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Identification and Prevalence of Ralstonia Solanacearum from Potato Fields of Kyrgyzstan

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Abstract For the first time in Kyrgyzstan Raltsonia *solanacearum* bacterium as a pathogen of bacterial wilt (quarantine for the country object) was obtained and identified by enzyme-linked immunosorbent assay (ELISA) and biochemical methods. Three potato (*Solanum tuberosum*) cultivars: Picasso, Sante and Nevskiy were used for isolation of pathogen, which were collected from different regions of Kyrgyzstan. Detection and identification of the pathogen by ELISA performed directly from diseased potato shoots and leaves, and from pure culture of *Ralstonia solanacearum* isolated from tubers of potato seed during storage. For ELISA was used *Ralstonia solanacerium* PathoScreen R Kit DAS ELISA (Agdia product, USA).Isolated races of *Ralstonia solanacearum* by biochemical characteristics were classified as a 3-biotype.

Keywords *the* potato (*Solanum tuberosum*) cultivars, identification of *Ralstonia solanacearum* , ELISA assay, biochemical tests.

1. INTRODUCTION

Ralstonia solanacearum is a soil-borne pathogen that naturally infects roots. It exhibits a strong and tissue-specific tropism within the host, specifically invading, and highly multiplying in the xylem vessels [1, 2]. It causes a wilt disease in more than 450 plant species of 54 botanical families across the globe [3,4,5]. *Ralstonia solanacearum* has been studied intensively both biochemically and genetically, and has long been recognized as a model system for the analysis of pathogenicity [6]. It is well adapted to life in soil in the absence of host plants [7], thereby providing a good system to investigate functions governing adaptation to such an ecological niche. Considering the genetic diversity among the strains responsible for wilting disease in different plants, the pathogen is now termed as *Ralstonia solanacearum species* complex [8].In a traditional way this pahogen has been classified into five races with respect to their host specificity and six biovars according to their biochemical properties [9].

The first signs of the disease are shown in the beginning of the flowering and tuber formation. Plants suddenly wilt; the leaves turn yellow, shrivel and droop. The lower basal part of the stem softens and rots. A typical feature of brown rot is the splitting of the stems, the cross-cut of them follow a drop of bacterial exudates. Subsequently, the bacteria penetrate into the stolon, then into young tubers, causing browning of the vascular ring. From sections of the affected vessels and tubers follows brown mucus [10]. Bacterial wilt occurs mainly in tropic, sub-tropic and warm temperature zones [11]. However, this disease has extended to more temperate areas [12].

Ralstonia solanacearum is a b-proteobacterium and whose complete genome sequence was presented by analysis of strain GMI1000. The 5.8-megabase (Mb) genome is organized into two replicons: a 3.7-Mb chromosome and a 2.1-Mb mega plasmid. The genome encodes many proteins potentially associated with a role in pathogenicity. [13].

Brown slimy bacterial bacteriosis of potatoes (bacterial wilt, or wilt) caused by *Ralstonia solanacearum potatoes (RS)* is a relatively a new disease in the fields of Kyrgyzstan. There are still no data and records of the scientists and experts on the biology and distribution of this disease in the potato crops regions of Kyrgyzstan. There are suggestions that this bacterial disease was brought with imported planting material to Kyrgyzstan from neighboring countries. So, the disease has been found in Russia in 1999 by quarantine inspection only in the area of 0.06 hectares, planted with imported varieties Santa, then the infestation of potato has been found in many regions of Russia : in the Urals, Far East, Western and Eastern Siberia [14].

In Kyrgyzstan, the potato (*Solanum tuberosum*) is a staple product for the population. Recently, in different regions the farms start to grow the varieties such as Picasso, Sante, Nevskiy, which were imported from Russia and other countries of the world, besides to local potato varieties. Approximately 32% of potatoes yields are lost per year due to viral, bacterial, fungal, and pest attack to potato tuber and potato plant [15]. There is a particular threat to potato production (especially the seed production) because of asymptomatic cases of these bacterial diseases; as apparently healthy tubers have a margin hidden (latent) infection and pose a threat to crops next year, so it is important to be able to identify it in the contaminated material. Still, the prevalence and host range of races and biovars of *Ralstonia solanacearum* is unknown in potatoes cultivated regions of Kyrgyzstan, but it is becoming increasingly clear that this species causes disease in vegetation period and in storage after harvesting.

The objective of this study was to develop simple and reliable tools to distinguish the biovars of *Ralstonia solanacearum* by using biochemical and ELISA tests and to determine the prevalence of pathogen races in commercial potatoes fields of Kyrgyzstan.

2. MATERIALS and METHODS.

2.1. Origin of isolates. For direct isolation of *Ralstonia solanacearum* were used potatoes tubers of Picasso, Sante and Nevskiy varieties, which were collected in the fall 2010 and 2011 from Issuk-Kul and Chy regions of country. All isolates from potatoes fields came from individual tubers of different plants. Each tuber was placed in an individual plastic bag after harvest.

2.2. Cultural characterization. The infected part of tubers was cut using a sterile sharp knife. A suspension from plant ooze and exudates was prepared in sterile distilled water and then streaked onto Kelman's tetrazolium chloride (TZC) agar and 2% sucrose peptone agar (SPA).After incubation at 28°C for 24 to 36 h, chartered colonies of *Ralstonia solanacearum* were selected on mediums. Isolates of *R. solanacearum* were maintained in sterile distilled water for following identification steps and stored at room temperature. Pure cultures were tested by biochemical and enzyme-linked immunosorbent assay (ELISA) methods. A mobility, gram negative reaction, catalase, amylolytic and lecithinase activity, liquefaction of gelatin, saccharolytic enzymes, the formation of indole and other biochemical properties were determined. For pigment formation tests the liquid mediums: meat-peptone broth and tryptophan broth were used. More consistent results were obtained when L-tyrosine was added to the medium. The ability to denitrification was tested using **the s**emi-solid medium: 10% peptone, 5% NaCL, 2,0% KNO_3, 3,0 % Bacto agar and Hiss reagent.

2.3. Test to determine the mobility. Cells of virulent races of *Ralstonia solanacearum* are motile when viewed microscopically, while avirulent races cells are immobile. The mobility was observed using the medium: 0, 1 % tryptone, 0, 1 % glycerol, 10% phosphate buffer, 3, 5 % Bacto agar.

2.4. The biovars test. The pathogen species is subdivided into races based on host range. Currently, polymerase chain reaction (PCR) is used for definitive identification of pathogen race. To identify the biovar of pathogen species we have used biochemical method based on the utilization of the disaccharides: cellobiose, lactose and maltose and oxidation of the hexose alcohols: dulcitol, mannitol, and sorbitol [9, 16].

2.5. Accumulation of Ralstonia solanacearum isolates in the host-plant tissue.

Healthy potato tubers of different varieties were used for accumulation the pathogen culture in the host cell. The tubers were washed profusely and thoroughly with water, and then were sterilized in 96% ethyl alcohol, after that thoroughly rinsed in sterile water and cut into pieces and placed in Petri dishes, on wet sterile filter paper. Bacterial suspensions at a concentration of 10^8 CFU/ml were infiltrated into potato slices. Inoculated slices were incubated at optimal temperature (28^0 C) for the bacteria. The optimum moisture ensured the rapid growth of bacteria.

2.6. Pathogenesis assays on potato seedlings and plants. Three potato (*Solanum tuberosum)* cultivars were used for pathogenicity tests: Picasso (highly sensitivity), Sante (medium resistant) and Nevskiy (highly resistant) .Three-week old plants grown in soil were inoculated by soil drench without root severing. The concentration of bacterial inoculums was 10^8 CFU/ml. The experiment was repeated at least two times, giving a total of six test plants. Inoculated plants were kept in a room condition with natural light and mean temperature at 28°C. Percentage of plants showing the wilting symptom was recorded during 28 days.

2.7. Tolerance to NaCL, 2, 0 % tests. To determine the sensitivity of *Ralstonia solanacearum* isolates to sodium chloride different media were included in this study : TTC medium (1% peptone, 0.1% casein hydrolysate, 0.5% glucose, 1,5% Bacto agar, 0.005% TTC); potato medium without gentian – violet (2.0% potato extract, 2,0% Bacto agar); peptone –yeast (0, 5% yeast extract , 1,0% peptone , 2,0% Bacto agar); extract sucrose- peptone (2,0 % saccharose, 0,5% peptone, 0,05% potassium phosphate dibasic, 0,025% magnesium sulfate, 2,0% Bacto agar) with the addition of 2,0 % sodium chloride.

2.8. Immunoblot ELISA test (Agdia). The *Ralstonia solanacearum (*RS) ELISA test was used with plant samples exhibiting symptoms of Rs and with bacterial culture samples. According to protocol of DAS ELISA of Agdia the samples were added to microplate coated with monoclonal antibodies to EPS of Rs. If EPS is present in the sample, it is bound by antibodies and captured on the microplate during the incubation period. After incubation, the plate was washed to remove unbound sample. An enzyme conjugate solution, containing a monoclonal antibody conjugated to peroxidase, is added and binded to any captured EPS. After incubation the plate is washed to remove any unbound conjugate. This final binding creates a sandwich of the target analyte between the two specific antibodies. Weels in which a blue color developed was indicated positive results. Wells in which there was no significant color development indicated negative result. Test results were valid only
if positive control wells give a positive result and buffer wells remain colorless.

3. RESULTS and DISCUSSION.

3.1. Origin of isolates and Organism Characteristics. We have analyzed potato tubers of Picasso, Sante, Nevskiy varieties. *Ralstonia solanacearum* - as a pathogen of bacterial wilt was obtained from Picasso variety. 12 isolates from potato fields of Issuk-Kul and 7 isolates from Chy regions were identified as Ralstonia *solanacearum species.*

Large, elevated, fluidal and white colonies of isolated bacteria were grown after two days on TZC medium, and white, fluidal with whorls characteristic colonies were appeared on SPA. The organism was capable to grow at 28 - 36 ° C temperatures aerobically and does not form endospores. The bacterium is slightly thick sticks with dimensions of 0.7-0.9 microns, gram – negative, motile and is non-encapsulated. Cells of obtained isolates *Ralstonia solanacearum* were motile when viewed microscopically, that is indicated to it's the ability of virulent. The isolates were catalase and oxidase positive.

New isolates of *Ralstonia solanacearum* were able to reduce nitrate to nitrite. Changing the medium color to red and formation a layer of foam from an intensive gas release indicate to a complete reduction of nitrate and denitrification (fig.1).

Fig.1. Formation a layer of foam from an intensive gas release indicate a complete reduction of nitrate and denitrification by *Ralstonia solanacearum*

3.2. Sensitivity to NaCL, 2, 0 % tests. The causative agent of potato brown rot is more sensitive to the presence of salt in the environment than other no spore forming plant pathogen bacteria. Typically, bacteria of *Pseudomonas* genus can develop tolerance to 3 % or more of sodium chloride [17]. Whereas *Ralstonia solanacearum* isolates have a sensitivity to 2% NaCL, even some species can prevent their growth in the presence in the medium only 1.0% salt.

The sensitivity of *Ralstonia solanacearum* isolates to sodium chloride was different in used media. Isolates have formed colonies differ in shape, size and color; also differ in the intensity of growth. The growth of bacteria was inhibited on the TTC medium with 2, 0% NaCL, so the colonies were slightly noticeable (fig.2, A). Whereas, the growth of bacteria colonies on the potato medium without gentian – violet and peptone –yeast medium was normal with a high visibility (fig.2, D, C). On the extract sucrose- peptone the growth of bacteria was slight, but the growth has not stopped and further continued (fig.2, B). Different compositions of used media with the same content of sodium chloride have a different effect on the sensitivity of *Ralstonia solanacearum* isolates to salt. The pathogen isolates have showed a considerable tolerance in potato medium without gentian – violet and peptone –yeast medium. The isolates have showed a very low tolerance on the TTC medium, a resistant tolerance was visible on the extract sucrose- peptone medium.

