The tiny, white, oval-shaped to elongated eggs are deposited in the ground near the host plant. When completely developed, the white, brown-headed larva measures 3.2 to 5.0 mm in length. Its head is close to three pairs of small legs. The white pupa resembles the adult in terms of size and shape. The larvae are not major pests even though they feed on the roots of their host plants while living in the soil. Rather, adult beetles feeding on the leaves are the main cause of harm. Beetles create tiny, circular pits in the cotyledons and leaves of immature plants with their teeth. Little "shot holes" are left in the leaves as the plants enlarge due to the ultimate drying out and falling away of the thin layers of tissue that remain. It is possible for young plants to die from this kind of damage. If there is significant damage, the seedlings might not survive. Furthermore, bugs could spread plant diseases (Andersen et al., 2006; Gruber et al., 2009).

Management

The population number of flea beetles in each plot, as determined by captures on yellow sticky traps and direct eye counts, was found to be associated with the degree of damage at harvest. Even though just 15% of the leaf area was removed, removing the outer two leaves of a single *Brassicae rapa* plant decreased the total number of holes per plant by 40% (Andersen et al., 2006).

Psylliodes chrysosephala L. (Col.: Chrysomelidae)

P. chrysocephala has a length of 3.0-4.0 mm. It comes in a variety of colors, but is typically a deep metallic blue. It can jump thanks to its huge hind femora, much as all flea beetles. These have a darker hind femur and are orange-red in colour. On the leaves of their host plants, adult beetles' mate in late August. Five to ten days after copulation, the eggs are initially laid. A single female may deposit up to 1000 eggs during oviposition, which occurs from the end of September through the winter and ends in mid-April. The eggs are placed in tiny clusters in the soil 3-5 cm below the host plant. After around 60 days, the larvae hatch and begin feeding inside the host plant's stem and leaves. In the early summer, fully grown larvae emerge and pupate in the ground. Every year in May, newly emerged grownups become visible. After the mature rape plants are harvested in the summer, adults may go through an aestivation stage. Some adults overwinter after mating in late summer (Kig, 2003; Hubble, 2012).

Management

Symptoms include deterioration of the roots and growth points and general destruction of the plant. For prevention and control, pyrethroid application in the fall months is prophylactically sprayed in the fields as the cost of pyrethroid application is quite low, but it should only be applied when it is very necessary. At the end of October and the beginning of November, the number of larvae should be observed, especially in the seedling stage of canola. Examining the seed of the previous harvested crop and using water traps also allow early detection of the amount of the pest (Hubble, 2012).

Trichoplusia ni Hübner (Lep.: Noctuidae) (see Spinach)

Mint (Mentha spp.) and its harmful insects

Mints are grown for their leaves, which are commonly used as a flavouring. They are members of the plant family Lamiaceae and belong to the genus Mentha, which has about 20 species. The majority of mint plants are aromatic perennials with upright, branching stems and oppositely paired, oblong to ovate or lanceolate leaves. The leaves have a serrated edge and are frequently covered in microscopic hairs. Depending on the kind, mint plants produce a terminal flower spike with either white or purple flowers. Mint plants have a rapid rate of growth and can spread widely. Once established, they will continue to grow for many years, reaching heights of 60 to 90 cm (Bunsawat, 2004).

***Aphis gossypii* Glov., *Myzus persicae* Sulzer (Hem.: Aphididae) (See lettuca)**

***Fraklinella occidentalis* Pergande (Thy.: Thripidae)**

A high population may cause the leaves to become deformed, covered in coarse stippling that gives them a silvery appearance, or dotted with black excrement. The bug is 1.5 mm in size, slim, and best observed via a hand lens; Nymphs are smaller and have a paler colour than adults, which range in color from pale yellow to light brown. Spread viruses, like as the tomato spotted wilt virus, which, once ingested, gives the insect lifetime immunity to the virus (Reitz, 2014; Buitenhuis and Shipp, 2008).

Management

Plant away from cereals, onions, and garlic where a lot of thrips might accumulate; apply reflective mulches early in the growing season to keep trips away; Use the proper insecticide if trips become an issue (Bauske, 1998).

Tetranychus urticae Koch. (Arac.Tetranychidae)

Leaves with yellow stippling, a bronze appearance, webbing covering the leaves, and mites that can be seen as small moving dots on the webs or underside of the leaves, best observed via a hand lens; typically, not noticed until the plant exhibits noticeable symptoms; As leaves turn yellow, they may fall off the plant. Dusty environments are ideal for spider mite growth, and plants that lack water are more vulnerable to infestation (Kumral and Atalay, 2013; Boom et al., 2003).

Management

Spider mite populations can be decreased in home gardens by spraying plants with a powerful water jet; if mites become an issue, treat plants with insecticidal soap; however, some chemical insecticides may actually increase mite populations by eliminating natural enemies and encouraging mite reproduction (Birch, 1948).

Dill (Anethum graveolens L.) and its harmful insects

A. graveolens, often known as dill, is a herbaceous annual plant in the Apiaceae family that is cultivated for its herbaceous leaves. Dill is an upright-growing, very fragrant herb. It has branching stems and tiny, pliable, fiber-like leaves that are blue-green in colour and grouped in an open cone. Dill, sometimes known as garden dill, is said to be native to the Mediterranean region, however its exact origins are unknown (Santos et al., 2002).

Caveriella aegopodii (Scopoli) (Hem.: Aphididae)

A heavy infestation of aphids can result in yellowing leaves, distorted leaves, necrotic spots, and/or stunted shoots. Aphids secrete a sticky, sugary substance called honeydew, which promotes the growth of sooty mould on the plants. Aphids are small, soft-bodied insects that are typically green or yellow in colour. The presence of cornicles, or tubular projections, which protrude from the aphid's body and usually do not move quickly when disturbed, is one of its distinguishing characteristics. The carrot, celery, and parsnip are also targeting for the willow-carrot aphid. Additionally, the virus-carrying insect can spread the carrot motley dwarf complex, which is characterized by the yellowing of the central leaves, the reddening of the outer leaves, the proliferation of roots, and the overall dwarfing of the plant. The virus is a combination of carrot mottle virus (CmoV) and carrot red leaf virus (CRLV) (Godoy and Cividanes, 2002; Kandoria and Jamwal, 1988; Kuo et al., 2006).

Management

Aphid infestations can be controlled by pruning them out if they are restricted to a small number of leaves or stems; Prior to planting, inspect transplants for aphids; if available, use tolerant varieties; Aphids can be discouraged from feeding on plants by using reflecting mulches, such as silver-coloured plastic; robust plants can be sprayed with a powerful stream of water to remove aphids from their leaves; Plants usually withstand low to medium levels of aphid infestation, therefore insecticides are typically only needed for severe infestations; Generally, the most effective technique of management is to use insecticidal soaps or oils like canola or neem; Before using, always read the product labels to determine the precise usage instructions (Kuo et al., 2006).

Aphis craccivora Koch (Hem.: Aphididae)

One little species of aphid is called *A. craccivora.* The female's legs are colored in shades of brown or yellow, and her torso is glossy and black or dark brown with noticeable cauda, or tail-like projection. The six segments of the antennae are pale proximally, or toward the body, and dark distally, or away from the body, along with the limb segments, cauda, and cornicles. The nymphs have a thin layer of wax on their dorsal surface, but the adults do not. *A. craccivora* damages the leaves, shoots and fruits of the host. It reduces seed and fruit yield, shoots and leaves fail to develop, deform and shrivel due to damage (Tsai and Wang, 2001; Özder and Sağlam. 2013).

Management (See Lettuca)

Neomyzus circumflexus* (Bukton*) (Hem.: Aphididae)

Reproduction of the spotted greenhouse aphid only occurs through parthenogenesis, with unfertilized fertile females continuously producing new generations of females. There is no sexual phase in the life cycle. Wingless females of the spotted greenhouse aphid are shiny whitish, yellowish or green, with black diagonal stripes interrupted along the midline on the back of the head and a large horseshoe-shaped spot on the back of the abdomen. These black markings can be quite variable. The background colour of immature *N. circumflexus* is usually the same as that of the parents, but lacks the typical black markings. Spotted greenhouse aphid colonies can greatly reduce plant vigour and kill the plant by sucking up plant sap. However, aphids at low densities can also damage plants, producing large amounts of fresh sap that provides an excellent substrate for fumagin. Large moldy areas covering the leaves can reduce photosynthesis and also cause the plant to become an unattractive plant with a much lower market value. *N. circumflexus* can also transmit plant virus (Wieczorek and Chłond, 2020; Ware et al., 2017).

Management (See spanach)

Purslane (Portulace oleraceae L.) and its harmful insects

Purslane, is a plant from the purslane family and is a vegetable whose leaves are used in salads or cooked like spinach. It originates from the Middle East and India, but is found in many parts of the world. It has been found to contain the highest amount of Omega-3 among vegetables. Purslane is an important food source whose benefits are countless. Rich in iron, calcium, potassium and vitamin C, purslane contains more omega 3 fatty acids than other green leafy vegetables. However, since it is a rich source of potassium, it is recommended not to be consumed with blood thinners (Anonymous, 2024b).

Schizoporella pilicornis (Holmgren) (Hym.: Argidae)

During its larval stage, the tiny bug *S. pilicornis* only consumes Purslane plants. As soon as the grub-like larvae hatch out of their egg, they start munching on Purslane leaf. A blotch leaf mine is produced when an insect burrows into a leaf and destroys it from the inside out. Damage from purslane sawflies manifests as black dots and white lines that cover the whole leaf. Purslane sawflies can produce multiple generations in a single growing season since they have a short life span and can deposit up to several dozen eggs. Removing and destroying damaged leaves is the quickest technique to deal with S. *pilicornis.* The larvae migrate to the soil and go through the pupae stage after feeding on the plant, and then they emerge as adults and lay eggs. Once the damaged foliage from the leaf mines has been removed, till the surrounding soil to disturb and eliminate the pupae stage of *S. pilicornis* (Smith,1971).

Management

To treat, *S. pilicornis* spray the plant with horticultural oil or a pesticide. If the eggs or larvae haven't yet caused damage to the leaves, these products will kill them. Because *S. pilicornis* have a limited life cycle and can infest a plant with numerous generations of insects, treatment may need to be applied over a few weeks. If *S. pilicornis* is bothering the plant, spray it with horticultural oil or a pesticide. Any eggs or larvae that have not yet harmed the leaves will be killed by these products. Given the short lifespan of *S. pilicornis* and the possibility of numerous generations of insects infesting the plant, treatment may need to be applied over a few weeks (Anonymous, 2025d).

Hypurus bertrand (Perris) (Col.: Curculionidae)

H. bertrand feeds on Purslane. The larvae of leaf miners burrow inside the leaves and consume them from within. The route the larvae followed as they made their way through the leaves is indicated by white lines on the leaf's exterior. The larvae leave the foliage after feeding and develop into weevils, which are beetles.