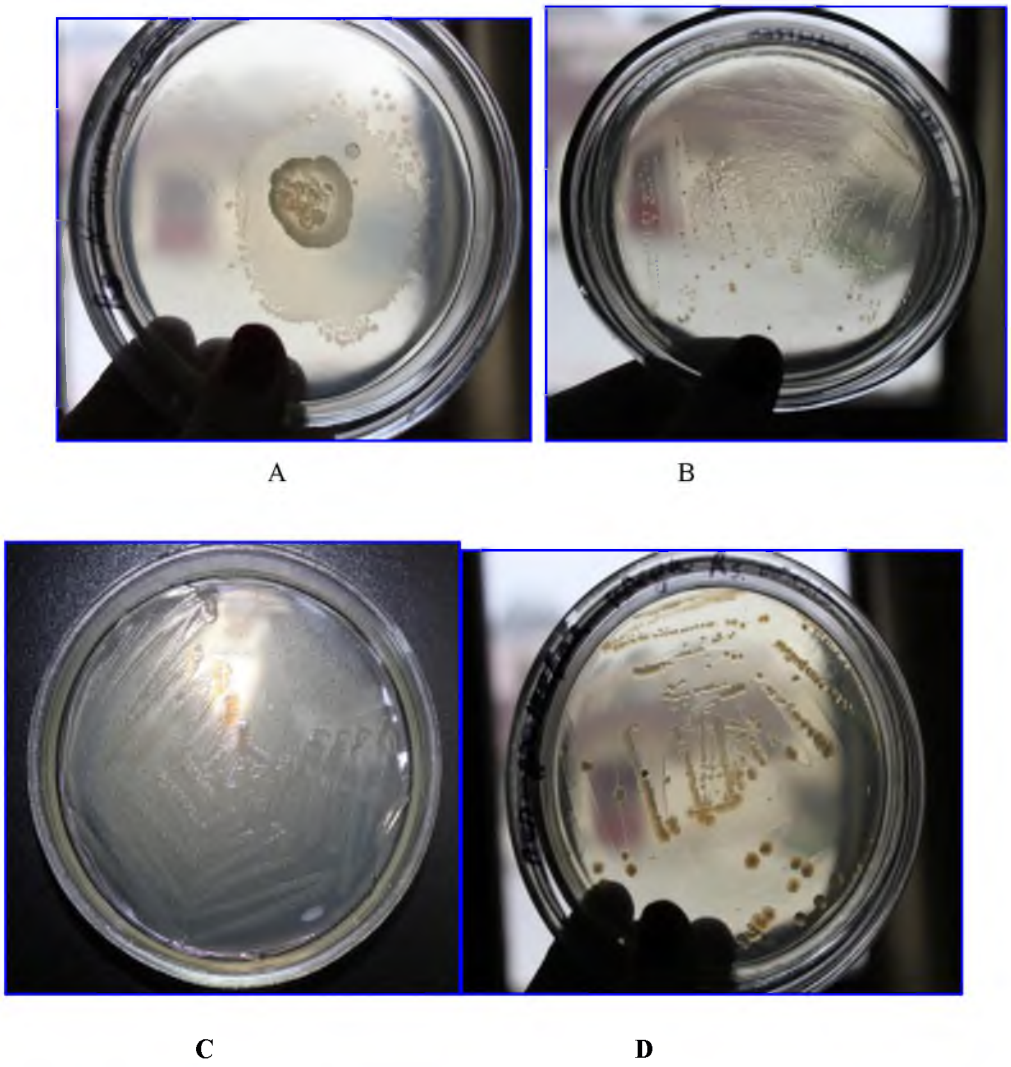


Fig.2. A- a growth inhibition on the TTC medium with 2, 0% NaCL, B- *inhibited* but continued growth on saccharose peptone medium with 2, 0% NaCL, C- a normal growth on the on Genthian violet medium with 2, 0% NaCL ; D- a normal growth on the peptone-yeast medium with 2,0 % NaCL, for 48 hours

3.4. The biovars test. Specific host range and distribution of *Ralstonia solanacearum* depends on the race and the biovars of the pathogen. In table 1. the data related to the relationship of race, biovars, host range, and geographic distribution of *Ralstonia solanacearum are* summarized. It is known the five races of potato brown rot. The most dangerous is a race 3 that is affecting the potatoes in low temperature. The infection persists for a long time in plant debris and potato tubers (in a latent form), and it is common in temperate regions. It's main sources are infected soil, crop residues, weeds of the genus Solanaceae [16].

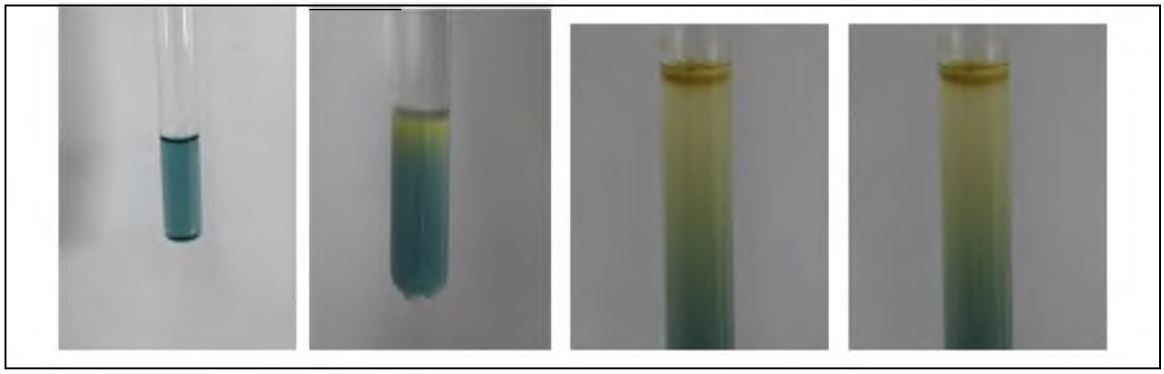
Table 1. Races and biovars of *Ralstonia solanacearum*.(Adapted from Daughtrey 2003) [10]

Race	Host Range	Geographic distribution	Biovar
1	Wide	Asia, Australia	3, 4
		Americas	1
2	Banana, other *Musa* spp.	Caribbean, Brazil, Worldwide	1
3	Potato, some other *Solanaceae,* Geranium; few other species	Worldwide except US and Canada	2
4	Ginger	Asia	3,4
5	Mulberry	China	5

Isolated races of *Ralstonia solanacearum* by biochemical characteristics were classified as a 3-biotype, so they were able to oxidize the disaccharide: cellobiose, lactose and maltose and the hexose alcohols: dulcitol, mannitol, and sorbitol. Table 2 illustrates the classification into biovars based on this method. When bromomethyl Blau was used as an indicator the medium becomes yellow as a result of oxidation , and when Andred indicator was used , the medium has changed to red. Transformation of these substrate by isolates has occurred slowly, for example as shown in Fig.3 in the presence of bromomethyl Blau indicator an oxidation of dulcitol was occurred only after 12 days (fig.3 A).

Table 2. Classification of *Ralstonia solanacearum* into biovars. (Adapted from French et al, 1995)[9]

	Biovars				
Physiological Tests	**1**	**2**	**3**	**4**	**5**
Utilization of disaccharides					
Cellobiose	-	+	+	-	+
Lactose	-	+	+	-	+
Maltose	-	+	+	-	+
Oxidation of alcohols					
Dulcitol	-	-	+	+	-
Mannitol	-	-	+	+	+
Sorbitol	-	-	+	+	



2 days 4-5 days 7-9 days 10-12 days

Fig.3 An oxidation of dulcitol by *Ralstonia solanacearum isolates* in the presence of bromomethyl Blau indicator

3.5. Accumulation of Ralstonia solanacearum isolates in the host-plant tissue.

In many cases *Ralstonia solanacearum* bacteria are closely interrelated with secondary pathogens such as the causative agent of soft rot *Erwinia carotovora var. atroseptica* [18].This creates some difficulties for the isolation of a pure culture of *Ralstonia solanacearum* from the affected tissue. For the accumulation of the culture of the pathogen in the host cell and to determinate it's virulence, bacterial suspensions of *Ralstonia solanacearum* at a concentration of 10^8 CFU/ml were infiltrated into sterile healthy potato slices. They were incubated at lower temperatures (22^0 C), in moisture chamber. The optimum moisture ensured the rapid growth of bacteria. The organism quickly began to multiply in infected host cells. On the third day a dark ringed circles were appeared on potato slices. Gradually, a rotting of the entire surface of potato slices has started. In 5 days there was a complete decay, with the release of odors and turning into mucous (fig. 4).

Of all the varieties tested only Picasso showed high sensitivity to rotting at low temperatures. These results allowed us to identify which varieties are more resistant or more susceptible to this disease. It is important to provide advice to farmers which varieties are the best to grow in different climatic zones of the republic. This test additionally has confirmed that obtained *Ralstonia solanacearum* new isolates are belong to biovar 3, which can survive at low temperatures. Some researchers have noted in their results that, high

temperatures and high soil moisture generally favors *Ralstonia solanacearum*, the exception being certain Race 3 strains that are pathogenic on potato and are able to grow well at lower temperatures [9].

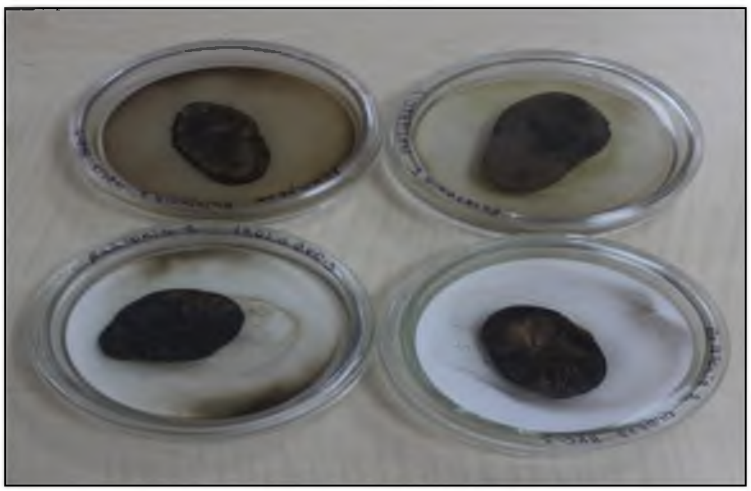


Fig.4. Rotted potato tubers of Picasso variety in 5 days after infiltration of a pathogen suspension.

3.6. Pathogenesis assays on potato seedlings and plants. Three potato (*Solanum tuberosum)* cultivars were used for pathogenicity tests: Picasso (highly sensitivity), Sante (medium resistant) and Nevskiy (highly resistant). In between 3-6 days began to appear the symptoms of disease in the Picasso variety plants. The first symptoms of the disease were wilting leaves on the ends of branches. During disease development, the leaves turn chlorosis and eventually necrotic. Close to the ground part of the stem of infected plants turn gray-brown. This is a characteristic symptom of potatoes brown rot (fig.5 A and B). In the variety of Sante the symptoms of disease began to appear in 2 weeks, and the lower leaves are browned and dry, turn yellow and chlorosis. Stems have stood relatively for long time, and then 4 weeks later started to bend. Nevskiy variety was resistant to the pathogen infected dose. Within 6 weeks there were no signs of disease. The specific symptoms: wilting of the leaves at the end of the day with recovery at night, the edges of the leaves turned black and curled were observed within 5 to 10 days, but no symptoms were observed on control plants treated with sterile water.

A B

Fig.5. A: close to the ground part of the stem of infected became grey brown; B: infected plants show yellowing, wilting, and browning of lower leaves followed by necrosis;

3.7. Immunoblot ELISA test (Agdia). Using the ELISA technology has allowed to identify *Ralstonia solanacearum* bacteria from diseased leaves of potato at a concentration of 10^3-10^4 cells\ml. Detection and identification of the pathogen by ELISA (Agdia product, USA) performed directly from diseased potato stems and leaves at a concentration of 10^3-10^4 cells\ml. Weels in which a blue color developed was indicated positive results. The bacterium was reisolated from the infected leaves and stems and identified as described above (fig.6).

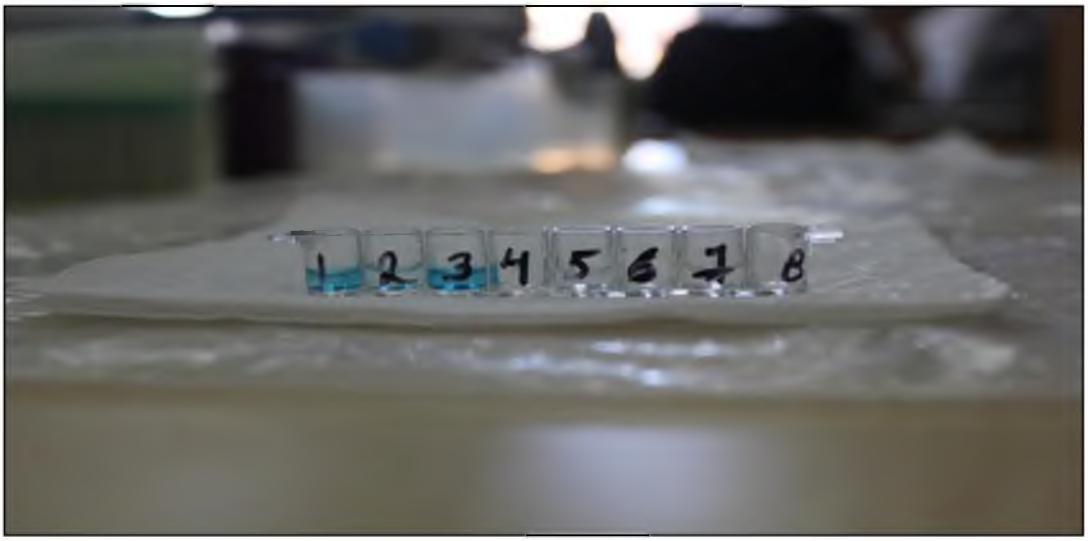


Fig.6. Weels with a blue color developed is indicated positive results from diseased potato stems and leaves at a concentration of 10^3-10^4 cells\ml.

In this study, we have used well known, efficient methods and bioassay for systematic screening of *R. solanacearum* for identification phenotypic and biochemical profile, also for pathogencity and virulence. As a result, an aggressive race, biovar 3 was most isolated from the potato fields of Tup district of Issyk-Kul region, especially in fields where Picasso variety was grown. This area is characterized by wet and temperate climate than other areas of the Issyk-Kul region. The low percentage of affection with this agent was noted in Sante variety. The pathogen was no almost obtained from Nevskiy variety plants and tubers. In this region, the pathogens were isolated from growing plants with character symptoms and tubers after harvest in storage, they were available for sale.

In Chuy oblast, where the climate is hot and the humidity is relatively low [15], pathogen races of *R. solanacearum* were obtained from Picasso and Santa potato varieties. In this region, essentially isolates were relieved from the tubers for sale, or in storage.

We have not found R. *solanacearum species as* causative agents of wilt in local potatoes varieties (red and white crumbly) grown in mountainous areas of Kochkor district, This indicates that the disease has penetrated into Kyrgyzstan from neighboring countries together with planting material.

Our results for the first time in Kyrgyzstan have revealed the presence *Ralstonia solanacearum* bacterium as a pathogen of bacterial wilt (quarantine for the country object) in the potato fields of Issyk-Kul and Chy regions. As well as our results have allowed to determine which varieties are most susceptible to the disease and in which district a threat constitutes to most of its wide dissemination. This is important to prevent farmers, which varieties they should buy as planting material. The areas in which have not yet been introduced commercial varieties should be remaining clean zones from this disease.

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Fungi Associated with Cysts of *Globodera rostochiensis*, *Heterodera cruciferae* and *Heterodera schachii* (Nematoda: Heteroderidae)

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Abstract Cysts of *Globodera rostochiensis* (Wollenweber) Behrens from potato (*Solanum tuberosum* L.) fields and *Heterodera cruciferae* Franklin from cabbage (*Brassica oleracea* L. var. *capitata* subvar. *rubra* L.) fields and *Heterodera schachtii* Schmidt from sugar-beet (*Beta vulgaris* L.) fields in Turkey were collected and examined for the presence of fungi. Of the total of 196 cysts of *G. rostochiensis*, 39.7% were colonized by one or more of 7 different species of fungi, all of which were from the genera *Cylindrocarpon, Fusarium, Gliocladium, Verticillium* and *Alternaria*. Of the total of 136 cysts of *H. cruciferae*, 37.5% were colonized by one or more of 7 different species of fungi, all of which were from the genera *Cylindrocarpon, Fusarium, Nematophthora, Periconia* and *Verticillium*, and 38.9% of the 154 cysts of *H. schachtii* were colonized by one or more of 7 different species from the same genera.

Keywords: Nematophagous fungi, *Globodera rostochiensis, Heterodera cruciferae, Heterodera schachtii,* biological control

Globodera rostochiensis, Heterodera cruciferae ve *Heterodera schachtii* (Nematoda: Heteroderidae)'nin Kistleri ile İlişkili Mantarlar

Özet: Türkiye'de patates (*Solanum tuberosum* L.) tarlalarından *Globodera rostochiensis* (Wollenweber) Behrens, lahana (*Brassica oleracea* L. var. *capitata* subvar. *rubra* L.) tarlalarından *Heterodera cruciferae* Franklin ve şeker pancarı (*Beta vulgaris* L.) tarlalarından *Heterodera schachtii* Schmidt kistleri toplanmış ve mantar mevcudiyeti bakımından incelenmiştir. Toplam 196 *G. rostochiensis* kistinin 39.7% si 7 farklı türe ait bir ya da daha fazla mantar türü ile beraber bulunmuştur. Bu mantar türleri, *Cylindrocarpon, Fusarium, Gliocladium, Verticillium* ve *Alternaria* cinslerine aittir. Toplam 136 *H. cruciferae* kistinin 37.5% i 7 farklı türe ait bir ya da daha fazla mantar türü ile beraber bulunmuş olup bunların hepside *Cylindrocarpon, Fusarium, Nematophthora, Periconia* ve *Verticillum* cinslerine ait mantar türleridir. *H. schachtii* ye ait toplam 154 kistin 38.9% u ise yine aynı şekilde bir önceki cinslere ait olan mantarlar ile ilişkili olarak bulunmuştur.

Anahtar Kelimeler: Nematofaj mantarlar, *Globodera rostochiensis, Heterodera cruciferae, Heterodera schachtii,* biyolojik kontrol

1. INTRODUCTION

Nematophagous (nematode-destroying) fungi are natural enemies of nematodes. Nematophagous fungi have been found in all regions of the world, from tropics to Antarctica. They have been reported from agricultural, garden and forest soils, and are especially abundant in soils rich in organic material [1]. They comprise three main groups of fungi; the nematode-trapping and the endoparasitic fungi that attack vermiform living nematodes by using specialized structures, and the egg and cyst parasitic fungi that attack these stages with their hyphal tips [2, 3]. The reason for the continuing interest in these fungi is, in part, their potential as biocontrol agents against plant and animal parasitic nematodes. From this point of view especially, the egg and cyst parasitic fungi have been investigated in depth because of the promise of these fungi as biocontrol agents [4, 5].

Biological control of plant parasitic nematodes using nematophagous fungi has received considerable attention recently, because of the urgent need for alternatives to replace synthetic nematicides that are being phased out due to environmental concerns [6, 7]. The potato cyst nematode (PCN), *Globodera rostochiensis* (Wollenweber, 1923) Behrens, 1975 and the cabbage cyst nematode (CCN), *Heterodera cruciferae* Franklin, 1945 and the beet cyst nematode (BCN), *Heterodera schachtii* Schmidt, 1871 are some of the most important plant parasitic nematodes in the world. Since nematophagous fungi were first discovered in soil in 1852 [8], more than 200 species of fungi have been identified as colonizers of cysts, eggs and females of eight species of cyst nematodes in soil, including PCN and BCN [9,10]. The percentages of cysts, eggs and females of cysts nematodes colonized by fungi in agricultural soil ranged from 10-90%, with about 50% being the most common [11, 12]. Two possible routes for biological management of plant parasitic nematodes have been proposed. One is mass produce an effective nematode destroying fungus in the laboratory, and then apply it to soil [13] and the other is enhance the natural nematophagous fungal populations in soil by altering their surrounding conditions. But commercial success of these approaches has been limited; however, there are encouraging reports on reducing nematode populations by adding certain kinds of amendments, such as chitin and green manure crops to soil [14, 15, 16, 17].

The objective of this study was to investigate the species and frequencies of fungi colonizing cysts of PCN, CCN and BCN collected from Central Anatolia of Turkey.

2. MATERIAL and METHODS

Fungal isolation from cysts of nematodes: Soil samples were collected from potato (*Solanum tuberosum* L.) fields (Nevşehir: 38° 37,2'N ; 34° 43,2'E) naturally infested with PCN, and from cabbage (*Brassica oleracea* L. var. *capitata* subvar. *rubra* L.) fields (Çorum: 40° 33,0'N ; 34° 57,0'E) naturally infested with CCN, and from sugar-beet (*Beta vulgaris* L.) fields (Eskişehir: 39° 46,2N ; 30° 30,0'E) infested with BCN in several areas of Central Anatolia in Turkey. The soil was air-dried overnight and the cysts were extracted by the Fenwick Can Method [18]. A total of 196 cysts of PCN, 136 of CCN and 154 of BCN were collected. Cysts were handpicked under a stereoscopic microscope (Meade model 8300), at 15 x magnification and transferred consecutively into a 10% sodium hypochlorite (NaClO) solution for 5 min, 100 µL L^{-1} streptomycin for 15 min, 20 µL L^{-1} malachite green for 10 min, and sterilized water for surface disinfestations. The cysts were partially air-dried afterwards. Five surface-dried disinfested cysts were placed onto the corners at a sterilized square cover glass which was on potato dextrose agar in a Petri dish (9 cm diameter) under sterile conditions. The Petri dishes were sealed with paraffin film and incubated at 23 °C. Fungi growing from the cysts were examined visually or with a light microscope (Olympus model CX21) at low magnification (x 40) to determine the sites from which the fungi grew. The fungal colonies emerging from cysts were transferred once they reached the agar under the cover glass. Identifications of fungi were made from these subcultures. Identification of the nematophagous fungi was based on the morphological characteristics of conidiophores and conidia [19, 20, 21, 22]. If needed, nematodes were added to fungal cultures to induce sporulation for identification. Sporulation was also induced in some cultures by exposing fungal mycelium to a black light lamp (Model X-15B 115 volts 60Hz).

3. RESULTS AND DISCUSSION

3.1. Fungi associated with cysts of PCN: Of the 196 cysts of PCN examined, 78 or 39.7% were colonized by fungi (Table 1). Seven species of fungi were identified, representing 5 different genera. Of the fungi identified, most were species of *Fusarium*. *Fusarium oxysporum* Schlechtendahl was found to be associated with 33 cysts or 16.8%. *Gliocladium roseum* Bainier, *Verticillium coccosporum* W. Gams, *Alternaria alternata* (Fr.) Keissl, *Cylindrocarpon destructans* (Zinser) Scholten were infrequently associated with cysts (Table 1; Figure 1). Most fungi isolated emerged from anywhere on the cysts surface whereas *C. destructans* emerged only from the vulva of the cysts. This difference is important for identifications of fungi.

3.2. Fungi associated with cysts of CCN: Of the 136 cysts of CCN examined, 51 (37.5%) were colonized by fungi (Table 2; Figure 2). Seven species of fungi were isolated and identified. Most fungi associated with cysts of PCN were species of *Fusarium*. *Fusarium oxysporum* was associated with 26 cysts (19.1%), and *C. destructans* associated with 11 cysts (8.0%). *Fusarium solani* and *F. tabacinum* each colonized 2.9% of the cysts. All other species from other genera occurred at relatively low frequency (1.5 - 2.5%).

3.3 Fungi associated with cysts of BCN: For this research, of the 154 cysts of BCN examined, 60 (38.9%) were colonized by fungi (Table 3; Figure 3). Seven species of fungi were isolated and identified. All of them were the same species of fungi that were isolated from cysts of BCN. The frequencies of association of these fungi with cysts of BCN were similar to those of CCN. Most fungi associated with cysts of BCN were species of *Fusarium*. *Fusarium oxysporum* was associated with 30 cysts (19.4%) but *C. destructans* was associated with 16 cysts (10.3%). All other species from other genera occurred at relatively low frequency for BCN (0.5 – 2.5%).

This research showed that numerous fungi were associated with cysts of cyst nematodes. The fungal genera from PCN, CCN and BCN were similar, especially those found in CCN and BCN. These fungi associated with nematodes may represent a distinct mycoflora in the soil. Agricultural soils generally contain hundreds of species of fungi belonging to 170 genera [20]. At the species level, 10 fungal species were isolated from cysts of PCN, CCN and BCN. *Fusarium oxysporum, C. destructans* and *V. coccosporium* were associated with these cyst nematodes whereas *F. heterosporium, G. roseum* and *A. alternata* were associated with only PCN. This suggests that the mycofloras of the cyst nematodes may be different. Because biological life cycle, hosts and nutritional needs of cyst nematodes are generally different.

Cylindrocarpon destructans has been reported as an egg parasite of several cyst nematodes [23, 24]. A *Fusarium* species associated with egg masses but not females has been reported to be an egg parasite [25]. All the fungi isolated from PCN, CCN and BCN have been reported to be associated with plant-parasitic nematodes, especially cyst-forming nematodes. A few of them have been proven obligate parasites of nematodes but most of them are opportunistic parasites and saprophytes. For those obligate parasites, their effectiveness in destroying nematodes in vitro has not led them to be successful bio-control agents of plant parasitic nematodes. However, there are reports which indicate that viability of nematodes was greatly reduced after being colonized by some of these opportunistic fungal parasites in laboratory [23]. In soil, the populations of these opportunistic fungi associated with nematodes can be significantly greater than populations of obligate parasites [26, 27, 28]. Many nematode trapping fungi have been found to occur more frequently in the rhizospheres of several plants, especially leguminous plants, e.g. soybean and pea, than in root free soil [29, 30, 31]. This effect could possibly be due to increased or changed root exudation in these plants. The suppressiveness of suppressive soils against plant parasitic nematodes has been reported to be positively related to the population of all the fungal parasites, including the opportunists [9]. Although a great deal of knowledge is lacking on the mode of action and population dynamics of these opportunistic fungal parasites, their importance in future integrated management of plant parasitic nematodes should not be underestimated.