Purslane may suffer from an infestation of Leaf Miners. An entire family of leaf miner weevils can destroy a plant in a matter of weeks, and one insect can lay hundreds of eggs. Eliminate foliage that exhibits symptoms of leaf-mining damage promptly. To kill the larvae and stop them from maturing and laying new eggs, destroy the damaged leaves. Removing leaves is a laborious method of treating leaf miner weevils, and it can take several weeks to eradicate the infestation (McFadyen, 1994; Colonnelli, 2004).

Management

Apply horticultural oil or insecticide on Purslane to stop leaf miner weevil infestations. Treatment will eliminate unspotted eggs and larvae and stop additional insects from invading the plant. Every month, give the plant a spray and check it for any signs of harm. If it is found evidence of leaf-mining damage, remove the injured leaves and increase the frequency of spraying to once a week (Colonnelli, 2004).

Aphis gossypii (See Lettuca)

Rocket, Aragula (Eruca vesicaria Mill.) and its harmful insects

Available in the wild and cultivated for agricultural purposes. Arugula, sometimes called rocket or roquette, is a leafy green that tastes good and is loaded with nutrients. It's frequently used as a garnish on salads and sandwiches. Many gardeners prefer it because of its quick growth and adaptability to a wide range of recipes. Even though it is hardy, arugula is susceptible to a number of pests that can hinder its development and productivity. Maintaining the quality of the produce and growing a robust arugula harvest require efficient pest management. Arugula is a healthy option, especially as it is rich in vitamin A, vitamin K, vitamin C, iron and calcium. It is also rich in antioxidants and other plant compounds. In this way, it contributes to strengthening the immune system and protecting against diseases (Yaniv et al., 1998).

Lipaphis erysimi (Keltenbach) (Hem.: Aphididae)

The female without wings has a pale or greyish green colour and two rows of dark stripes on her thorax and abdomen that merge into one band close to her abdomen's tip. The legs are pale with dark joints, the cornicles are pale with dark ends, and the antennae are dark. There is a light dusting of white powder on the body. The turnip aphid is primarily viviparous, though it has occasionally been observed to lay eggs. It is incredibly prolific; in warm climates like Texas, up to 35 generations have been documented annually. Over the course of twenty to forty days, the wingless females give birth to up to six young each day, for a total of eighty to one hundred young. Although they can spread to other plants, winged females give birth to fewer offspring (Kawada and Murai, 1979). Many plant diseases that cause larger losses than direct feeding harm are transmitted by aphids. This is frequently the most severe effect of an infestation of aphids. Approximately ten non-persistent plant viruses, such as the mosaic diseases of turnip, radish, and cauliflower, and the black ring spot on cabbage, are spread by the turnip aphid (Blackman and Eastop, 1984). Aphids just assist in the spread of the virus and the infection process in nonpersistent transmission, where the virus replicates within the plant (Sachan and Bansal. 1975; Capinera, 2001).

Crickets (Gryllus sp.) (Ort.: Gryllidae)

The bodies of crickets, which range in size from tiny to medium, are primarily cylindrical and somewhat flattened vertically. The head is spherical, with two big compound eyes situated just behind the long, thin antennae that emerge from cone-shaped scapes (first segments). Populations of crickets proliferate amid desert vegetation, Sudan grass, and cotton farms. Crickets migrate from these fields into arugula fields at the end of summer. Overhead sprinkler irrigation promotes inhabitancy by giving crickets the perfect habitat because the female Eggs are laid by crickets in moist soil (Tinghitella et al., 2018).

Management

Disking fields as soon as they are harvested will assist keep the population of crickets under control (Bernstein et al., 1985).

Pogomyrmex rugosus Emery (Hym.: Formicidae)

Although ants are not a common agricultural problem in growing aragula, they may be cunning when they do appear in a field. The main problem period for harvester ants is during stand establishment. They will return to their nest with the sown seeds and seedlings, and they will eat the seedlings. In a field with ants, the ant hill is usually surrounded by no vegetation. In general, mature arugula plants are not harmed by ants. Because they swarm individuals and bite them painfully, ants can also be a nuisance to those who work in the field (Lighton, 1893; Del Toro et al., 2010).

Managenent

Ant migration into the field can be reduced by erecting a canal filled with water around the field. Nevertheless, if the ants are already in the field, this approach is impractical (Toro et al., 2010).

Flea beetles; *Phyllotreta striolata (*Fabricus*), Epitrix cucumeris* Harris, *Phyllotreta pusilla* Horn, *Phyllotreta ramosa* (Crotch) (Col.: Chrysomelidae)

Flea beetles come in different varieties, but they all have huge hind legs and a hard body. Flea beetles can jump a long distance when disturbed thanks to their big rear legs. The female flea beetle deposits her eggs in the ground, on leaves, or in the arugula plant's cracks and holes. The larvae of the arugula plant consume either the leaves or the roots, depending on the type. The arugula plant is another food source for adult beetles, who gnaw tiny pits and holes into the underside of the leaf. The pests that cause the most damage during stand establishment are these insects. A stand of seedlings might be stunted or even killed by a tiny population *(*Linzmeier, 2018).

Management

In and around the field, it's critical to remove weeds and volunteer plants that can serve as flea beetle hosts. Crop rotation is also crucial, but not all crops can be rotated because flea beetles have a broad variety of hosts. Disked arugula fields are necessary. Additionally, as Sudan grass frequently shelters populations of flea beetles, it is crucial that it be plowed under within a week of the final harvest. Trap crops can be used as sacrificial planting that is intended to be highly attractive to insect pests and thus draw pests away from the main crop *(*Linzmeier, 2018).

Presley [Petroselinum crispum (Mill.)] and harmful insects

Grown for its leaves, which are consumed as a herb, parsley is a herbaceous biennial or perennial plant of the Apiaceae family. The aromatic parsley plant has an upright growth habit, hollow stems that are branching, and dark green, flat or curled leaves that are grouped alternately on the stalks. Younger plants have a rosette formed by the leaves. On umbels, the plant has tiny yellow blooms. It is often grown as an annual and harvested after one growing season. Garden parsley is another name for parsley, which is probably Mediterranean in origin. It contains vitamins such as vitamin A, C, K, folic acid and minerals such as potassium, calcium and iron. In addition, parsley, which is very rich in fiber, is also known for having no cholesterol content. Parsley, which has anti-inflammatory and antibacterial properties, is also rich in flavonoids. With these properties, parsley can be listed among healthy foods and is recommended to be consumed by nutritionists. As a culinary herb, parsley leaves can be used either fresh or dried. As a garnish, fresh leaves are also frequently utilized. Certain varieties have edible taproots that can be consumed like vegetables. The parsley blossoms can be used to extract essential oil, which is then utilized as a flavoring (Meyer et al., 2006).

***Cavariella aegopodii* (See Dill)**

Mythimna unipuncta (Haworth) (Lep.: Noctuidae)

Plants may have single or closely clustered holes in their foliage that range in shape from round to irregular; young larvae that feed heavily can cause leaves to become skeletonized; fruit may have shallow, dry wounds; there may be egg clusters of 50–150 eggs on the leaves, which are covered in a whitish scale that gives the cluster a fuzzy, cottony look; older larvae are typically darker green in color with a dark and light line running along the side of their bodies and a pink or yellow underside. An insect can have three to five generations annually (Guppy,1969; McNeil,1987)

Management

Although there are chemicals available for commercial control, many of them are not effective in controlling armyworm larvae. Other organic methods of controlling armyworms include applying Bacillus thuringiensis and using natural enemies that parasitize the larvae (Guppy,1969; McNeil,1987).

***Agrotis* spp.**

Young transplants or seedlings may have their stems cut at the soil line; if infection develops later, irregular holes are eaten into the fruit's surface; the damage-causing larvae are typically active at night and hide during the day in the soil at the base of the plants or in falling plant debris; they are 2.5–5.0 cm (1–2 in) long and can have a variety of patterns and colors, but when disturbed, they typically curl up into a C shape (Anonymous, 2025 e)

Management

After harvest, or at least two weeks prior to planting, remove all plant debris from the soil; this is particularly crucial if the prior crop was another host, such beans, alfalfa, or an a leguminous cover crop; Larvae severing plants can be avoided by covering the lowest three inches of plant stems above the soil line with plastic or foil collars that reach a few inches into the ground; Apply the proper insecticides to affected portions of the garden or field if it is not growing organically; hand-pick larvae after dark; and cover the base of the plants with diatomaceous earth, which forms a sharp barrier that will cut insects if they attempt to crawl over it (Anonymous, 2025f).

Asaparagus officinalis Carl Linnaeus and harmful insects

Asparagus is a thick-stemmed herbaceous perennial plant with highly branched, hairy leaves, typically growing to a height of 100-150 centimetres It is known to grow up to 3.5 meters. The leaves are needle-like cladodes in the axils of scaly leaves; they are 6-32 millimetres long and 1 mm wide, and clustered together in a rose-like shape in quadruplets of up to 15. Usually only the young asparagus shoots are eaten: when the buds begin to open, the shoots quickly become woody. The shape of edible spears can vary by variety; typical shapes are long slender spears, 8 mm to 24 mm in diameter, no longer than 22 cm. The roots contain starch (Gruben, 2004; Diderot, 2009).

Chioceris asparagi* L. *(Col.: Chrysomelidae)

C. asparagi is a significant pest of asparagus crops in North America and Europe. Its only food plant is asparagus. The beetle is slightly elongated and ranges in length from 6.0 to 9.5 mm. It has a red-bordered elytrum and is metallic blue-black with cream or yellow dots. The larvae are dark-headed, plump, gray *grubs* (Cranshaw, 2017; Sorensen, et al., 2003).

The asparagus fronds' needle-like leaves are stripped off by the adult beetles and their larvae, which prevents the plants from photosynthesizing and storing energy for later use. They also produce a lot of eggs on the spears and gnaw them, making the crop useless. After a few weeks of feeding on the plants, the larvae fall to the ground to pupate. The beetle may produce two or three generations in a single year. The adults spend the winter inactive, either underground or in leaf litter close by (Diderot, 2009; Grubben and Denton, 2004).

Management

Cultural practise; asparagus beetles hibernate in the field. When ferns turn entirely brown, indicating that they are dormant, remove them. Before snowfall, asparagus might not be completely dormant. If so, burn the ferns in the spring or remove them from the field. Get rid of other field residue, such as straw, residue, and cover crops, if you're dealing with persistently high asparagus beetle populations. Reduce the number of egg-laying sites by harvesting frequently and quickly.

Biological controls; *Tetrastichus coeruleus* Nees (Hym.: Eulophidae) a parasitic wasp that is mostly found in the United States and Europe, has been effectively employed for biological control and can result in up to 71% field mortality (Capinera and Lilly, 1975*;* Morrison and Szendrei, 2014).

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Determination of Energy Balance for Table Grape Production in Thrace Region of Türkiye

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ABSTRACT

Purpose of this research was to determine energy usage productivity in grape production for wine in Thrace Region of Türkiye. Questionnaires were carried out with farmers to determine agricultural production inputs such as fertilizers, pesticide, agricultural machinery, time and fuel consumption etc., and yield. Energy equivalent of the production inputs and yield were calculated to establish and energy budget for grapevine production. According to the results, energy rate was calculated as 15.45. Net energy was 187617.31 MJha-1. Specific energy and energy productivity were 0.06 $MJkg^{-1}$ and 1.31 $kgMJ^{-1}$ for the table grape production, respectively. Direct energy and its share were calculated as 474.11 $MJha^{-1}$ and 36.77 %, respectively. Indirect energy and its percentage in the total energy were 8208.58 $MJha^{-1}$ and 63.23%. Renewable energy was small as 1649.95 $MJha^{-1}$and its share 12.71% in the production of the table grape because of this result was the agricultural inputs used in all stages of the production were almost fully based on non-renewable energy usage. Non-renewable energy was 11332.75 $MJha^{-1}$ and 87.29%. Fertilizer was the most important input for the growing of the grape production for wine. Pesticide and diesel follow the fertilizer. Fungicides were used mostly to protect vineyard. Agricultural machineries were generally used for soil tillage, chemical fertilizer and pesticide applications. Fuel consumption of soil tillage took big portion of total fuel consumption. Human labour was used for pruning, removing leaves and branches, harvesting and packaging in the grape production. Future work may be focused on improving vineyard mechanization and protecting over fertilization and pesticide usage in the vineyards.

Keywords – Grape, Energy, Balance, Inputs, Outputs.

INTRODUCTION

Grape was produced in 3 722 850 ha. and total production was 3 400 000 tonnes, 1 825 915 tonnes for table grape, 1 261 347 tonnes for dried grape (raisin) and 303 738 tonnes for wine in Türkiye in 2024 (TUIK 2025). Türkiye took place as 9th in the world with 3 400 000 tonnes grape production value and 3.95 % in 2023. (FAO 2025).

Energy efficiency was investigated for grape production in Eivan County, Iran. Weighted average of energy efficiency, energy efficiency, net energy and energy cost per kg were determined as 5.44 $KgMJ^{-1}$, 0.67$KgMJ^{-1}$, 126049.6 $MJha^{-1}$ and 1.48 $MJkg^{-1}$, respectively. Share of direct, indirect, renewable and non-renewable energy of total energy consumption were 54.68 %, 45.32 %, 22.47 % and 77.53 %, respectively. The total amount of input and output energy were 28364.25 $MJha^{-1}$ and 154413.86 $MJha^{-1}$, respectively (Kamari et al. 2021: 177-178).

Energy efficiency and CO2 use in grape production was determined by a non-parametric method of data envelopment analysis. The results indicated that energy use efficiency, energy productivity and net energy were determined 4.14, 0.35 and 64178 MJ ha^{-1} respectively. Total CO2 emissions were 1207.37 kg CO2 eq. ha-1 (Alizadeh and Taromi, 2014: 1).

Mechanization is important to continue agricultural production. Mechanization indicator was $kWha^{-1}$, tractor/1000 ha, ha/tractor, ekipman/tractor (Ülger et al., 2002). Mechanization of the grape production was determined in Trakya Region, Türkiye. Indicators of the mechanization level were determined as 33.73 $kWha^{-1}$, 4.1 equipment per enterprise and 5.02 equipment per tractor. Mechanic energy usage for the most applications except tillage and sprayers was found insufficient because of inappropriate plantation (Durgut and Arin 2005 :1).

Energy use patterns and cost of grape production for greenhouse and open-field were determined (Özkan et al, 2007:1). Total input energy was 24513.0 $MJha^{-1}$ for greenhouse and 23640.9 $MJha^{-1}$ for open-field production. Total Output energy of greenhouse grapes was lower as 73396.0 $MJha^{-1}$ than open-field grapes as 120596 $MJha^{-1}$. The output–input ratio for greenhouse and open-field grape production were 2.99 and 5.10, respectively (Özkan et al. 2007:1).

Korkutal et al. (2019:127) studied on vineyard structure in Thrace Region. It was stated that the 72.09% of Yeniköy vineyards, 71.05% of Kırcasalih vineyards and 61.76% of Aslıhan vineyards use chemical fertilizers.

Production costs and gross margin were determined for Sultana grapes variety production by using energy analyses. Total energy input was found as 37 488.00 $MJha^{-1}$. The gross product and total variable costs were US$ 6,039.00 and US$ 2,847.23, respectively. The gross margin was determined as US$ 3191.77 (Koçtürk and Engindeniz 2009: 938).

Organic grape production was investigated in terms of energy analysis in Besni, Türkiye. Energy input was 24 875.06 $MJha^{-1}$ and energy output was 163 430 MJ ha–1. Energy use efficiency, energy productivity, specific energy and net energy were 6.57; 0.56 $kgMJ^{-1}$, 1.79 $MJkg^{-1}$ and 138554.94 $MJha^{-1}$, respectively (Baran et al. 2017:275).

Relationship between energy input and yield were examined in Malayer Region in grapevine production. Mean yield and energy consumption were determined as 18530 $kgha^{-1}$ and 45213.66 $MJha^{-1}$, respectively. Fertilizers, electricity and farmyard manure were the highest energy inputs with 37.25%, 19%, and 17.84%, respectively. The energy ratio and energy productivity were found to be 4.95 and 0.42 $kgMJ^{-1}$ (Hamedani et al. 2011:6345).

Energy consumption in different sub-patterns and features of energy consumption structures was compared by using statistical data for grape. Total energy consumption was 210534.3 $MJha^{-1}$ in 2011, 211504.6 $MJha^{-1}$ in 2012, and 222571.8 MJ ha−1 in 2013 for grape production. Indirect and non-renewable energy consumption were higher than that of direct and renewable energy, which accounted for 90% of energy consumption (Tian et al. 2018:1).

Life cycle greenhouse gas (GHG) emissions, energy and fresh water use in wine grape growing in USA were investigated. Different production scenarios based were modelled. Energy use and global warming potential (GWP) per metric ton (t) across all 240 production scenarios range between 1669 - 8567 MJ and 87-548 $kgCO_2e$. Comparison by region shows energy use, GWP and water use for typical practices were more than twice as great in Napa (6529 MJt^{-1}, 456 $kgCO_2e/t$, and 265 m3 H_2O/t) than Lodi (2759 MJt^{-1}, 203 kg CO2e/t, and 141 m^3 H2O/t), but approximately 16% greater on a per hectare basis. Hand harvest (versus mechanical harvesting) and frost protection processes in Napa contributed to higher values per hectare, and lower yields in Napa account for the even larger difference per metric ton. Hand harvesting and lower yields reflect the higher value of Napa wine grapes (Steenwerth et al. 2015:1243).

Energy consumption and energy utilization was assessed for two-harvest-a-year of grape production system in Guangxi, China. Total energy input and output were calculated as 67630 $MJha^{-1}$ and 50462 $MJha^{-1}$. Energy input structures in two production seasons were quite similar for they both consume large proportions energy of chemical fertilizer and pesticide, which respectively were 41.65% and 25.20% in the first season and 39.29% and 25.66% in the second season (Tian et al. 2019:1).

Energy use patterns and energy input-output analysis in grape production in Iran were investigated. Total energy inputs were 33873.78 $MJha^{-1}$. Energy use efficiency, energy productivity and net energy of grape production were calculated as 1.73, 0.15 $kgMJ^{-1}$ and 24748.62 $MJha^{-1}$, respectively. Among input energy sources, chemical fertilizers with 51.64% and electricity with 23.95% were the highest energy (Rasouli et al. 2014:517).

Energy consumption of input and output used in raisin production were determined and making a cost analysis in Aegean Region. In this study the cost of raisin production was calculated by Manisa Viticulture Research Institute's records in 2015. The total energy input necessity for raisin production was 39066.91 $MJha^{-1}$. The energy ratio and energy productivity were found to be 6.04 and 0.51 kg/MJ. Gross production value and total variable costs for raisin were $ 8,600 and $ 4,528.25, respectively. As a result of cost analysis, gross margin was calculated as $ 4,071.75 (Uysal and Saner, 2016:1).

A research was carried out in order to determine the structure of viticulture in Yayaköy, Yorguc, Mursallı, Çınarlı, Gazikoy and Kirazlı in Şarköy district of Tekirdağ. As a result of the research, it was determined that the bond fragments were large in number and larger than 10 decares. In Şarköy, it was determined that 43% of the vineyards produced table grapes, 27% wine grapes and 30% of both table grapes and wine grapes. At the same time, Percentage of the Alphonse Lavallee (25%) and Cardinal (22%) varieties were high (Korkutal et al. 2018:475).

Energy flow and environmental impacts in grape production system were studied in a research study. Life Cycle Assessment (LCA) and Data Envelopment Analysis (DEA) was conducted in Arak County, Iran. Energy input and output were computed as 33264.47 $MJha^{-1}$ and 211715.80 $MJha^{-1}$, respectively. Results indicate that 22.41% of the studied vineyards operate efficiently. The optimization by using constant returns to scale (CRS) method shows saving of 3628.18 $MJha^{-1}$ (10.90%) in energy consumption. The most potential reduction in energy consumption was related to potassium fertilizer, by 27.14% (Mohseni et al. 2018:937).

An artificial neural network was used to estimate energy and environmental indices for grape production. The results indicated that the energy input and output for grape production were 39968.49 and 218713MJ ha-1, respectively. Nitrogen (35.6 %) and irrigation water (21.81 %) took big portion in the inputs. Total greenhouse gas emission was estimated at 858.621 kg CO_2eq ha^{-1} for grape production with the greatest portions for chemical fertilizers and irrigation, respectively (Mardani and Taghavifar, 2016:15).

Energy balance of grape growing was investigated in Shahriar, Iran. Total energy was 31777 $MJha^{-1}$. The major energy inputs were Nitrogen, manure, and irrigation water in grape production by a share of 36%%, 17, and 11% of the total energy inputs, respectively. The energy output was estimated as 202871 $MJha^{-1}$. Net energy, specific energy, energy efficiency, and energy productivity were calculated as 171095 $MJha^{-1}$, 1.85 $MJkg^{-1}$, 6.38, 0.54 kg MJ^{-1}, respectively (Karimi and Moghaddam 2018:191).