4. CONCLUSION

One important aspect of nematophagous fungi is the possibility of using them for biological control of plant- and animal- parasitic nematodes. Plant parasitic nematodes, e.g. root knot and cyst nematodes, are global pests in agriculture and horticulture, causing severe yield losses.

Owing to the ban of many nematicides, e.g. methyl bromide, because of health and environmental concerns, new alternatives for nematode control are therefore needed. Biological control may be such an alternative.

Mostly, plant parasitic nematodes attack plant roots and, therefore, the ability of the nematophagous fungi to grow in the rhizosphere is of great importance for their capacity to control these nematodes.

Table 1. Fungal species associated with cysts of *Globodera rostochiensis*

	Cysts colonized by fungi	
Fungal species	**Number (n)**	**Percentage (%)**
Fusarium heterosporum	10	5.1
Fusarium oxysporum	33	16.8
Fusarium solani	4	2.0
Gliocladium roseum	5	2.5
Verticillium coccosporum	7	3.5
Alternaria alternate	8	4.0
Cylindrocarpon destructans	11	5.6
Total cysts colonized *	78	39.7
PSD: 9.21		

* A total of 196 cysts were examined.
PSD: Population Standart Deviation

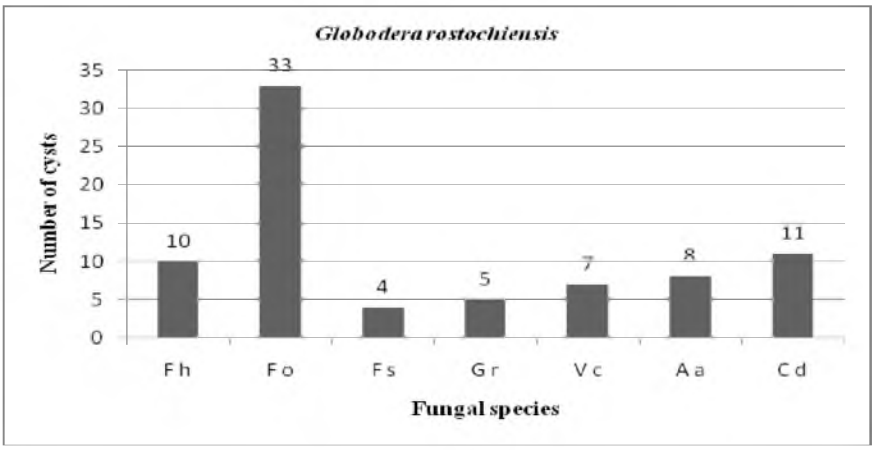

Figure 1. Fungal species associated with cysts of *Globodera rostochiensis* (F h. *Fusarium heterosporum*, F o: *Fusarium oxysporum*, F s: *Fusarium solani*, G r: *Gliocladium roseum*, V c: *Verticillium coccosporum*, A a: *Alternaria alternate*, C d: *Cylindrocarpon destructans*).

Table 2. Fungal species associated with cysts of *Heterodera cruciferae*

	Cysts colonized by fungi	
Fungal species	**Number (n)**	**Percentage (%)**
Cylindrocarpon destructans	11	8.0
Fusarium oxysporum	26	19.1
Fusarium solani	4	2.9
Fusarium tabacinum	4	2.9
Nematophthora gynophila	2	1.4
Periconia macrospinosa	1	0.7
Verticillium coccosporium	3	2.2
Total cysts colonized *	51	37.5
PSD: 8.20		

* A total of 136 cysts were examined.
PSD: Population Standart Deviation

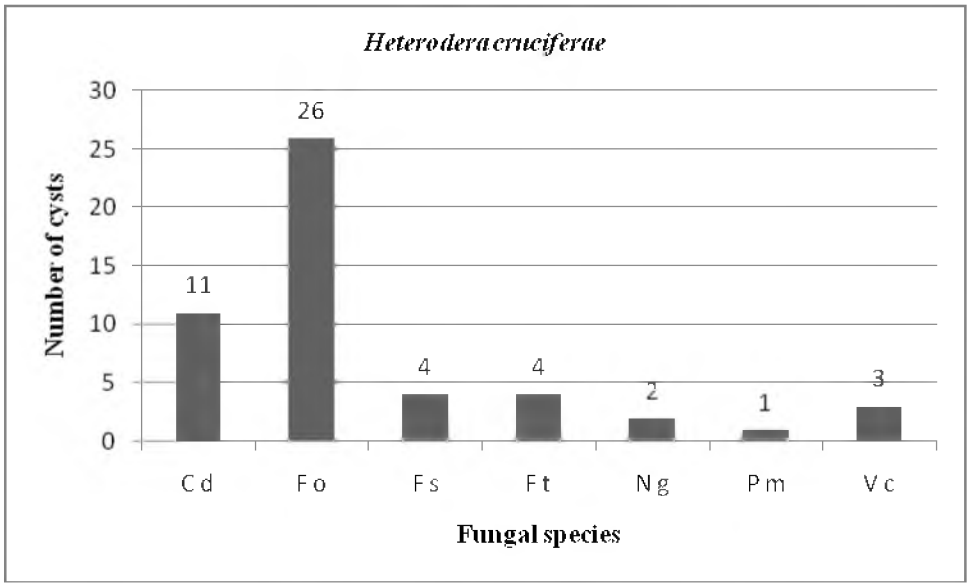

Figure 2. Fungal species associated with cysts of *Heterodera cruciferae* (C d: *Cylindrocarpon destructans*, F o: *Fusarium oxysporum*, F s: *Fusarium solani*, F t: *Fusarium tabacinum*, N g: *Nematophthora gynophila*, P m: *Periconia macrospinosa*, V c. *Verticillium coccosporium*).

Table 3. Fungal species associated with cysts of *Heterodera schachtii*

	Cysts colonized by fungi	
Fungal species	**Number (n)**	**Percentage (%)**
Cylindrocarpon destructans	16	10.3
Fusarium oxysporum	30	19.4
Fusarium solani	4	2.5
Fusarium tabacinum	2	1.2
Nematophthora gynophila	4	2.5
Periconia macrospinosa	3	1.9
Verticillium coccosporium	1	0.6
Total cysts colonized *	60	38.9
PSD: 9.91		

* A total of 154 cysts were examined.
PSD: Population Standart Deviation

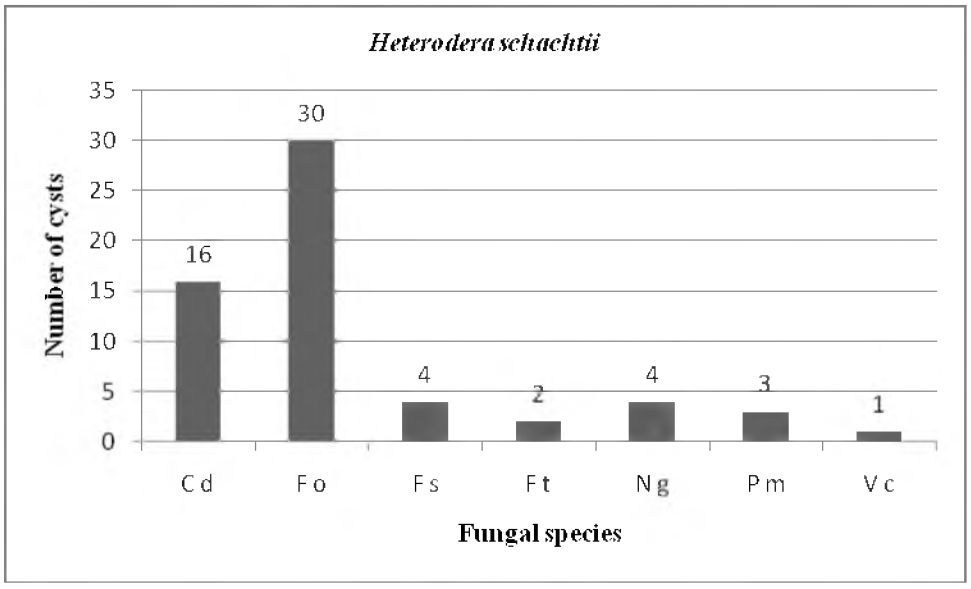

Figure 3. Fungal species associated with cysts of *Heterodera schachtii* (C d: *Cylindrocarpon destructans,* F o: *Fusarium oxysporum*, F s: *Fusarium solani*, F t: *Fusarium tabacinum*, N g: *Nematophthora gynophila*, P m: *Periconia macrospinosa*, V c. *Verticillium coccosporium*).

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Phytoplankton Dynamics and Some Physicochemical Variables in Cakmak Reservoir (Samsun, Turkey)

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Abstract Phytoplankton dynamics and some physicochemical properties of Cakmak Reservoir were investigated between May 2003 and April 2005 which is used for irrigation and drinking water supply. A total of 132 taxa were identified belonging to the following divisions; Cyanobacteria, Charophyta, Chlorophyta, Cryptophyta, Euglenozoa, Myzozoa and Ochrophyta. Although Ochrophytes were rich in respect to species diversity, Chlorophytes attained a larger population density. *Ulnaria ulna*, *Fragilaria tenera* and *Goniochloris mutica* from Ochrophyta, *Chlorella vulgaris*, *Monoraphidium obtusum* and *Ulothrix tenerrima* from Chlorophyta, *Cryptomonas ovata* and *C. erosa* from Cryptophyta increased in some months. The seasonal variation of phytoplankton based on depth was compatible with surface water. Phytoplankton abundance was lower in winter and there was an increase in summer in Cakmak Reservoir. The reservoir water was slightly alkaline according to the pH; was alkaline according to the calcium; was in the slightly hard water group according to the hardness values; had low and medium productivity degree according to the phosphorus.

Keywords *Phytoplankton, reservoir, seasonal variation, water properties;*

Özet İçme suyu temini ve sulama amaçlı kurulan Çakmak Baraj Gölü'nün fitoplankton dinamiği ve bazı fizikokimyasal özellikleri Mayıs 2003 - Nisan 2005 tarihleri arasında incelenmiştir. Cyanobacteria, Charophyta, Chlorophyta, Cryptophyta, Euglenozoa, Myzozoa ve Ochrophyta divizyolarına ait 132 takson tespit edilmiştir. Ochrophyta divizyosu tür çeşitliliği açısından zengin olmasına rağmen Chlorophyta divizyosunun populasyon büyüklüğü daha fazladır. Ochrophyta divizyosundan *Ulnaria ulna*, *Fragilaria tenera* ve *Goniochloris mutica*, Chlorophyta divizyosundan *Chlorella vulgaris*, *Monoraphidium obtusum* ve *Ulothrix tenerrima*; Cryptophyta divizyosundan *Cryptomonas ovata* ve *C. erosa* türlerinin bazı aylarda sayıca arttığı gözlenmiştir. Derinlik örneklerinde fitoplanktonun mevsimsel değişimi yüzey suyu örnekleri ile benzer mevsimsel değişim göstermiştir. Çakmak Baraj Gölü'nde fitoplankton bolluğu kışın daha düşük iken yaz aylarında artış kaydedilmiştir. Baraj suyunun pH değerlerine göre hafif alkali iken kalsiyum değerlerine göre alkali olduğu; sertlik değerlerine göre hafif sert sular grubunda; fosfor değerlerine göre ise düşük ve orta verimlilik derecesine sahip olduğu belirlenmiştir.

Anahtar sözcükler: Fitoplankton, baraj gölü, mevsimsel değişim, su kalitesi;

1. INTRODUCTION

In order to control flood events and water utilization, reservoir construction is essential in human life. Water quality is a critical factor for its utilization. Therefore, to use water efficiently from a reservoir, water quality monitoring and evaluation are needed [1]. Anthropogenic influences and natural processes impair their use for drinking, industrial, agricultural, recreation or other purposes [2].
Water quality affects species composition, abundance and the physiological status of aquatic species. Studies have shown that most algae are sensitive to changing environmental conditions. Planktonic organisms respond promptly to environmental changes and exhibit more conservative characteristics than physical and chemical variables [3]. The sustainability of aquatic ecosystems can be provided with an effective ecological management of resources and accurate monitoring. According to the Water Framework Directive (WFD), it requires an emphasis on local conditions. WFD's aim is the prevention of further destructions of aquatic ecosystems and other ecosystems, the improvement of the aquatic environment, long-term protection of existing water resources and it also aims to promote the sustainable use of water resources and to reduce the pollution in groundwater [4].
There is no phycological study on Cakmak Reservoir. The aim of this study is to summarize structure of phytoplankton community and to determine water quality in Cakmak Reservoir used for irrigation and drinking water supply.