Energy use efficiency, energy productivity, specific energy and net energy were investigated for vineyard in a semi-arid zone of Iran. labour, machinery, chemicals, farmyard manure (FYM), diesel, electricity and water for irrigation were determined as input energies. Results of sensitivity analysis showed that machinery had the greatest impact on grape yield followed by diesel fuel and labour (Khoshroo et al. 2018:992).

Evaluate the energy consumption of a winery and to discuss and understand the main parameters involved in the process of fermentation was investigated in a research article. The weather profile during fermentation and the schedule of charging the tanks with freshly affect strongly the needs of cooling power, and the energy use. The study conducted at the Adega da Ervideira in the South of Portugal allowed to define a model for the computation of the cooling power and the electricity consumption. The heat gains from outdoor in convection mode and the heat released during maturation and fermentation phases are the main contributors for the cooling requirements at a winery. As a result of the real fact study, it will allow an oenologist to estimate the cooling power and energy for a winery as well as to produce other types of wines (Correia et al. 2017:1).

Energy usage productivity in grape production for wine in the Thrace region of Türkiye. were investigated in research. Energy rate, Net energy, Specific energy and energy productivity were calculated as 9.72, 105855.37MJha^{-1}, 0.10 MJkg^{-1} and 0.82 kgMJ^{-1}, respectively. Direct energy was calculated as 3936.05MJha–1 and 32.41 %, respectively. Indirect energy and its share were 8208.58 MJ ha–1 and 67.59 %. Renewable energy was calculated to be 743.27 MJ ha–1, representing 6.12 % of wine grape production. The share of chemical fertilizer was 32.40 % of the total energy budget, followed by diesel (26.29 %) and pesticides (24.44 %). Fungicides were used mainly to protect vineyards. Agricultural machinery was generally used for soil tillage and for chemical fertilizer and pesticide application. Fuel consumption for soil tillage was taken a large proportion of total fuel consumption with 81.48 %. Human labour was used for different works such as pruning, cleaning of leaves and branches, harvesting, and packaging. Future work should focus on improving vineyard mechanization and preventing over fertilization and pesticide use in vineyards (Akdemir, 2022:103).

Energy use efficiency, specific energy, energy productivity and net energy values were calculated, respectively as 3.84, 3.07 MJ kg^{-1}, 0.33 kg MJ^{-1} and 174690.11 MJha^{-1} for organic table grape production. The used total energy inputs in organic table grape production can be classified as 42.50% direct, 57.50% indirect, 28.30% renewable and 71.70% non-renewable. Total GHG emission was calculated as 4411.47 kgCO_2-eqha^{-1} for organic table grape production, with electricity having the greatest share by 3239.85 kgCO_2-eqha^{-1} (73.44%). GHG ratio was calculated as 0.22 kgCO_2-eqkg^{-1}. In addition, according to the study, the production cost of table grapes is 7.543 TLkg^{-1} and the income is 9.470 TLkg^{-1} (Ağızan et al., 2024:269).

Energy balance in family-based viticulture in a hot climate region in Brazil was investigated. The energy inputs were categorized as direct and indirect energy. The study considered ripe grapes and vine pruning residues as available energy. The direct input energy accounted for 60.62% (18515.5 MJ), and the indirect input accounted for 39.38% (12027.01 MJ). Renewable energy contributed 24% (7180.27 MJ) and non-renewable energy contributed 76% (23362.24 MJ) of the entries. The ripe grapes energy output percentage was 78% (192771.88 MJ) and pruning residues was 22% (52820.0 MJ). Total energy efficiency, grape energy efficiency and grape energy conversion were determined as 8.04, 6.31, and 0.53 kgMJ^{-1}, respectively. The grape specific energy and net available energy were 1.87 MJkg^{-1} and 215,049.37 MJ, respectively (de Souza et al., 2024:973).

Purpose of this research was to determine energy efficiency for table grape production in Thrace Region where it is one of the important grape production areas in Türkiye. Surveys were carried out with farmers to establish data about agricultural production inputs (fertilizers, pesticide, machinery etc.) used for table grape production, application amount, time and yield. The results were used for calculating of energy budget and productivity of energy usage for grape production in Thrace Region where its agricultural potential is very good for grape production.

MATERIALS AND METHODS

Research was carried out in Tekirdağ, Kırklareli and Edirne cities in Thrace Region of Türkiye. Thrace Region total land was 1 022 498 ha., area of fruits, beverages and spices was 21 385.9 ha. (Fig.1). Survey method was chosen as randomized sampling method. Surveys were carried out with farmers specialized on table grape production in Şarköy-Tekirdağ, Lüleburgaz-Kırklareli and Edirne.

Fig 1: Thrace region and research area (Anonymous, 2025; Yandex, 2022)

Inputs and outputs used in table grape production were determined. Amount of the production inputs used for growing of the table grape were determined for each production stages by survey carried out with farmers in Tekirdag, Kırklareli and Edirne Cities, Türkiye.

The agricultural production inputs of table grape production were taken into account as working hours for human and machineries, tractor, agricultural machinery, fuel, fertilizers and pesticides. Yield data were obtained from farmers and Turkish Ministry of Agriculture and Forestry. Amount of inputs and outputs was calculated per hectare. Energy equivalents of the input and output were determined from literature and given in Table 1.

Table 1. Energy equivalents of the inputs and output

Input	Energy equivalent (MJ per unit)	Literature
Human Labour (h^{-1})	2.67	Özcan (1985:78-80), Arin and Akdemir, (1987:195)
Tractor (h)	64.8	Singh, 2002
Agricultural machinery (kg)	121.3	Özcan (1985:78-80),
Diesel + Oil (l)	56.31	Singh, 2002
Nitrogen (kg)	78.10	Gemtos et al, (2013:54)
Phosphorous (kg)	17.00	Gemtos et al, (2013:54)
Potassium (kg)	13.70	Gemtos et al, (2013:54)
Herbicide (kg)	461.00	Gemtos et al, (2013:54)
Grape	11.80	Singh, 2002

Energy inputs of the agricultural machineries used for soil tillage, fertilization, spraying, harvesting and transportation were calculated by given formulae (Yaldız et al. 1990).

$$ME = \frac{W.E}{T.EEC} \tag{1}$$

Where;

ME: Machinery energy input ($MJha^{-1}$)
W: Equipment weight (kg)
E: Manufacturing energy of agricultural machinery ($MJkg^{-1}$)
T: Economic lifetime (h)
EFC: Effective Field Capacity (hah^{-1}).

Total energy input and energy output were calculated for each stage of table grape growing. Energy ratio, specific energy and energy productivity were also calculated by using following equations (Arin et al., 1988):

$$\text{Energy Rate} = \text{Energy Output}/\text{Energy Input} \quad (2)$$

$$\text{Specific Energy} = \text{Total Energy Input}/\text{Total crop harvested} \quad (3)$$

$$\text{Energy Productivity} = \text{Total harvested product}/\text{Total Energy Input} \quad (4)$$

Net Energy Productivity=Energy output-Energy input (5)

Energy input was also evaluated for renewable/non-renewable and direct/indirect energy types. Fuel was evaluated as direct energy, and others (fertilizers, pesticides and machine power) as indirect energy, human labour as renewable, and other (fuel, fertilizers, pesticides and machine power) as non-renewable energy (Şeflek et al. 2018).

RESULTS AND DISCUSSIONS

Field operations, type, application time and amount of agricultural inputs used in the table grape production were given in Table 2.

Table 2. Agricultural inputs of grape growing for the table grap production

Field operation	Starting time	Input	Amount
Tillage with plough	September-November	Diesel Worker	10.0 lha^{-1} 2.0 hha^{-1}
Tillage with chisel plough	January	Diesel Worker	15.0 lha^{-1} 1.33 hha^{-1}
Tillage with duck foot cultivator	March-April	Diesel Worker	7.0 lha^{-1} 1.0 hha^{-1}
Fertilization with centrifugal fertilizer spreader	January April	DAP (18-46-0) (N-P-K) 15-15-15 (N-P-K) Diesel Worker	170 $kgha^{-1}$ 250 $kgha^{-1}$ 2.0 lha^{-1} 0.33 hha^{-1}
Pruning	February-March	Worker	200 hha^{-1}
Collecting of cut branches	February-March	Worker	100 hha^{-1}
Leaf removing	June	Worker	42.67 hha^{-1}
Cultivation with spike tooth and rotary harrow combination	April	Diesel Worker	4,5 lha^{-1} 1.17 hha^{-1}
Spraying with air-assisted sprayer	April, May, June, July, August May March	Fungicide for powdery mildew Sulphur application Herbicide Insecticide Diesel Worker	12.00 $kgha^{-1}$ 250 $kgha^{-1}$ 1.50 $kgha^{-1}$ 1.89 $kgha^{-1}$ 4.00 lha^{-1} 3.24 hha^{-1}
Hoeing	August	Diesel Worker	4.50 lha^{-1} 1.17 hha^{-1}
Harvesting	September	Worker	240.0 hha^{-1}
Packaging and loading	September	Worker	19.00 hha^{-1}

Name of the agricultural machineries and their specifications were given in Table 3. Field capacity, fuel consumption and electrical energy consumption, time requirement and labour requirement were calculated from the data. The results were given in Table 4. Estimated life for agricultural machinery were taken from ASABE (2015) and Okursoy (2009).

Table 3. Agricultural machines and technical specifications

Agricultural machines	Unit Number /Capacity	Working width (m)	Weight (kg)	Estimated life (h)	Speed (kmh^{-1})	Power (kW)
Tractor-1	-	-	2590	12000		48.0
Plough	5 unit	1.15	200	2000	4.3	
Chisel plough	7 units	2.20	625	2000	3.4	
Rotovator		2.20	750	2000	3.0	
Duck Foot Cultivator	17	2.40	450	2000	4.8	
Spike tooth + rotary harrow combination	35	2.40	390	2000	3.6	
Centrifugal fertilizer spreader	2 discs	12.00	115	1200	5.0	
Air assisted sprayer	8 nozzles	5.40	845	2000	8.0	

Table 4. Field capacity, fuel and electrical energy consumption, time and human labour requirement of agricultural machines

Agricultural machinery	Effective Field capacity (hah^{-1})	Fuel (lha^{-1})	Time (hha^{-1})	Human working (hha^{-1})
Plough	0.50		2.00	2.00
Chisel plough	0.75		1.33	1.33
Duck foot Cultivator	1.00		1.00	1.00
Rotovator	0.67		1.50	1.50
Spike tooth harrow +rotary harrow	1.00		1.17	1.17
Fertilizer spreader	6.00		0.67	0.67
Air assisted sprayer	2.70		0.40	0.40

Energy budget details of grape production for wine were given in Table 5.