2. MATERIALS and METHODS

Cakmak Reservoir is located in the south east of Samsun in Turkey (41° 44' and 40° 05' N; 37° 05' and 35° 30' E). It was established on River Abdal between 1985 and 1988 in order to ensure drinking water and use it for industrial purposes; the active storage volume is 76 hm^3 and the area is 6.5 km^2 and the highest water level is 122.75 m. It has approximately 5 km length and 1-1.5 km width [5].
Four stations were selected in order to determine phytoplankton dynamics, its seasonal variation and physicochemical properties of water (Figure 1). Water samples were collected from stations, monthly. The water samples were collected with Hydro-Bios Nansen water sampler. Samples were preserved in formaldehyde that will result in concentration of 4%. Phytoplankton were identified and counted at 400X magnification using the method of Utermohl [6] under Prior inverted microscope. The results were calculated according to method of Lund *et al.* [7]. Diatoms were prepared according to the method of Round [8]. Physicochemical variables described below were measured in surface water samples taken from the station 1. The conductivity, temperature, dissolved oxygen and pH were measured with Consort C534 sampling equipment and water transparency was measured with a secchi disc. The ammonia-N, nitrite-N, nitrate-N, bicarbonate, calcium, total hardness, magnesium, ortho-phosphate, sulfate and organic matter analyses were determined according to the standard methods at DSI VII. Quality Control Laboratory [9].
Algal species were identified according to the following: Anagnostidis and Komárek [10], Komárek and Anagnostidis [11-13], Hartley [14], Krammer and Lange-Bertalot [15-18], John *et al.* [19], Wehr and Sheath [20], Krammer [21], Tsarenko *et al.* [22]. All taxa were also checked on the algaebase web site [23].

3. RESULTS and DISCUSSION

Cakmak Reservoir is used for irrigation and drinking water supply. Phytoplankton dynamics and some physicochemical properties of the reservoir were investigated between May 2003 and April 2005. A total of 132 taxa were identified belonging to the following divisions; Cyanobacteria (16), Charophyta (10), Chlorophyta (27), Cryptophyta (2), Euglenozoa (17), Myzozoa (6) and Ochrophyta (54). The taxa identified in Cakmak Reservoir were given in Table 1.

Throughout the investigation period, conductivity, temperature, dissolved oxygen, pH, water transparency, ammonia-N, nitrite-N, nitrate-N, bicarbonate, calcium, total hardness, magnesium, ortho-phosphate, sulfate and organic matter analyses were measured and presented in Table 2.

The temperature which is important for aquatic organisms influences many chemical and biological processes [24]. The temperature was measured between 9.4 °C and 25.6 °C in surface water samples. Fogg and Thake [25] reported that phytoplankton abundance in temperate lakes is low in winter even if there are sufficient nutrients, low temperature and low light intensity. Phytoplankton abundance in reservoir was lower in winter and there was an increase in summer. According to the average secchi disc depth (115 cm), the trophic state of the reservoir has eutrophy [26]. The pH (7.2 to 8.6) indicated that the reservoir water was slightly alkaline. The measured pH values were within the range (6.5-9.0) of freshwater aquatic life [27]. pH measured in the lakes of the Black Sea Region also showed slight alkaline properties [28-29]. The water conductivity (77-104 μmhos cm^{-1}) was between limit values in natural waters according to Boyd [30]. The nitrite-N, nitrate-N and ammonia-N concentrations were determined as 0.000 to 0.084 mg l^{-1}, 0.04 to 1.35 mg l^{-1} and 0.00 to 1.50 mg l^{-1}, respectively. Horne and Goldman [31] reported nitrate and ammonia are low concentrations in natural water and nitrite is too low due to the nitrate conversion in the presence of oxygen. According to measured values (0.00 to 0.06 mg l^{-1}) of phosphorus, the reservoir was between low and medium productivity degrees [32]. The reservoir water hardness was ranged from 137.5 to 212.5 °FS and in terms of these results, the reservoir water was in the slightly hard water group [33]. Bicarbonate values varied between 113 mg l^{-1} and 203 mg l^{-1} and the calcium levels were determined between 39 mg l^{-1} and 60 mg l^{-1}. Presence of high concentrations of calcium indicated that water showed alkaline character. Low Mg concentrations affect the productivity of phytoplankton in lakes and thus the reservoir (6.7-15.2 mg l^{-1}) has oligotrophic character [33]. The concentration of sulfate in natural waters varied from a few mg l^{-1} to several hundred mg l^{-1} [34]. Sulfate concentrations of reservoir water were measured between 1.9 mg l^{-1} and 59.0 mg l^{-1}.

The most common taxonomic group in phytoplankton was Ochrophyta, occupying the 40% of the diversity among the taxonomic groups as in most of the algological studies in our country [29, 35, 36]. Centric diatoms are described as planktonic organisms by Round [37]. *Cyclotella* species were present in all seasons. *Cyclotella meneghiniana* and *Melosira* spp. are often present in oligotrophic lakes. Among pennate diatoms, *Ulnaria ulna* was over reproduction in the winter. This species is characteristic for eutrophic lakes [38], however it has also been dominant in oligotrophic lakes [39, 40]. The identified species in reservoir *Fragilaria*, *Amphora*, *Nitzschia* and *Navicula* were found in neutral and slightly alkaline waters and *Amphora ovalis*, *Navicula cryptocephala* existed in alkaline waters [41].

Chrysophyceae was represented by *Dinobryon sertularia* in the reservoir. This species was dominant in early autumn and winter. Rawson [42] stated that it was accepted as an indicator of oligotrophic lakes. *Chlorella vulgaris* and *Monoraphidium obtusum* from chloropyhtes increased in number during summer months and *Pediastrum* was represented by 1 species. Legnerova [43] reported that *Monoraphidium* species are common in oligotrophic and mesotrophic lakes while *Pediastrum* members are characteristic of mesotrophic lakes. Charophyta was represented by 10 species in Cakmak Reservoir. *Cosmarium* and *Closterium* are usually present in oligotrophic lakes [37, 38, 42]. *Cosmarium* species are often present in Cakmak Reservoir. *Ceratium* spp. from Myzozoa were observed commonly in phytoplankton. *Ceratium hirundinella* reached significant numbers in the autumn. *C. hirundinella* can be found in oligotrophic and eutrophic lakes and almost all over the world distribution [19]. Myzozoa members were commonly found in spring and autumn and rare in winter in the reservoir. In our country, it was found to be common as well [44]. *Peridinium cinctum* was characteristic dinoflagellate of eutrophic and mezotrophic lakes and this species can be found in many different environments [42]. Reynolds [45] stated that most species are

abundant in epilimnion, while dinoflagellates are adapted to deeper waters. Dinoflagellate and ochrophyte density were increased in phytoplankton in Cakmak Reservoir. Euglenozoa members were more abundant in polluted waters [46]. However Euglenozoa members were found in the most of the oligotrophic reservoirs in our country [28, 44, 47].

The seasonal variation in the water column was generally shown as an adjustment to the seasonal change in the surface water in Cakmak Reservoir phytoplankton. The abundance of Chlorophyta and Cyanobacteria descended through deeper water while Ochrophyta and Myzozoa increased. Since light cannot reach to the deep, photosynthetic algae existed near the surface, whereas the heterotrophic or mixotrophic organisms were able to distribute in deeper water levels.

The reservoir water was unpolluted according to the average dissolved oxygen concentration; was slightly alkaline according to pH; was alkaline according to calcium concentration and was in the slightly hard water group according to hardness values. The trophic state of the reservoir had eutrophic character according to the average secchi disc depth, while it was between low and medium productivity degrees according to phosphorus concentration and had oligotrophic character according to Mg concentrations. Furthermore, morphometric structure of the lake, poor aquatic macrophytes, water color ranging from blue to blue-green and phytoplankton dynamics have been supporting that the lake had oligotrophic character.

4. TABLES

Table 1. The taxa identified in Cakmak Reservoir

Divisio	**:Cyanobacteria**
Class	**:Cyanophyceae**
Aphanocapsa incerta (Lemmermann) Cronberg & Komárek	
Chroococcus minor (Kützing) Nägeli	
Chroococcus pallidus Nägeli	
Chroococcus turgidus (Kützing) Nägeli	
Gloeothece linearis Nägeli	
Gomphosphaeria aponina Kützing	
Limnococcus limneticus (Lemmermann) Komárková, *et. al.*	
Merismopedia elegans A. Braun ex Kützing	
Merismopedia glauca (Ehrenberg) Kützing	
Merismopedia punctata Meyen	
Microcystis aeruginosa (Kützing) Kützing	
Oscillatoria tenuis C. Agardh ex Gomont	
Spirulina major Kützing ex Gomont	
Spirulina princeps West & G. S. West	
Spirulina subsalsa Oerstedt ex Gomont	
Wollea saccata (Wolle) Bornet & Flahault	
Divisio	**:Charophyta**
Class	**:Zygnematophyceae**
Closterium acutum Brébisson	
Closterium dianae Ehrenberg ex Ralfs	
Closterium moniliferum Ehrenberg ex Ralfs	
Cosmarium bioculatum Brébisson ex Ralfs	
Cosmarium formosulum Hoff	
Cosmarium granatum Brébisson ex Ralfs	
Cosmarium laeve Rabenhorst	
Spirogyra varians (Hassall) Kützing	
Spirogyra weberi Kützing	
Staurastrum gracile Ralfs ex Ralfs	
Divisio	**:Chlorophyta**
Class	**:Chlorocophyceae**
Acutodesmus obliquus (Turpin) Hegewald & Hanagata	
Ankistrodesmus falcatus (Corda) Ralfs	
Asterococcus sp.	
Chlamydomonas globosa J. W. Snow	
Coelastrum microporum Nägeli	
Desmodesmus abundans (Kirchner) E. Hegewald	
Desmodesmus communis (E. H. Hegewald) E. H. Hegewald	
Monoraphidium griffithii (Berkeley) Komárková-Legnerová	

Monoraphidium minutum (Nägeli) Komárková-legnerová
Monoraphidium obtusum (Korshikov) Komárková-Legnerová
Monactinus simplex (Meyen) Corda
Pediastrum duplex Meyen
Pseudocharacium obtusum (A. Braun) Petry-Hesse
Pseudopediastrum boryanum (Turpin) E. Hegewald
Raphidocelis subcapitata (Korshikov) G. Nygaard *et. al.*
Scenedesmus ecornis (Ehrenberg) Chodat
Scenedesmus obtusus Meyen
Scenedesmus verrucosus Y. V. Roll
Selenastrum gracile Reinsch
Stauridium privum (Printz) E. Hegewald
Tetraedron minimum (A. Braun) Hansgirg
Tetrastrum komarekii Hindák

Class :Trebouxiophyceae

Botryococcus braunii Kützing
Chlorella vulgaris Beyerinck [Beijerinck]
Gloeotila subconstricta (G. S. West) Printz
Oocystis borgei J. Snow

Class :Ulvophyceae

Ulothrix tenerrima (Kützing) Kützing

Divisio :Cryptophyta

Ordo :Cryptophyceae

Cryptomonas erosa Ehrenberg
Cryptomonas ovata Ehrenberg

Divisio :Euglenozoa

Class :Euglenophyceae

Astasia shadowskii Korshikov
Euglena clavata Skuja
Euglena elongata Schewiakoff
Euglena gracilis Klebs
Euglena oxyuris Schmarda f. *skvortzovii* (Popowa) Popowa
Euglena retronata L. P. Johnson
Euglena splendens P. A. Dangeard
Lepocinclus oxyuris (Schmarda) Marin & Melkonian
Phacus acuminatus Stokes
Phacus caudatus Hübner
Phacus longicauda (Ehrenberg) Dujardin var. *rotunda* (Pochmann) Huber-Pestalozzi
Strombomonas verrucosa (E. Daday) Deflandre
Trachelomonas crebea Kellicott var. *brevicollis* Prescott
Trachelomonas hispida (Perty) F. Stein
Trachelomonas inflata Skvortzov var. *crenulatocollis* Skvortzov
Trachelomonas oblonga Lemmermann var. *pulcherrima* (Playfair) Popova
Trachelomonas volvocina (Ehrenberg) Ehrenberg

Divisio :Myzozoa

Class :Dinophyceae

Ceratium furcoides (Levander) Langhans
Ceratium hirundinella (O. F. Müller) Dujardin
Ceratium hirundinella var. *silesiacum* (Schroeder) Huber-Pestalozzi
Peridiniopsis thompsonii (Thompson) Bourrelly
Peridinium aciculiferum Lemmermann
Peridinium cinctum (O. F. Müller) Ehrenberg

Divisio :Ochrophyta

Class :Bacillariophyceae

Amphora ovalis (Kützing) Kützing
Asterionella formosa Hassall
Aulacoseira granulata (Ehrenberg) Simonsen
Aulacoseira granulata var. *angustissima* (O. F. Müller) Simonsen
Aulacoseira islandica (O. F. Müller) Simonsen
Brachysira brebissonii R. Ross
Caloneis dubia Krammer
Cocconeis pediculus Ehrenberg
Cocconeis placentula Ehrenberg
Cocconeis placentula var. *klinoraphis* Geitler
Coscinodiscus rothii (Ehrenberg) Grunow
Cyclotella meneghiniana Kützing
Cyclotella ocellata Pantocsek

Cymatopleura solea (Brébisson) W.Smith
Cymbella affinis Kützing
Diatoma anceps (Ehrenberg) Grunow
Diatoma vulgaris Bory de Saint-Vincent
Discostella glomerata (H.Bachmann) Houk & Klee
Encyonema minutum (Hilse) D. G. Mann
Encyonema prostratum (Berkeley) Kützing
Eunotia pectinalis (Kützing) Rabenhorst
Fragilaria tenera (W. Smith) Lange-Bertalot
Fragilariforma virescens (Ralfs) D. M. Williams & Round
Gomphonema clavatum Ehrenberg
Gomphonema truncatum Ehrenberg
Gyrosigma acuminatum (Kützing) Rabenhorst
Gyrosigma macrum (W. Smith) J. W. Griffith & Henfrey
Halamphora normanii (Rabenhorst) Levkov
Hantzschia amphioxys (Ehrenberg) Grunow
Luticola obligata (Hustedt) D. G. Mann
Melosira varians C. Agardh
Navicula cincta (Ehrenberg) Ralfs
Navicula cryptocephala var. *veneta* (Kützing) Rabenhorst
Navicula longicephala Hustedt
Navicula radiosa Kützing
Navicula rhynchocephala Kützing
Neidium bisulcatum (Lagerstedt) Cleve var. *subampliatum* Krammer
Neidium iridis (Ehrenberg) Cleve
Nitzschia acicularis (Kützing) W. Smith
Nitzschia palea (Kützing) W. Smith
Pleurosigma angulatum (Queckett) W.Smith
Rhoicosphenia abbreviata (C. Agardh) Lange-Bertalot
Stauroneis anceps Ehrenberg
Surirella linearis W. Smith
Surirella ovalis Brébisson
Synedra camtschatica Grunow
Tabellaria fenestrata (Lyngbye) Kützing
Tabularia gaillonii (Bory de Saint-Vincent) Bukhtiyarova
Ulnaria acus (Kützing) M. Aboal
Ulnaria danica (Kützing) Compère & Bukhtiyarova
Ulnaria delicatissima (W. Smith) M. Aboal & P. C. Silva
Ulnaria ulna (Nitzsch) P. Compère

Class :Chrysophyceae

Dinobryon sertularia Ehrenberg

Class :Xanthophyceae

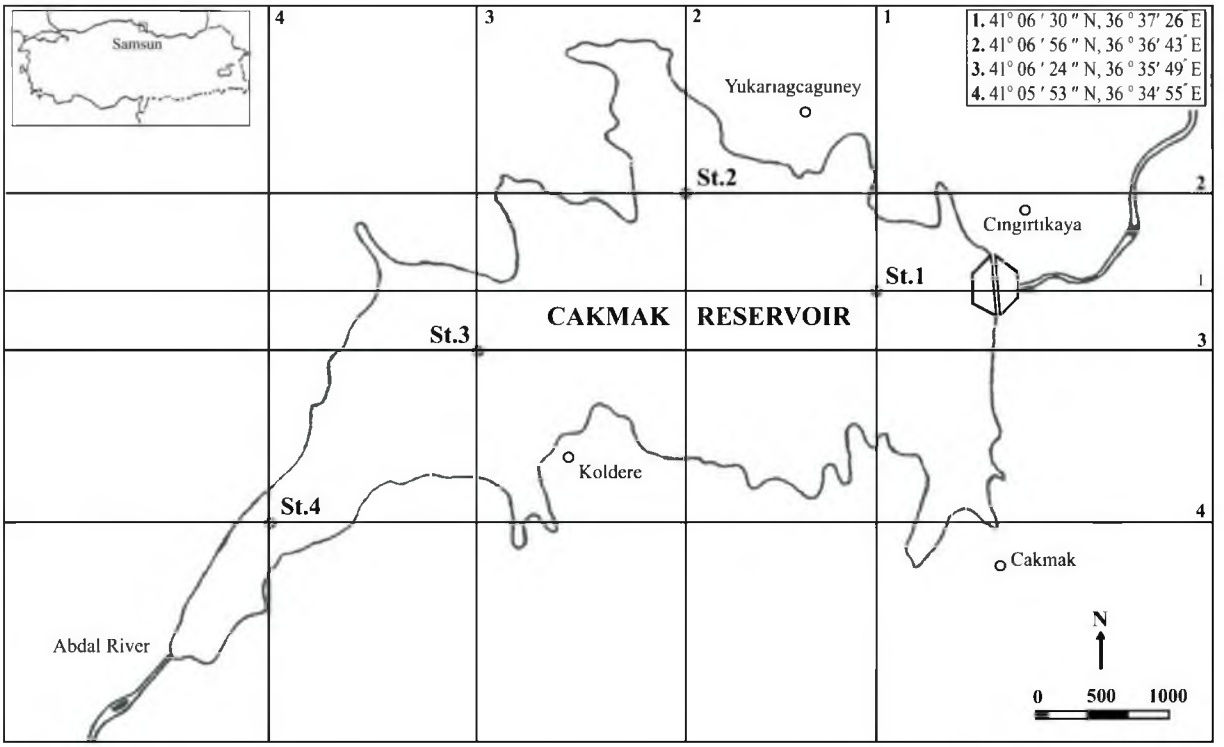
Goniochloris fallax Fott
Goniochloris mutica (A. Braun) Fott

Table 2. Physicochemical variables in surface water samples taken from the station 1 at Cakmak Reservoir

Analysis / Months	rature (°C)	ved oxygen (mg l^{-1})		ctivity (µmhos/cm)	nia-N (mg l^{-1})	-N (mg l^{-1})	-N (mg l^{-1})	onate (mg l^{-1})	m (mg l^{-1})	ardness (°FS)	sium (mg l^{-1})	phosphate (mg l^{-1})	(mg l^{-1})	ic matter (mg l^{-1})	transparency (cm)
May 03	17.9	6.5	8.4	94	0.60	0.000	1.02	143	45	162.5	12.3	0.00	25.9	1.92	210
June 03	25.5	4.3	8.3	104	0.40	0.003	0.04	158	43	142.0	9.7	0.01	21.6	1.56	70
July 03	25.0	4.6	8.5	98	0.10	0.000	0.55	165	46	158.0	12.2	0.02	50.4	1.84	100
August 03	24.8	4.6	8.6	98	0.05	0.007	0.05	170	42	165.0	12.0	0.02	33.6	1.56	80
September 03	22.6	5.0	8.3	96	0.15	0.038	0.11	138	39	142.5	10.9	0.06	13.0	1.76	120
October 03	17.0	6.8	7.8	92	0.00	0.001	0.24	138	40	157.0	14.0	0.03	13.0	1.60	90
November 03	12.4	8.7	8.0	92	1.50	0.084	0.55	150	45	175.0	15.2	0.05	31.7	2.04	150
December 03	11.9	9.0	8.2	92	0.20	0.003	0.40	145	46	156.5	14.6	0.04	27.4	1.98	240

January 04	9.8	11.1	7.9	82	0.10	0.004	0.90	155	48	188.0	9.9	0.02	51.8	1.75	90
February 04	9.4	11.2	7.5	77	0.15	0.006	0.60	163	56	185.0	10.9	0.03	26.4	1.84	90
March 04	11.2	9.2	8.2	92	0.05	0.003	0.60	168	55	197.5	14.6	0.00	30.7	1.68	75
April 04	12.5	8.6	8.1	82	0.00	0.003	0.80	203	59	200.0	12.8	0.03	2.4	1.96	90
May 04	18.1	6.0	7.8	90	0.00	0.010	0.30	140	46	175.0	10.2	0.00	7.7	1.64	180
June 04	25.0	4.6	8.4	98	0.05	0.008	0.35	155	50	155.0	7.3	0.00	1.9	1.80	90
July 04	25.4	4.5	8.5	96	0.20	0.006	1.04	158	52	167.5	9.7	0.01	21.6	1.64	60
August 04	22.5	5.2	8.0	96	0.05	0.003	0.55	165	58	212.5	12.2	0.00	50.4	1.92	80
September 04	18.3	6.0	7.2	99	0.00	0.013	0.20	145	39	142.5	10.9	0.01	2.9	1.68	130
October 04	14.4	8.0	7.6	97	0.15	0.000	0.55	155	42	155.0	12.2	0.02	4.3	1.36	90
November 04	13.1	8.3	8.1	98	0.00	0.003	0.70	160	45	145.0	12.8	0.03	19.7	1.22	120
December 04	11.0	10.2	7.8	96	0.00	0.006	0.70	158	60	190.0	12.4	0.01	33.6	1.44	180
January 05	10.0	11.0	7.2	97	0.05	0.000	0.60	113	44	137.5	6.7	0.00	23.5	1.56	130
February 05	12.2	8.8	8.2	94	0.20	0.000	0.60	158	54	187.5	12.8	0.00	33.1	1.64	100
March 05	16.6	7.5	8.1	101	0.00	0.040	1.05	133	58	187.5	10.3	0.01	59.0	1.68	75
April 05	18.0	5.9	7.9	94	0.05	0.005	1.35	163	52	187.5	13.9	0.01	28.8	0.64	120

5. FIGURE



Şekil 1. Geographic location of the Cakmak Reservoir and sampling stations

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The Vegetation and Productivity of The Caspian's Shores In Azerbaijan

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Abstract This study was performed on the phloristic and phytosociologic features and the classification and productivity of the vegetation of Caspian shores in Azerbaijan. Between Abseron peninsula and Astaraya (100-150 m shore zone) of the shore, 34 families, 93 geneses, and 134 species were defined. In the study area 17 species are submerged in water, 25 of them are partially submerged and 79 of them are expanded in the swamps and damp places. In the region, desert, semi-desert, swamp, and forest ecosiistems, sandy-desert, halophytic damp desert, halophytic arid desert, subtropical semi-desert, ephimeric subtropical semi-desert, swamp, meadow-swamp, shore plain forest, and shore tugay forest, consisting of 48 formations and 57 associations were identified. The productivity of the ground surface and underground phytomasses were 40-6400 gr and 50-4560 gr, respectively.

Keywords: *Azerbaijan, Caspian Sea, vegetation, productivity*

Hazar'ın Azerbaycan'a ait sahil vejetasyonu ve verimliliği

Özet Bu çalışmada Azerbaycan sınırları içerisinde kalan Hazar Denizi sahil kesimlerindeki vejetasyonun floristik ve fitososyolojik özellikleri ve verimliliği araştırılmıştır. Azerbaycan'ın Abşeron yarımadasından Astaraya kadar olan güney kesimlerini kapsayan sahilinde (denizden 100-150 m olan sahil zonu) 34 familya, 93 cinse ait olan 134 bitki türü tespit edilmiştir. Araştırma alanındaki bitkilerin 17 türü su içerisinde suya batmış şekilde, 25'i yarıya kadar suya batmış şekilde, 79'u ise bataklık ve nemli yerlerde yayılmaktadır. Araştırma alanında: çol, yarı-çol, su-bataklık, orman ekosistemlerine ait, kumul-çöl, halofitik sucul çöl, halofitik çoraklaşmış-çöl, subtropik yarı-çöl, efemerli subtropik yarı-çöl, sulu bataklık, çimenleşmiş bataklık, kıyı düzlük orman ve kıyı tugay ormanı olmak üzere 48 bitki birliği ve 57 alt birlik tespit edilmiştir. Araştırılan alanın bitki örtüsünde rastlanan birliklerde topraküstü fitokütlenin verimliliği 40-6400 gr, toprakaltı fitokütlede ise 50-4560 gr aralığında değişmektedir.

Anahtar Kelimeler: *Azerbaycan, Hazar Denizi, vejetasyon, verimlilik*

1. GİRİŞ

Hazar Denizinin kumullarında genelde psammofit bitkiler yayılış gösterir. Özellikle yapraksız çalılar ve yarı çalılar karakteristiktir. Bunlara örnek olarak; *Calligonum bakuense* Litu. ve *C. petunnikowii* Litu., *Ephedra distachya* L., *Eleagnus caspica* (D.Sosn) A.Grossh., *Nitraria schoberi* L., *N. komorowii* İljin et Lava., *Artemisia arenaria* DC., *Convolvulus persicus* L., *Glycyrrhiza glabra* L., *Astragalus igniarius* M. Pop., *A. hyrcanus* Pall., *A. bakuensiz* Bge., *Medicago coerulea* Less. ve *M. littoralis* Rohde., *Elymus giganteus* Vahl., *Phragmites communis* (L.) Trin. taksonlarını vere biliriz.