Table 5. Energy budget details of table grape production

Input	Total quantity per hectare	Total energy equivalent ($MJha^{-1}$)	Percentage in total sub-division energy input (%)	Percentage in total energy input (%)
Human Labour (h)	622.62	1649.95	100.00	12.71
Soil tillage	5.83	15.46	0.94	
Pruning	200.00	530.00	32.12	
Leaf removing	42.67	113.07	6.85	
Branch removing	100.00	265.00	16.06	
Hoeing	1.17	3.09	0.19	
Fertilization	0.67	1.77	0.11	
Green pruning	10.00	26.50	1.61	
Spraying	3.24	8.59	0.52	
Harvesting	240.00	636.00	38.55	
Packaging and loading	19.05	50.48	3.06	
Machinery (h)	24.08	1304.82	100.00	10.05
Tractor	13.04	817.81	62.68	
Soil tillage	5.83	365.75	28.03	
Hoeing	1.17	8.63	2.36	
Fertilization	0.33	20.90	1.60	
Spraying	3.24	62.70	0.05	
Harvesting	0.46	29.03	2.22	
Diesel-Oil (l)	57.50	2748.50		24.06
Soil tillage	47.00	2646.57	96.29	
Hoeing	4.50	253.40	9.22	
Fertilization	2.00	112.62	4.10	
Spraying	4.00	225.24	8.20	
Chemical Fertilizer (kg)	92.00	3935.40	100.00	30.31
Phosphorus (P)	30.00	510.00	12.96	
Nitrogen (N)	40.00	3124.00	79.38	
Potassium (K)	22.00	301.40	7.66	
Pesticides (kg)	265.39	2968.36	100.00	22.86
Herbicide	1.50	403.50	13.59	
Insecticide	1.89	404.46	13.63	
Fungicide	12.00	1880.40	63.35	
Sulphur	250.00	280.00	9.43	

Total Energy Input		*12982.69*	100.00
Output			
Grape (kg)	17000.00	200600.00	
Total Energy Output		200600.00	

Evaluation of the results of the Table 5 were given below;

Energy equivalent of the human labour was calculated as 1649.95 MJha-1 (622.62 h ha-1) and its share was calculated as 12.71%. Human labour requirement of the pruning. harvesting. leaf removing and head cutting were major jobs for human labour in the table grape production. Human labour requirement was determined as 319.4 h ha-1 by Alizadeh and Tarom (2014).

Total energy equivalent and share of the machinery as tractor. soil tillage equipment. fertilization etc. were determined 1304.82 MJha-1 (24.08 h ha-1) and 10.74%. respectively. Energy equivalent of the tractor used in the vineyard was 817.81 MJha-1 and 62.68% in the total energy equivalent of the agricultural machinery. Machinery working hours were determined as 31.55 h ha-1 by Alizadeh and Taromi. 2014. 32.49 h ha-1 by Şimşek et al.. 2022. 51 hha-1 by Uzun and Baran 2022).

Energy equivalent of the fuel consumption was calculated as 3192.78 MJha-1 and its share 26.29% in total energy equivalent of the agricultural production inputs for grape production. Fuel consumption of the soil tillage in the grape production was 2601.52 MJ ha-1. This value was highest value and percentage as 81.48% in the all-production activities.

Chemical (mineral) fertilizer with 3935.40 MJha-1 energy equivalent and 32.40% was the highest production input in the energy budget. Nitrogen accelerates developing of the green part growing. Energy equivalent and percentage of the nitrogen (N) were 3124.0 MJha-1 and 79.38% in the total fertilizer energy budget.

Pesticide energy equivalent and its percentage were determined as 2968.36 MJha-1 and 24.44 %. respectively. Fungicide with 1880.40 MJha-1 energy equivalent and 63.35 % share were the highest values in the total energy equivalent of the pesticides.

The energy ratio. specific energy. energy productivity and net energy production for different energy content possibilities were calculated and were given in Table 6.

Table 6. Energy efficiency, specific energy, energy productivity, net energy production

Energy evaluation criteria	
Energy ratio (%)	15.45
Specific Energy (MJ kg^{-1})	0,06
Energy Productivity (kg MJ^{-1})	1,31
Net energy production (MJ ha^{-1})	187617.31

Energy rate of the output and input energy was calculated as 15.45 for table grape production in Thrace Region, Türkiye. The net energy defined as differences between output and input energy equivalents was also indicator of the high yield of table grape. Net energy values were 187617.31 MJ ha-1. Specific energy and energy productivity were determined as 0.06 MJkg-1 and 1.31 kg MJ-1 for grape production in this research study, respectively.

Energy use efficiency, energy productivity, specific energy, and net energy in grapes were computed as 10.94, 0.92 kg MJ–1, 1.08 $MJkg^{-1}$, and 191,597.23 $MJha^{-1}$, respectively (Uzun and Baran, 2022). Şimşek et al. (2022) was also investigated grape yield, energy input, energy output, energy use efficiency, specific energy, energy productivity, and net energy in grape production. They were calculated grape yield, energy input, energy output, energy use efficiency, specific energy, energy productivity, and net energy in grape production as 10118.53 $kgha^{-1}$; 14226.97 $MJha^{-1}$; 119398.64 MJha–1; 8.39, 1.41 $MJkg^{-1}$; 0.71 kgMJ–1; and 105171.67 $MJha^{-1}$, respectively. The results of energy use efficiency (4.14), energy productivity (0.35) and net energy (64178 MJha-1) for grape production in Iran were smaller than Turkish grape production (Alizadeh and Taromi, 2014).

Direct energy and indirect energy for grape production for wine were given in Table 7.

Table 7. Direct energy and indirect energy for grape production

Energy	Amount (MJ ha^{-1})	Percentage (%)
Direct energy	4774.11	36.77
Indirect energy	8208.58	63.23
Total	12982.69	100,000

Direct energy in the total input energy was calculated as 3453.533936.05 $MJha^{-1}$ and 32.4129.61%, respectively. Indirect energy and its percentage share in the total energy were determined as 8208.58 $MJha^{-1}$ and 63.23 %.

Renewable energy and non-renewable energy for grape production were given in Table 8.

Tablo 8. Renewable energy and non-renewable energy for grape production

Energy	Amount (MJ ha^{-1})	Percentage (%)
Renewable energy	1649.95	12.71
Non-renewable energy	11332.75	87.29
Total	12982.69	100.00

Renewable energy usage was so small as 1649.95 $MJha^{-1}$ and 12.71 % because agricultural inputs used in all stages of the grape production was almost fully based on non-renewable energy usage. Non-renewable energy was 11332,75 $MJha^{-1}$ and 87,29 %. Renewable energy input in grape production was calculated as 3810.96 $MJha^{-1}$ (26.79%), and non-renewable energy input was calculated as 10416 $MJha^{-1}$ (73.21%) (Şimşek et al., 2022).

CONCLUSIONS

Energy budget is very important for sustainability. In this research, the energy budget established for table grape production in Thrace Region of Türkiye. Agricultural production inputs and output were determined for all stages. Then energy equivalent of the inputs and output were calculated.

The specific energy was determined 0.11 MJ kg-1 and the energy productivity was 0.06 kg MJ-1. The direct energy equivalent was 4474.11 MJha-1 and 36.77 %. Indirect energy was determined 8208.58 $MJha^{-1}$ and its percentage 63.23 % in total input energy.

Total energy input was 12982.95 $MJha^{-1}$ Renewable energy was 1649.95 $MJha^{-1}$ and 12.71 % and non-renewable energy 11332.75 $MJha^{-1}$ and 87.29 % in total input energy.

Fertilizer was the most important input with 3935.40 $MJha^{-1}$ for the growing of the table grape. Energy cost of the pesticide and diesel follow the fertilizer as 24.06 % and 22.86 %, respectively. Number of the pesticide application varied between 6 and 10. Fungicides were used mostly to protect vineyard. Insecticide and herbicide usage were less than fungicide usage. Excessive fertilization and pesticide application increase production cost of the grape and environment effect of the chemicals. Fuel consumption of soil tillage took big portion of the total fuel consumption. Agricultural machinery was generally used for soil tillage, hoeing, and chemical fertilizer and pesticide applications. Human labour was used for pruning, removing leaves and branches, top cutting, harvesting and packaging in the grape production Future work may be focused on precision farming applications for vineyard mechanization for establishing variable rate applications and yield map for preventing over fertilization and pesticide usage in the table grape production.

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Biological Characteristic and Control of Important Aquatic Plants

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ABSTRACT

Vascular and non-vascular plants that have adapted to live in freshwater or saltwater settings are known as aquatic plants, or hydrophytes. Aquatic plants in lakes, rivers, and wetlands serve as substrate for benthic invertebrates and cover for aquatic creatures including fish, amphibians, and aquatic insects. The majority of aquatic plants are found in coastal lake or shallow water environments. A vital habitat and breeding ground for fish, the aquatic plant community also provides oxygen to all living things, serves as a haven for prey, and provides food for predators. The overall primary productivity of lakes can be greatly increased by aquatic plants, which also serve as a buffer against erosion and sediment resuspension from coastal inputs and waves. Through photosynthesis, it generates oxygen and provides food for certain herbivorous animals. To float on the water's surface and survive for extended periods of time, aquatic plants require unique adaptations. The most prevalent adaption is the existence of lightweight inner packing cells called parenchyma. Because they can only survive in soil or water that is constantly saturated, aquatic plants are often found in marshes and wetlands. Water lily, duckweed, mosquito fern, floating heart, water milfoil, mare's tail, water lettuce, water hyacinth, and algae are all recognized types of aquatic plants. To float on the water's surface and survive for extended periods of time, aquatic plants require unique adaptations.

Keywords: Aquatic plants, biology, control

INTRODUCTION

Aquatic plants are those that have evolved to live in freshwater or saltwater environments. They are frequently referred to as hydrophytes or macrophytes to distinguish them from algae and other microphytes. A macrophyte is a plant that grows in or next to water and can be either emergent, submergent, or floating. Macrophytes in lakes and rivers supply oxygen, act as food for some fish and species, and give cover for fish and aquatic invertebrates. Invasive aquatic plants include algae, which are basic creatures with chlorophyll, and plants, which belong to the kingdom Plantae, which grow partially or entirely submerged in water. This includes plants that are rooted in the sediment with all or part of their body submerged, as well as plants that float freely without touching the sediment. Aquatic plants can take over freshwater and marine environments, such as lakes, rivers, estuaries, coastal zones, irrigation systems, hydropower systems, and aquaculture facilities (Anderson 2011; Smith 2011)

In addition to hosting many plant and animal species, wetlands also affect the climate structure of the region. Although there is no fixed definition of a

wetland, "All waters that are natural or artificial, permanent or seasonal, brackish, fresh or salty, with flowing or stagnant waters, with a depth not exceeding six meters during the ebb of the tidal movements of the seas and that create a habitat for living things are ecologically defined as wetlands Wetlands are areas where the soil structure in the region is completely or partially covered with water, at least during the vegetation period, even if it is temporary, and is a transition zone between terrestrial and aquatic ecosystems (Cowardin et al., 1979). Wetlands have influenced social, cultural and economic processes throughout human history due to their ecological importance (Tırıl, 2006).
The availability of water is the primary factor governing the dispersion of aquatic plants. But other elements, such as salinity, grazing, wave disturbance, and nutrient availability, might also affect where they are found. Certain types of aquatic plants can survive in brackish, saline, or salt water (Tomlinson,1986).