Kumulların bitki formasyonları ile sertleştiği ve taban suyunun yüzeye yakın durumda olduğu engebeli topoğrafyalarda, yukarıda sayılan bitkilere ek olarak *Kochia prostrata* (L.) Schrad., *Salsola pestifera* A.Nes., *S. paulsenii* Litu., *Tournėfortia sibirica* L., *Centaurea adpressa* Ledeb., *Gypsophylla bicolor* Freyn., *Limonium meyeri* (Boiss.) Ktze., *Alhagi pseudoalhagi* (M.B.) Desv., *Melilotus caspicus* Grun., *Calamogrostis gigantea* Roshev., *C.glauca* (M.B.) Trin., *Erianthus purpurascens* Anderss., *Cynodon dactylon* (L.) Pers., *Aeluropus littoralis* (Goudn) Parlatore., *Carex extensa* Good., *C. melanostachya* M.B., *Juncus littoralis* C.A.Mey., *J. acutus* L. bitkileri bulunmaktadır.

Araştırma alanınında rastlanan bitki birliklerinin fitokütlelerinin (topraküstü ve toprakaltı) araştırılması ve yem olarak toprak üstü kütlenin değerlendirilmesi de ekonomik ve ekolojik açıdan önem taşımaktadır.

2. GEREÇ ve YÖNTEM

Hazar Denizi'nin kıyı kesimlerinde yapılan arazi çalışmaları Abşeron yarımadasının kuzeyinden (Buzovna-Bilgeh) başlayarak güneye doğru Kızılağaç Körfezine kadar olan geniş bir alanı (yaklaşık 450 km) kapsamaktadır. 11 değişik noktada örneklik alan seçilmiş ve bu noktalarda karakteristik bitki birlikleri belirlenmiştir. Örneklik alanlarda bitki örtüsünün floristik ve fitososyolojik özellikleri incelenmiştir. Bitkilerin teşhisi 8 ciltlik Azerbaycan Florası eserine göre, vejetasyon sınıflandırması ise dominantlık prensipine göre yapılmıştır (1, 2, 3). Deniz kıyısından yaklaşık 100-150 m uzaklaştıkça bitki birlikleri ve onların yayılışı incelenmiştir, yaptığımız kayıtlar ve notlara dayanarak ve kaynaklara dayanarak,
Azerbaycan'ın Hazar Denizi sahil kesiminin vejetasyon haritası verilmiştir (4, 5, 6, 7, 8, 9, 10). Haritanın çizimi "MS World" programında, harıtanın lejandası ise Azerbaycan'ın Hazar Denizi sahil kesiminin vejetasyon sınıflandırılması baz alınarak yapılmıştır (19). Araştırma alanında yayılış gösteren birlikler ve bunların topraküstü ve toprakaltı fitokütlesinin verimliliği (25 cm^2-lik alanda gram cinsinden) ve mutlak nem oranı belirlenmiştir (3, 11).

3.TARTIŞMA

Hazarın kıyı kesimlerinde yapılan arazi çalışmaları Abşeron yarımadasının kuzeyinden (Buzovna-Bilgeh) başlayarak güneye, Kızılağaç körfezine kadar olan geniş bir kıyı kesimini kapsamıştır (Şekil 1).

Daha düşük yükseklikte olan topografyalarda halofitik bitkiler (*Salsola soda, S.crassa, Salicornia europea, Petrosimonia brachiata, Kalidium caspicum, Suaeda dendroides, Halostachus caspicus, Tamarix ramasissima)* ve onların oluşturduğu bitki gruplaşmaları ile yanısıra su-bataklık birliklerine (*Phragmites communis, Carex bordzilowskii, C.exteusa, Juncus littoralis, J. acutus, J.marittimus, Bolboschaenus maritimus, Typha angustifolia* rastlanmaktadır. Ancak, yukseklikği deniz seviyesinin üstünde olan topografyalarda ise yarı çöl, ve çoraklaşmış çöl tipli bitki birliklerine (*Artemisia fragrans, Salsola dendroides, Bromus japonicus, Zerna rubens*) rastlanmaktadır. Kıyıdan uzaklaştıkca toprakta sıcaklık değerinin arttığı, ortamın ise asit ortamdan bazik bir ortama doğru değiştiği görülmektedir.

R. Şahsuvarovun (7) Samur Deveçi Düzünde yaptığı araştırma sonuçları ile mükayese edersek Hazarın güney ve kuzey kesimlerde bir birine benzer olduğunu, fakat floristik açıdan Kuzey kesimlerde floranın daha zengin olduğu görülmektedir. Bu farklılığın nedeni ise bizim araştırmalarımızın sadece kıyıya yakın olan alanların dışına çıkılmamasından kaynaklanmaktadır.

Hazarın sahil kesimlerinin kumul vejetasyonu ekolojik özelliklerine göre psamnofit-litoral, fitososyolojik özelliklerine göre ise çöl vejetasyonu tipinin kumul-çöl alt tipine girer (12). Deniz kıyısında bu bitkilere tek tek, saf veya karışık şeklinde rastlanmaktadır.

Mayılov'a göre (12) Azerbaycan'da kumullar yaklaşık 117650 hektar alanı kapsamaktadır. Bunun yaklaşık 24150 hektarı hareketli kumullu alanlar olup tümü Hazar Denizi'nin sahil kesimlerini kapsamaktadır. Bazı araştırmalara göre Hazar Denizinin Azerbaycan'la sınırlanan sahil kesimleri dar bant şeklinde kumul-çöl vejetasyonu ile örtülüdür (4, 5, 6, 12, 13, 14 15, 16).

Aliyev 'e göre (13) Abşeron'un 300 bin hektarı kumul alanlardan oluşur, bunun da % 30-35'ini hareket eden kumullar oluşturur.

R. Şahsuvarov Hazarın Azerbaycana ait kuzey kıyı kesimlerinde (Samur-Deveçi düzünde) deniz kıyısı nemli çoraklaşmış, hereket eden kumullu, yarı hareketli kumullu ve sertleşmiş kumullu substratlarda; kumul-çöl, su-bataklık, çayır-çimen, orman, kayaca bağlı olan vejetasyon tiplerinde 17 formasyon, 59 assosasyon ve 56 familyaya ait 298 vasküler bitki türünün oldugunu belirlemiştir (7). Bu alan Abşeron yarımadasının kuzey kesimlerini kapsamaktadır.

Hazar Denizinin, Yalama, Hazmaz, Deveci ve Lenkeran düzü ile sınırlanan kesimlerinde bataklaşmış çimenler ve otlu bataklıklar geniş yayılış gösterir.

Ramsar listesine giren, Uluslararası düzeyde kuşların korunması amacı ile koruk alanı ilan edilmiş Kızılağaç körfezi de araştırma alanımız kapsamınadadır. Burada yaygın olan sucul bitkiler, bataklaşmış-çimenler ve asıl-bataklıklar kışlayan kuşların meskeni olup, balıkların üremesi ve avcılık için de önemli bir alandır. Burada yaygın olan sucul bitkilerden: Myriophyllum verticillatum L., M. spicatum L. , Nymphaea alba L., Alisma plantago-aquatica L., Polygonum amphibium L.var. natans Leyss., Potomogeton densus L. , P. pectinatus L., P. crispus L., Najas minor All., N.marina L. , Ceratophpyllum submersum L., C. demersum L., Najas marina L., N. minor All., Bolboschoeanus maritimus (L.) Pall., Sparganium neclectum Beeby, Zannichelia major Boen., Trapa hyrcana Woron. taksonlarını örnek vere biliriz.

V. Atamov (19) Hazar'ın sahil kesimlerinin bitki örtüsünde; Phrametum, Bolboschetum, Thyphetum, Calamogrostisetum, Juncetum, Kalidietum, Halocnetum, Halostachusetum gibi bitki birliklerinin geniş alanları kapsadığı ve ot verimliliğinin yüksek olduğu ortaya konmuştur.

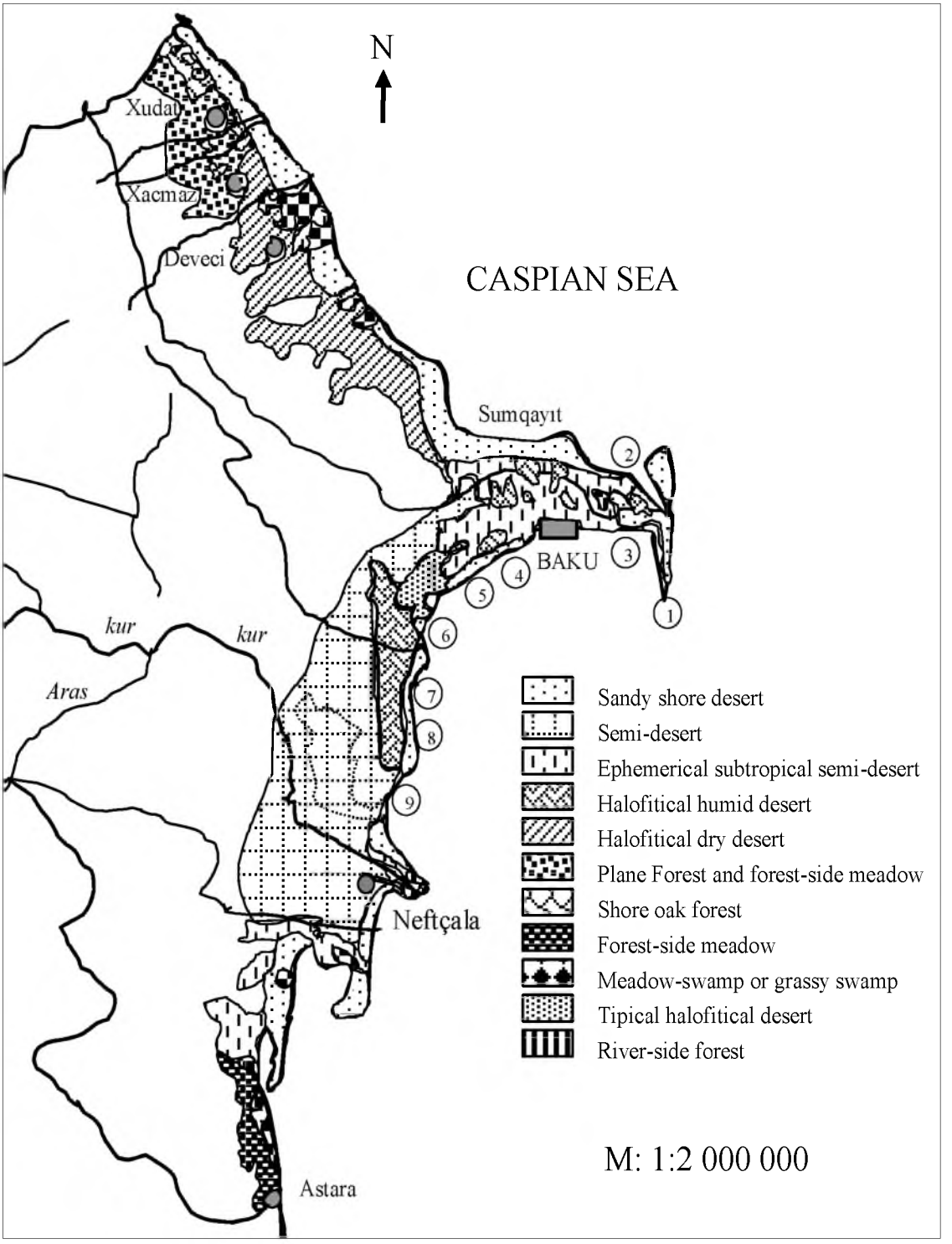
M. Musayev, V. Atamov (20) tarafından Azerbaycan'ın su-bataklık florasında: 62 familya ve 208 cinse ait toplam 502 takson olduğu, bu bitkilerden 169'un hidrofit, 243'ün higrofit, 90'ının ise hidatofit olduğu belirlenmiştir.

Seçmen ve Leblebici (21) Türkiyenin sulak alanlarının florası ve bitkiliğinin araştırılması sonucu bu ekosistemlerin yıllık temel üretim gücünün en üst düzeyde olan sistemler olduğunu belirtmişlerdir.

Hazar Denizi'nin Deveci, Abşeron, Masallı ve Lenkeran bölgelerinde yaygın olan Juncus littoralis C.A.Mey. ve Phragmites communis (L.) Trin. türleri genellikle saf, bazen ise Glycyrrhiza glabra L., Alhagi pseudoalhagi Desv., Artemisia szovitsiana (Boiss.) A. Grossh., Limonium meyeri (Boiss.) Ktze., Phsylliostachys spicata (Willd.) Nevski., Tripolium vulgare (L.) Nessab gibi türlerin katılımı ile birlikler oluşturur. Bu kesimlerde rastlanan Scirpus tabernaemontani Gmel., S .lacustris L., Carex bordzilowski V.Krecz. , C. compacta Lam. , C.divisa Huds. , C.riparia Curt., Thypha latifolia L., T. angustifolia L., T. laxmannii Lep., Sparganium polyedrum A.et.G., S. neglectum Beeby., S. microcarpum (Neum.) Cel., Juncus acutus L., J. littoralis C. A. Mey., J. gerardi Leis., J. maritimus Lam. gibi türler de kıyı kesimlerde yaygın olan türlerdendir.