Important Aquatic Plants

Table 1. Scientific name and family of aquatic plants

Scientific name	Family name
Alternanthera philoxeroides (Mart.)	Amaranthaceae
Azolla filiculoides Lam	Salviniaceae
Ascohyllum nodosum (L.) Le Jolis	Fucaceae
Caulerpa taxifolia (Vahl) C.	Caulerpaceae
Crassula helmsii (Kirk) Cockayne	Crassulaceae
Ceratophyllum demersum L.	Ceratophyllaceae
Didymosphenia geminata (Lyngb.) M. Schmidt	Cymbellaceae
Elodea canadensis Michx.	Hydrocharitaceae
Ecklonia maxima (Osbeck)	Lessoniaceae
Echinochloa stagnina (Retz.) P. Beauy).	Poaceae
Eichhornia crassipes (Mart.) Solms	Pontederiaceae
Lemna minor L.	Lemnaceae
Lagarosiphon major (Ridley) Moss	Hydrocharitaceae
Lythrum salicaria L.	Lythraceae
Ipomoea aquatica Forssk	Convolvulaceae
Nymphaea alba ***L.***	Nymphaeaceae

Alternanthera philoxeroides

Alligator weed is a plant that grows all throughout Florida, having been unintentionally brought there in 1894 by ships' ballast water. Although it can grow in a number of locations, this root-bearing perennial plant is usually found close to water. When it stretches out into huge mats over deep rivers or along shorelines, it can be an annoyance on land. Although seeds are produced in Australia, they are rarely viable in the climate (Parsons and Cuthbertson, 2001). Maybe spread by people confusing weed with the sometimes-used vegetable mukunu-wenna (*A. sessilis*).

During times of high-water load, thick mats of alligator weed obstruct drainage canals, ditches, streams, and other minor waterways from quickly emptying, resulting in floods. When mats come loose, they pile up against dams, bridges, and acute river bends, causing obstacles. Mosquito habitat is also expanded by thick mats. Both shoreline navigation in large waterways and navigation in small waterways is impeded. Swimming and fishing may be impacted, while fishing is probably benefited by a modest alligator weed fringe. An almost glabrous perennial herb that grows as a free-flowing aquatic plant, a rooted emergent plant, or both. 10- to 70-cm-long stems frequently produce enormous, intricately woven mats. Dark green, opposing, sessile, linear leaves that are 2 to 7 cm long and 5 to 40 mm broad are present (Parsons and Cuthbertson, 2001).

Management

Cultural ad physical method: pphysical control efforts often result in more alligator weed spreading because the weed spreads quickly through fragmentation. Mechanical; attempts to control alligator weed mechanically frequently result in the weed spreading more widely because it spreads quickly through fragmentation. Biological method: these insects are used as biological agents. Alligator weed flea beetle, *Agasicles hygrophila* Salman and Vogt (Col.: Chrysomelidae) Alligator weed thrips, *Amynothrips andersoni* O'Neill (Thy.: Phlaeothripidae) *Alligator weed* stem borer, *Arcola malloi* (Pastrana) (Lep.: Pyralidae). Chemical control is carried out using some insecticides (Anonymous, 2025 b)

Ascohyllum nodosum

Large brown algae, or *Ascophyllum nodosum*, belongs to the Phaeophyceae family of seaweeds, which also includes the Fucaceae family. In certain places, Other names for A. nodosum include knotted kelp, Norwegian kelp, rockweed, knotted wrack, and egg wrack. This seaweed is found only in the northern Atlantic Ocean, along the northwest coast of Europe (from the White Sea to Portugal), including east Greenland (Morton, 2003), and the northeast coast of North America. Warmer ocean waters prevent it from growing further south of these latitudes. It is a dominant species in the intertidal zone (Morton, 1994). A. nodosum has been utilized extensively in scientific studies and has even been shown to have positive effects on human health when consumed.

The brown seaweed *A. nodosum* is one kind of it. In colder parts of the world, like Iceland and Northern Canada, it grows along the shorelines. Since A. nodosum is overharvested for its alginate component, it is currently protected in many nations. It also includes nutrients including fatty acids like oleic acid, carbs, and iodine. *A. nodosum* is used to treat a variety of ailments, including weight reduction, gum disease, teeth plaque, iodine deficiency, and many others, although these claims are not well supported by scientific research. A. nodosum should not be confused with other seaweed species, including sea moss, dulse, *Ecklonia cava*, *Fucus vesiculosus*, and blue-green algae. These aren't interchangeable (Anonymous, 2025c). *Azolla*, freshwater fern, is of great importance for agricultural activities in developed and developing countries. *A. azollae* symbiosis is the only symbiotic relationship between the eukaryotic partner *Azolla* and the prokaryotic endosymbiont *A. azollae.* The agronomic potential of this relationship stems from the plant's ability to grow successfully in areas low or deficient in nitrogen (Pabby et al, 2003). *Azolla* is a good alternative nitrogen source to mineral nitrogen fertilizer in paddy cultivation. The positive aspects of its use as a biofertilizer in paddy agriculture are its high nitrogen-fixing capacity, rapid growth, rapid mineralization and the fact that the nitrogen it contains is in the form of ammonium, which can be taken up relatively easily by plants (Singh and Sing, 1989). The symbiotic system between Azolla-Anabaena-bacteria biotechnology by considering biology in a broad framework, use in various fields such as biofertilization and environment is of great importance. While investigating the factors that promote the sporulation process in the reproductive mechanism of the plant is a priority, studies on the collection, storage and germination of sporocarps should also be supported. Due to nitrogen fixation, it can be said that this symbiotic partnership can have important effects on the development of agriculture in our country, especially in areas such as soil fertility and environmental pollution by reducing the use of chemical fertilizers (Köksakal, 2013).

Azolla filiculoides

Azolla filiculoides is naturally distributed in western America, Asia and Australia (Carrapiço et al.,2000). Symbiotic partner of *Azolla*, an aquatic fern with *Anabaena azollae,* a cyanobacterium and nitrogen fixing cohabitants. Common habitats for the plant include lakes, ponds, wetlands, canals, slow-moving rivers, rice floating on the surface of fields, and tropical and temperate climates. This symbiotic relationship fertilizers and use as an alternative in animal nutrition potential, it has recently become very important is gaining (Kösesakal, 2013). Stem small alternate and imbricate covered and hidden by leaves (fronds). Adventive roots are formed from the lower side of the stem and are vertical in water develops as a leaf. Each leaf is two-lobed. Lower lobe does not contain chlorophyll and is responsible for the plant's buoyancy, and the upper lobe, which contains chlorophyll, provides the connection to the external environment. has developed a sophisticated aperture and *A. azollae* live symbiotically (Tyagi et al., 1980;

Pabby et al., 2003). Numerous tiny, overlapping leaves that resemble scales and have roots floating in the water allow azolla to float on the water's surface. The cyanobacterium Anabaena azollae, which fixes nitrogen from the atmosphere, develops a symbiotic connection with them. The plant grows quickly, doubling its biomass every two to three days, and it may readily colonize watery environments. Phosphorus is usually the limiting factor on its growth. Azolla blooms are frequently caused by an abundance of phosphorus, such as that which results from eutrophication or chemical runoff. Its symbiotic bacterium is passed on directly from one generation to the next, in contrast to all other known plants. Since many of its genes have either been deleted or moved to the nucleus of *Azolla'*s cells, A. azollae is entirely reliant on its host (Van et al., 2002). Because of its ability to fix nitrogen, *Azolla* is widely used as a biofertilizer, particularly in southeast Asia. For more than a millennium, China has utilized the plant to boost agricultural output. *Azolla* can be planted and then swiftly grow, covering the water and controlling weeds when rice fields flood in the spring. Up to nine tons of protein per hectare are produced annually by the nitrogen that the decomposing plant matter releases into the water for rice plants (Nyalemegbe, 1996). In various regions of the world, azolla weeds completely cover some bodies of water. The plant is commonly referred to as "mosquito fern" because to the misconception that mosquitoes cannot pierce its canopy and lay their eggs in the water (Köksakal, 2013), which may also hinder the survival of certain larvae. In addition to its use in agriculture, it is also used in animal feed, biogas production, weeding and mosquito control. control and bioremediation studies" (Kösesakal, 2013).

Caulerpa taxifolia

One invasive marine alga commonly known as "Killer Algae" is *Caulerpa taxifolia*. Fronds emerge from horizontal stolon’s and are bright green, pinnate, and fern-like, measuring between 2 and 26 inches (5 and 65 cm) in length. The stolons, which can reach a maximum length of 10 feet (3 meters), cling to submerged materials like rocks, mud, or sand using roots-like rhinotorids. It doesn't bloom. There is only vegetative propagation; there is no sexual reproduction. Stem and stolon fragment up to 0.5 in (1,2 cm) length can proliferate into new algae. Fishing and boating are easy ways to move these shards (Guiry and Guiry, 2007). Because of their aesthetic appeal and capacity to inhibit the establishment of undesirable species, *Caulerpa* species are frequently employed in aquariums. Since the early 1970s, *C. taxifolia* has been grown in western Europe for use in aquariums. A cold-resistant clone of the algae was discovered in the tropical tank of the Wilhelma Zoo in Stuttgart, and it was further grown by subjecting it to UV radiation and chemicals. The strain was shared by the zoo with the

Oceanographic Museum of Monaco and other aquariums (Jousson et al., 1998; Madi and Yip, 2004).

Management

C. taxifolia can be managed by applying salt, mechanically removing it, or poisoning it with chlorine. The University of Nice's researchers looked into the potential use of the sea slug species *Elysia subornata* as a natural control mechanism, but they discovered that the Mediterranean region's chilly winter water temperatures and low population density made it unsuitable for usage there (Thibaut et al., 2001)

Crassula helmsii

Although endemic to Australia and New Zealand, *C. helmsii* has been reported to be invasive or possibly invasive in North Carolina and Florida (Dawson, 1994; Watson, 2001) *C. helmsii* is widespread in Belgium, Denmark, France, Germany, Netherlands, United Kingdom (Great Britain, Northern Ireland, Guernsey) Australia (New South Wales, South Australia, Tasmania, Victoria, Western Australia), New Zealand. *C. helmsii* is a perennial succulent herb that can be found in water or semi-terrestrial areas. It has spherical, floating or creeping stems that are 10 to 30 cm long, and roots that form at the nodes. The opposite, sessile, succulent leaves are ovate-lanceolate to linear-lanceolate, acute, and measure 4–20 mm in length and 0.7–1.6 mm in width. There is various growth types of *C. helmsii.* The aerial leaves of the terrestrial version are succulent-looking and have a yellowish-green colour. The stems can be creeping or erect. Typically, the emergent form grows in water that is 0.6 meters or less deep as stands of short, closely spaced stems. With long, sparsely leafed branches that can float above the water, the submerged form grows from a basal rosette that is securely anchored at the base. The three variations vary based on the current circumstances (Dawson and Warman, 1987).

Management

C. helmsii is difficult to control since it can withstand prolonged periods of shade, frost, and desiccation. Native species are preserved and efforts are spared with early and successful treatment. One resource for the re-establishment of native species should be the natural seed bank. With long, sparsely leafed branches that can float above the water, the submerged form grows from a basal rosette that is securely anchored at the base. Avoid using mechanical control since this can lead to additional fragments that could re-infest the treated area or spread the plant downstream. Heat from flame-throwers is insufficient to destroy the roots (Dawson and Henville, 1991), but small regions can be successfully frozen using liquid nitrogen. On sites with large stands (> 1000 m2), chemical management would be a helpful answer, but it would need to be used extremely carefully in the natural setting. Herbicide formulations containing glyphosate and diquat can harm *C. helmsii* (Dawson and Henville, 1991).

Ceratophyllum demersum

C. demersum is an aquatic plant with stems that can grow up to three meters (10 feet) in length. A single specimen of this plant seems to be a big, bushy mass due to its many side shoots. Simple or forked into two to eight thread-like segments surrounded by spiky teeth, the leaves range in length from 8 to 40 mm. They are rigid and brittle, and they are formed in whorls of six to twelve. It is monoecious, meaning that the same plant produces different flowers for the male and female Because *C. demersum* excretes chemicals that prevent phytoplankton and cyanobacteria (blue-green algae) from growing, it exhibits allelopathic properties. Its rapid development has the potential to displace other aquatic vegetation, resulting in a decline in biodiversity. It has led to issues with hydroelectric power stations in New Zealand (Blamey and Wilson, 1989). Because it secretes compounds that prevent the growth of cyanobacteria (blue-green algae) and phytoplankton, *C. demersum* has allelopathic qualities. Because of its rapid development, it may outcompete other underwater vegetation, resulting in a loss of biodiversity. It has led to issues with hydroelectric power stations in New Zealand. It frequently serves as a model organism in research on plant physiology. This is due in part to the fact that it permits research on impacts on shoots without affecting roots, which frequently makes it more difficult to interpret toxicity and nutrition tests in terrestrial plants. Due to its free-floating nature, which eliminates the need for a solid substrate, it has been effectively employed in spaceflight's "Aquarack/CEBAS" and "Omegahab" biological life support systems. (Yung et al., 2020; Blüm et al., 1994; Voeste et al., 2003).).

Didymosphenia geminate

The small freshwater diatom D. geminata is found throughout Asia, Europe, and North America. Over the past few years, a pattern of spreading range and bothersome blooms has emerged throughout North America and Europe. In 2004, the diatom was identified as an invasive species after it was found in New Zealand (Kilroy et al., 2007). A diatom is a kind of single-celled algae, such as *D. geminata*. Because their silica cell walls are frequently well-preserved in sediments, diatoms are remarkable in this regard. Many studies have been conducted on the valve morphology of the genus *Didymosphenia* (Stoermer et al., 1986; Kilroy et al., 2007). *Didymosphenia* is classified as belonging to the cymbelloid branch of diatoms, not the gomphonemoid lineage (Kociolek and Stoermer, 1988). A feature called a raphe gives cells the ability to move on surfaces. Additionally, the cells have

an apical porefield that secretes a mucopolysaccharide stalk. Kociolek and Stoermer (1988) provide a description and illustrations of the morphological traits.
Through photosynthesis, diatoms, which are present in almost all freshwater and marine habitats, contribute significantly to the global carbon budget. Diatoms are one of the main groups of organisms in the plankton assemblage in both rivers and seas, and they also grow adhering to surfaces. Diatoms accumulate lipid within the cell and store chrysolaminarin (ß1,3 linked glucan). Diatoms are an important food source for other creatures because lipids, which are rich in oil, are a source of energy. Diatoms reproduce both vegetatively and sexually. An extracellular stalk produced by the diatom can cling to plants, rocks, or any other submerged substrate. A dense mass of branching stalks is formed when the diatom cell divides, or by vegetative reproduction, as both progeny cells continue to create stalks. The excessive development of extracellular stalk is what causes *D. geminata*'s detrimental effects, not the diatom cell itself. The stalk's extracellular polymeric substances (EPS) are primarily polysaccarides with trace levels of protein (Gretz et al., 2006). They are resilient to deterioration and are intricate, stratified structures.
Thick mats of *D. geminata* blossoms can cover kilometres of riverbed. According to Reid et al. (2014) they are linked to an increase in organic matter, the deposition of fine benthic silt, the displacement of native benthic algal and macroinvertebrate communities, and alterations in nutrient cycling and ecosystem function. The release of polyphenols may have contributed to the decrease in the motility time of salmon (Salmo salar) spermatozoa in contaminated rivers in Chile (Reid et al. 2014).

Management

Mechanical or physical control, In the Canadian Rocky Mountains, it has been demonstrated that channel maintenance techniques such as flushing flows diminish *D. geminata* benthic mats (Cullis et al., 2015).
Chemical control, through experimental trials, eleven possible control agents (biocides/algaecides) were investigated (Jellyman et al., 2005). Based on how well the control agents caused cell death and biomass degradation, they were graded. In addition, consideration was given to the costs, length, application practicality, and effects on the ecosystem.

Elodea canadensis

The perennial aquatic plant or underwater macrophyte E. canadensis, often known as American waterweed, Canadian waterweed, or pondweed, is indigenous to the majority of North America. Numerous places outside of its normal habitat have seen its introduction (Anonymous, 2025 c). It inhabits lakes and rivers up to 2,000 meters (6,600 feet) above sea level, mostly in waters that are rich in lime (Hussner, 2012). Young plants begin as a seedling stalk with roots growing in the water's muck at the bottom. As the stalk grows, more accidental roots are generated, which can either cling to the bottom or hang freely in the water. The stem's tips continue to grow eternally, and individual specimens can grow up to 3 meters (9.8 feet) in length. The oblong, transparent, bright green leaves measure 6–17 mm in length and 1-4 mm in width. They are carried in rings of three, infrequently two or four, around the stem. Except for the tiny white or pale purple flowers that float on the surface and are joined to the plant by thin stalks, it is completely submerged. The lowest portion of the petals that come together to form a flower tube are called hypanthias. This flower tube has a length-to-width ratio of 300 times and may reach a maximum length of 30 cm (12 inches) with a width of just 1 mm. However, one study claims that this ratio can occasionally reach a thousand times. The fruit is a 6 mm long, round capsule with many seeds that ripen in water. The smooth, spindle-shaped seeds measure 4-5 mm in length. From May until October, it blooms. Under ideal circumstances, it can choke canals, shallow ponds, and the banks of some slowly moving rivers. It also grows quickly. It requires moderate to strong light levels and summer water temperatures between 10 and 25 °C. In Europe, Asia, Africa, and Oceania, it is an invasive species. It has been especially prevalent in Europe, where records date back to 1836 in Ireland's County Down and 1841 in Great Britain, where it is currently widespread (Bailley 1935; Francis, 2006; Simpson, 1984; Huxley, 1992).

Management

Both mechanical and physical control, Raking or netting can be used to remove elodea from the pond, but the residual pieces and roots will allow it to grow again. Fertilizing to create algal "blooms" or phytoplankton stops the majority of bottom-rooted algae from growing and gives pond fish a robust food chain. Like fertilization, non-toxic dyes or colorants limit the amount of sunlight that reaches aquatic plants, preventing or slowing their growth. Nevertheless, dyes will restrict the pond's natural food cycle and do not improve it (Anonymous, 2025d). Mechanical harvesting, chopping, and dredging have become commonplace methods to lessen *Elodea* sp. epidemics.

Biological Control, for this plant, herbivorous grass carp are a suitable management strategy. Following mechanical removal or herbicide control, common carp and other bottom-feeding fish that produce murky water can also effectively inhibit plant regeneration. This species has been known to have abrupt population collapses, and it's possible that self-regulation plays a role in some circumstances. Whether this is caused by a pathogen or a stem mining insect has not yet been determined. In Europe, there are no chemical

control measures for Elodea species. Some pesticides are authorized outside of Europe; readers should check with their local government's Environment Agency or similar agency (Newman and Duenas, 2010).
Chemical control, in Europe, there are no chemical control measures for Elodea species. Some pesticides are authorized outside of Europe; readers should check with their local government's Environment Agency or similar agency (Newman, and Duenas, 2010).

Ecklonia maxima

The species can be found in open seaweed forests up to 8 meters (26 feet) deep and is common in shallow, temperate waters in these areas.
A well-developed holdfast of branched haptera, an elongated cylindrical stipe up to 1.5 m long (to 10 m on the west coast) with a gas-filled bulb toward the top, and a small triangular primary blade with marginal secondary blades make up a sporophyte, which can reach a height of about 4 m (to at least 10 m on the west coast). Young examples are strap-shaped, flexuous, and up to 1 m long, whilst mature specimens have shorter, inflexible, triangular primary blades. The edges of the smooth blades are somewhat dentate. Occasionally, elder plants have some tertiary blades in addition to bilateral secondary blades. Mucilage ducts are found on blades and stipes. Raised sore near the center of the secondary blade with patches or strips of plurilocular sporangia. Gametophytes are filamentous and small. The moss anchors itself by clinging to a rock or other moss with its holdfast. From this root-like structure, a single long stalk arises and travels to the surface waters, where a massive pneumatocyst holds a tangle of blades on the surface to promote photosynthesis. This species is economically important since it is harvested for both agricultural augmentation and as food for farmed abalones (Anderson et al., 2006; Button et al., 2012; Guiry, 2015; Guiry et al., 2014; Papenfuss, 1924).

Echinochloa stagnina

Common in tropical Africa and Asia, *E. stagnina* is an *Echinochloa* species that is invasive on numerous Pacific islands. The Fulani people once grew it as one of the main grasses in the Inner Niger Delta of the Niger River. They utilized the seeds for food and to manufacture alcoholic and non-alcoholic drinks (National Research Council,1996). The inflorescence is a terminal panicle that can grow up to 35 cm long and is either erect or hardly bent. Its shape ranges from oval to pyramidal, and it is made up of a sequence of spike-like racemes inserted along an axis that can be braced against one another or regularly separated. There are four rows of spikelets. Racemes are made up of four rows of oblong-ovoid spikelet's that culminate in a ridge that is up to 2 cm long. There are two flowers on each spikelet, but only the outer one is viable. The oblong, flat seed measures roughly 2.5 mm in length. Because of its high flood resistance, it has been replanted in Africa, where it has reduced erosion and produced hay for animals. This little-known grain, a traditional food crop in Africa, has the potential to enhance food security, boost nutrition, encourage rural development, and support sustainable land care (Isaiah and Komi, 2015).

Eichhornia crassipes

Water Hyacinth is a plant belonging to the Pontederiaceae family and is geographically native to Brazil, Central and South America countries, while it has spread in many countries of the world, especially in Egypt, Australia, Indonesia, India, Japan, China and Burma and is known as an invasive species growing in tropical and subtropical regions (Jiménez, 2014). Water Hyacinth is a very aggressive invader that forms thick layers on the surface of water and covers the entire surface of aquatic systems, causing depletion of dissolved oxygen in the water and fish mortality (Sanders et al., 2010). Water Hyacinth, which has the ability to grow and spread very fast, causes blockage of water channels and is defined as the world's most harmful aquatic plant. For these reasons, it is considered an invasive species whose reproduction should be kept under control. In Australia in 1994, it caused considerable damage to dams, rivers, lakes and water channels around More and caused great economic losses due to the expenses incurred to control its spread. The presence of Water Hyacinth in aquatic systems creates problems for humans and aquatic organisms. Since the plant completely covers the water surfaces, it prevents the sun's rays from reaching the bottom, creating problems for other plant and animal organisms. It also causes visual pollution and odor formation (Huynh et al., 2021). The plant *E. crassipes* has enormous lilac-colored blooms, cylindrical or bulging petioles, straight leaf edges, and creeping stems. *E. crassipes* is a type of aquatic plant that occasionally roots in the ground and typically floats on the water's surface. It stands between 0.4 and 0.8 meters tall. The leaves are smooth, green, round, and single. It has two methods of reproduction: seeds and shoots. The plant floats because its leaves and blossoms are above the water's surface (Sanders et al., 2010).

Management

Given its long-term impacts on the environment and human health, chemical control is the least popular of the three water hyacinth management techniques. To handle and spray impacted areas, the use of herbicides needs rigorous approval from government protection agencies and qualified personnel. Chemical herbicides are only applied in cases of severe infestation of water hyacinth. However, more water hyacinth cover is likely to tolerate herbicides and can be broken down to further spread a broader region of water hyacinth cover, therefore herbicides work best when applied to smaller areas of infest. Though more water hyacinth cover is likely to tolerate herbicides and be broken down to further disseminate a broader area of water hyacinth cover, the most effective use of herbicides is performed on smaller regions of infestation. It is also less expensive and time-consuming than mechanical management, but it can have an adverse effect on the environment because it can enter the groundwater system and harm not just the ecosystem's hydrological cycle but also the nearby water system and public health. Additionally, the usage of herbicides is undoubtedly not specific to water hyacinths; the chemicals can kill important species and critical creatures like microalgae and upset delicate food webs (Willamagna and Murphy, 2010).

Physical control, water-based devices like plant shredders, dredgers, and duckweed harvesters, or land-based devices like bucket cranes, drag machines, or booms, are used for physical control. The best temporary remedy to stop the plant's spread is thought to be mechanical removal. An aquatic plant harvester can release the material to the coast after gathering the aquatic plants in a warehouse using a conveyor belt. Water hyacinth pieces that can reproduce asexually are left behind by the spinning cutters of plant harvesters (Willamagna and Murphy, 2010).

Lemna minor

A common, free-floating aquatic macrophyte, duckweed serves both a home for small aquatic invertebrates and a food source for waterfowl. It outgrows other vascular plants in terms of growth and reproduction. Because of its small size, quick growth, and ease of culture, duckweed is a good plant model for assessing the toxicity of various chemicals. The fungicide Folpet's impact on duckweed fronds' enzymatic defenses against oxidative stress was investigated It has been demonstrated to have immunomodulatory qualities, specifically the capacity to improve phagocytosis Additionally, it was investigated how copper affected the antioxidant enzymes' activity in duckweed fronds. In addition to these benefits, duckweed has been utilized extensively as a raw material to make antipyretic and analgesic medications (Kiosev, 2001; Teisseire, 2001; Tkalec, 1998; Popov, 2000). L. minor is ideal for the manufacture of bioethanol. Its low cellulose content (about 10%) makes it easier to convert starch to ethanol than it is for terrestrial plants. When L. minor is cultivated in a swine lagoon's diluted water, it acquires 10.6% of its dry weight as starch. The percentage of starch to total dry weight is marginally greater (12.5%) with optimal pH and phosphate, nitrate, and sugar availability. Starch accumulation can increase by up to 36% when L. minor is grown in the dark and its photosynthetic activity is suppressed by adding glucose (Ge et al., 2012).

Lagarosiphon major

Native to South America, *L. major* is an evergreen submerged aquatic plant species. The species was brought to Europe and is now found in a number of European nations (Hussner, 2012). Since no seed production has been documented as of yet, it spreads only by fragments. *L. major* forms dense monospecific beds in both rushing and stagnant water. Mislabelled or contaminated plant material in trade frequently results in the unintended introduction of aquatic species (Brunel, 2009; Champion et al., 2014; Hussner et al., 2014). Therefore, thorough controls of imported plant material should be put in place at the points of entry and sale of imported aquatic plants in order to detect mislabelled or contaminated material and prevent unintended introductions of *L. major*. During inspections, *L. major* can be identified with the use of DNA barcoding technologies. Invasive alien aquatic plants frequently spread into new bodies of water by way of plant fragments carried by boats and trailers used for water sports (Johnstone et al., 1985; Johnson et al., 2001). *L. major* is a submerged aquatic rhizomatous perennial plant. It has many small, narrow, downward-curving leaves on long, fragile stalks. Plants are related to and resemble *Hydrilla verticillata* and *Egeria densa.* When they reach the water's surface, the quickly growing stems spread out to create dense mats. It is possible to entirely cover shallow lakes up to a foot deep. Tiny, translucent, white, or pinkish flowers are produced. Only famele plants are known to exist outside of their natural range, despite the fact that all plants are dioecious (sexes on distinct plants).

Management

Cultural practise, although dewatering in the summer may hinder some subsequent growth, plants will bounce back until the bottom is thoroughly dried for a few weeks. Although *Lagarosiphon* gets the majority of its nutrients from the sediment, reduced nutrient inputs can also be beneficial (Caffrey et al., 2011).

Hand removal, mechanical harvesting, diver-assisted suction removal, and dredging can all be effective methods in addition to mechanical control, which can produce live fragments that can disseminate, lodge on the bottom or shoreline, and start new populations. Bottom barriers can be used to regulate small spaces. Jute has been effectively used to control *Lagarosiphon* in Ireland. This also led to the release of native plants that sprouted through the jute. Only natural matting or untreated jute should be used; some jute is chemically treated to help preserve it. Suppliers and sources must use prudence (DiTomaso et al., 2013).

Lythrum salicaria

Purple-loosestrife or *L. salicaria* is a flowering plant that is a member of the Lythraceae family. It should not be mistaken for other plants with the same name that belong to the family Primulaceae and the genus Lysimachia. The temperate regions of Europe, Asia, northern Africa, and eastern Australia are the native habitats of this herbaceous perennial plant (Anonymous, 2025e, f, g). Introduced to temperate regions of North America and New Zealand, purple-loosestrife is now officially listed in several controlling agents and has become largely naturalized, or spreading on its own. Rarely, infestations can cause significant disturbances to the flow of water in rivers and canals, affecting the life cycles of aquatic life, amphibians, and algae (Anderson, 1995). Up to 2.7 million small seeds may be produced each year by a single plant. The seeds overwinter in damp soils and are easily transported by wind and water. Pieces of root left in the ground or water can also cause the plant to grow again. Once established, mechanical and chemical methods of removing loosestrife stands are expensive and time-consuming (Anonymous, 2014). The threat posed by loosestrife and other notorious invasive plants, however, is primarily motivated by media attention rather than science, according to studies on how invasive species are depicted in the media (Woodworth et al., 2023). The scientific literature supports a considerably more moderate evaluation of how awful the species is outside of its native region, even though it does have severe effects on the natural ecosystem. It also suggests that resources would be better spent minimizing disturbance of wetlands rather than removing purple loosestrife (Lavoie, 2010).

Management

Biological control, one example of an effective biological pest control method is purple-loosestrife. Since research started in 1985, the plant has been well-managed, and many insects now eat it. Purple-loosestrife is a natural food supply for five different species of beetles, which can seriously harm the plant. Three weevil species (*Hylobius transversovittatus, Nanophyes breves, and Nanophyes marmoratus*) and two leaf beetle species (*Galerucella calmariensis* and *Galerucella pusilla*) are employed as biological control agents. A stand of purple-loosestrife can be completely eradicated by infestations of either of the *Galerucella* species, which can defoliate up to 100% of the plants in a given region. *Ectropis crepuscularia* is a polyphagous moth that is not appropriate for biological management and is a nuisance species in and of itself (Wilson et al., 2004).

Ipomoea aquatica

I. aquatica thrives in damp soil or water. The stems are 2-3 meters (6.6-9.8 ft) or more long, the roots emerge from nodes and the roots are hollow so they can float. Leaves are typically pendulous, lanceolate (arrowhead-shaped), 5-15 cm long and 2-8 cm wide. Flowers are trumpet-shaped, 3-5 cm in diameter. It usually has white flowers with a mauve canter. Either cutting root shoots that will root along the nodes or planting seeds from the flowers that create seed pods are the two methods used for reproduction (Austin, 2007; Pinker et al., 2006) The regions of eastern, southern, and southeast Asia are where *I. aquatica* is most frequently grown. It needs little care and grows naturally in waterways. It is used extensively in Indonesian, Burmese, Thai, Lao, Cambodian, Malay, Vietnamese, Filipino and Chinese cuisines, especially in rural or kampung (village) areas. The vegetable is also very popular in Taiwan, where it grows well. During the Japanese occupation of Singapore in World War II, the vegetable grew remarkably easily in many areas and became a popular wartime crop (Austin, 2007; Pinker et al., 2006).

Nymphaea alba

One kind of water lily in the water lily family is the white-water lily. It is a cold-resistant plant that grows naturally along the banks of slowly moving rivers, lakes, and ponds in western and central North America, Europe, and Asia (Akhani, 2014). Since Nymphaceae alba is an aquatic plant, its specialized trichomes are hydropodes formed on the off-axis surface of the young leaf and tightly packed in the rosette at the flattened apex of the rhizome. The rhizomes contain high amounts of carbohydrates and protein (Kordyum et al.,2021).

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