Bu birliklerde Phragmites communis'in 1 m^2 alanda ortalama topraküstü yaş kütlesi 5 kg, ortalama boyu ise 2.5-3 m'ye ulaşır. Sahilin kurak yerlerinde ise bu bitkinin ortalama boyu 1,8 m, 1m^2-de olan gövde sayısı 24, 1 m^2-de olan yaş kütle ise 3,5-4,0 kg civarındadır (10, 18).

Hazar Denizi'nin kuzey kıyısındakı Deveci limanında ve güneyindeki Celilabad ve Masallı bölgeleri arasındakı sahil kesimlerinde Juncus littoralis, J. acutus, J. marittimus türlerinin oluşturduğu saf birliklere rastlanır. Bu birliklerin floristik kompozisyonu alanın nemlilik ve tuzluluk oranına bağlı olarak değişmektedir.



Şekil 1. *Azerbaycan'ın Hazar Denizi kıyısındaki vejetasyon tipleri.*

Deniz kıyısından uzaklaştıkça *Juncus littoralis*'in bolluğu, verimliliği ve örtüş derecesi belli bir uzaklığa kadar gitgide artar. Bu birliğin ortalama boyu 1 m, örtüş derecesi % 90'dır. Şıhov sahil kesimlerinde *Phragmites communis* bazı yerlerde 20-30 m eninde olmak üzere geniş alanlara yayılmaktadır (8, 10).

Apşeron yarmadasının kuzeyinden güneyine (Astara'ya) kadar olan bölgede geniş alanları kaplayan; su-bataklık (Hövsan, Zire, Şıhav, Kızılağac Körfezi, Şahdili); kumul-çöl (Hövsan, Türkan, Artyom, Sangaçal, Elet); halofitik-çöl (Taşgil, Şirvan koruğu, Sangaçal, Saratovka, Neftçala); ve yarı-çöl (Hövsan, Türkan, Artyom, Elet Dres, Daşğili) vejetasyon tiplerine rastlanmaktadır (Şekil 1).

Şekil 1'de Hazar Denizi'nin kıyı kesimlerinde yayılış gösteren bitki birlikleri (çöl, yarı-çöl, su-bataklık, orman), ve alt tipleri (kumul-çöl, halofitik sucul (nemli)-çöl, halofitik çoraklaşmış-çöl, subtropik yarı-çöl, efemerli subtropik yarı-çöl, çimenleşmiş su-bataklık ve bataklaşmış çimen ve kıyı ormanlar) haritanın lejandasında verilmiştir. Araştırma alanında yaygın rastlanan 23 bitki birliğinde topraküstü ve toprakaltı fitokütlenin yaş ve kuru ağırlıkları incelenmiş ve mutlak nem oranının assosastonlara göre değişme oranı belirlenmiştir. Fitokütle oranının değişmesi 0,25 cm^2'lik alanda incelenmiş ve veriler tablo 1-de verilmiştir.

Tablo 1. Hazar Denizi'nin Azerbaycan sahil kesimlerinin yaygın assosasyonlarının verimliliği.

	Assosasyonlar	Topraküstü Fitokütle (gr/25cm^2)			Toprakaltı Fitokütle (gr/25cm^2)		
		Yaş	*Kuru*	Nem	Yaş	Kuru	Nem
1	*Juncusetum littoralisae*	4000	1350	1650	1200	2060	5140
2	*Juncusetum .marittimae*	900	208	693	-	-	-
3	*Junco marittimii – Limonietum meyeriae*	1440	6400	800	6400	2480	3920
4	*Junco marittimii –Glycyrrhizetum glabrae*	160	65	95	100	47	53
5	*Ephedretum distachyae*	1150	665	485	250	163	88
6	*Astragaletum hyrcanusae*	200	158	43	50	40	10
7	*Astragalo hyrcanae –Juncusetum littoralisae*	4800	2800	2000	5440	4560	880
9	*Ephedreto distachya-Artemisetum szovitsianae*	250	75	175	448	112	336
10	*Calamagrosto giganthei- Phragmetum-communisae*	640	470	170	4300	1164	3136
11	*Thyphetum angustifoliae*	536	224	312	3392	1520	1872
12	*Carexetum divisae*	644	434	210	389	202	187
13	*Kalidetum caspicumae*	550	252	298	252	195	57
14	*Salsoletum dendroidesae*	2048	640	1408	464	240	224
15	*Artemisetum szovitsianae*	550	129	422	184	144	40
16	*Artemisetum fragransae*	255	154	101	69	47	22
17	*Salsoletum ericoidesae*	990	648	342	596	364	232
18	*Alhagetum pseudalhagiae*	400	339	61	118	82	36
19	*Tamarixetum ramassisimae*	810	447	343	725	367	358
20	*Alhago pseudoalhagi-Hordetum leporiniae*	102	50	52	258	170	88
21	*Atropa gigantei-Halocnemetum strobilaseae*	172	78	93,5	505	170	335
22	*Salicorno europea-Kalidietum caspicae*	2600	291	2309	692	250	445
		1210	470	740	304	91	213
23	*Petrosimo brachiata-Salicornietum europeae*	714	187	527	320	130	190
24	*Salicornietum europeae*						

Tablo 1'den de görüldüğü gibi mutlak nem oranı 2500-3000 gr aralığında değişmektedir. *Myriophyllum verticillatum, M. spicatum , Nymphaea alba , Alisma plantago-aquatica, Polygonum amphibium* var. *natans., Potomogeton densus., P. pectinatus., P. crispus., Najas minor, N.marina. , Ceratophpyllum submersum., C. demersum, Bolboschoeanus maritimus, Sparganium neclectum, Zannichelia major, Trapa hyrcana* taksonlarının saf veya karışık şekilde oluşturmuş oldukları birliklerde mutlak nem oranı 2500-3000 gr. arasında deyişmektedir.

Mutlak nem oranı 2500 gram ile 1500 gram arasında deyişen birliklere; *Salicorno europea-Kalidietum caspicae* (2309 gr), *Astragaletum hyrcanusae* (2000 gr), *Juncusetum littoralisae* (1650 gr), *Salsoletum dendroidesae*(1408 gr) örnek verilebilir. Bu birliklerde mutlak nem oranı 2309-1408 gr aralığında değişmektedir (Tablo 1).

Mutlak nem oranı orta derecede (100-1000 gr aralığında) olan assosasayonlara: *Petrosimonio brachiatae-Salicornietum europea, Junco maritimus-Limonietum meyeriae, Juncusetum littoraliae,. Salicornietum europae, Salsoletum dendroidesae, Artemisietum fragransae, Thyphetum angustifoliae, Ephedretum distachiae, Kalidietum caspicae, Carexetum divisae, Phragmetum communisae, Ephedro distachyii-Calamagrostisetum giganteumae* örnek verilebilir.

Hazar Denizinin Azerbaycan'a bağlı kıyı kesimlerinin nem oranı en düşük olan birliklere (50-100 gr); *Junco maritimus-Glycyrrhizetum glabrae, Astragaletum hyrcanusae, Alhagetum pseudoalhagae, Alhago pseudoalhagii-Hordetum leporiniae, Atropiseto gigantei-Halocnemetum strobilaseumae*'yi örnek verebiliriz.

Juncusetum littoralisae (5140 gr), *Junco maritimii-Phragmetum communisae* (3920 gr), *Phragmetum communisae* (3136 gr), *Thyphetum angustifoliae* (1872 gr) birliklerinde toprakaltı fitokütlede mutlak nem oranı 1872-5140 gr aralığında değişmektedir. Bunların dışında kalan diğer birliklerde topraküstü ve toprakaltı fitokütledeki nem oranı daha düşük orandadır (22-880 gr aralığında).

Tablo 1'de görüldüğü gibi bazı birliklerde topraküstü fitokütlede mutlak nem oranı *Salicorno europae-Kalidietum caspicae* (2309 gr), *Astragaletum hyrcanusae* (2000 gr), *Juncetum littoralisii*(1650 gr), *Salsoletum dendroidesae* (1408 gr) toprakaltı fitokütledeki nem oranına göre daha yüksek olduğu halde, bazı birliklerde; *Juncusetum littoralisae* (5140 gr), *Junco littoralisii-Phragmetum communisae* (3920 gr), *Phragmetum communisae* (3136 gr), *Thyphetum angustifoliae* (1872 gr) ise tam tersi görünmektedir. Bazılarında ise topraküstü ve toprakaltı fitokütlede olan mutlak nem oranı birbirine yakın orandadır. Örneğin, topraküstü ve toprakaltı mutlak nem oranı sırası ile *Junco littoralisii-Glycyrrhizetum glabrae* için 94,8-53,2 gr, *Astragaletum hyrcanusae* 42,5-10 gr, *Carexetum divisae* 210-187 gr, *Salsoletum dendroidesae* 342-232 gr, *Alhagetum pseudoalhagae* 61-36 gr, *Tamarixetum ramasissimusae* 343-358 gr.

SONUÇ

Hazar Denizi'nin Azerbaycan'a ait sahil kesimlerinde çöl, yarı-çöl, su-bataklık, orman, Kumul-çöl, halofitik nemli-çöl, halofitik çoraklaşmış-çöl, efemerli subtropik yarı-çöl, subtropik yarı-çöl, sulu bataklık ve bataklaşmış çimen, kıyı olmak üzere 48 bitki birliği ve 57 alt birliğe rastlanmıştır. Azerbaycan'ın Abşeron yarımadasından Astaraya kadar olan güney kesimleri kapsayan sahilinde 34 familya, 93 cinse ait olan 134 bitki türüne rastlanmıştır.

Tür sayısı bakımından en zengin olan familyalar: *Poaceae* (26 tür), *Chenopodiaceae* (24), *Asteraceae* (13), *Cyperaceae* (12), ve *Fabaceae* (5 tür)'dir. Bu familyalara ait olan taksonlar toplam takson sayısının %54'ünü (75 tür) oluşturur. Araştırma alanında rastlanılmış cinslerden: *Salsola* (7 tür) ve *Artemisia* (4 tür) tür sayısı bakımından daha zengin, *Zerna, Juncus, Carex, Medicago* (her biri 2 türle temsil olunur), *Lepidium, Centaurea, Aegilops, Limonium, Suaeda, Chondrilla* (her biri 1 türle temsil olunur) gibi cinsler ise tür sayısı daha az olmalarına ragmen populasyon yoğunlukları daha fazladır. Bu cinslere ait olan tür sayısı toplam tür sayısının % 30,3'ünü (37 tür) oluşturmuştur.

Araştırılan alanın bitki örtüsünde rastlanan birliklerin topraküstü kuru ot verimliliği 25 cm^2 alanda 40-6400 gr, toprakaltı fitokütle ise 50-4560 gr (40 cm derinlikte) arasında değişmektedir.

*Junco littoralii-Phragmetum communisae ,Astragalo hyrcanusae-Juncusetum littoralisae, Phragmetum communisae, Thyphetum ancustifoliae'*nin verimliliği daha fazla olup 25 cm^2'de toprakaltı kısımları 1164-4560 gr, topraküstü kısımları ise 470-640 gr aralığında değişmektedir. Diğer birliklerin topraküstü kısımlarının verimliliği ise 25 cm^2'de 50-470 gr, toprakaltı kısımları ise 40-1164 gr aralığında değişmektedir. Bu birliklerde mutlak nem oranı topraküstü fitokütlede 60-1650 gr, toprakaltı fitokütlede ise 10-5140 gr arasında değişmektedir. Mutlak nemin yüksek oranda olması bu birliklerin sulu bir ortamlarda gelişmesinden kaynaklanmaktadır.

Toprakaltı fitokütledeki mutlak nem oranı *Astragaletum hyrcanusae, Artemisietum szovitsianae, Alhagetum pseudoalhagae, Ephedretum distachyae, Junco marittimusae Glychyrrizetum glabrae, Alhago pseudoalhagii-Hordetum leporiniae* 'de daha düşük olup 10-88 gr arasında; *Juncusetum littoralisae, Phragmetum communisae, Thyphetum angustifoliae'*de 1872-5140 gr, diğerlerinde ise 187-445 gr arasında değişmektedir. *Alhagetum pseudoalhagae , Alhago pseudoalhagii-Hordetum leporiniae, Junco marittimusii-Glycyrrhizetum glabrae'*de mutlak nem 52-94,8 gr arasında değiştiği halde, diğer birliklerde bu oran 101-2309 gr aralığında değişmektedir. Toprakaltı fitokütle mutlak nem oranı açısından topraküstü fitokütle ile kıyaslandığında daha düşük olduğu görülür. Bunun nedeni ise bu bitkilerin sulu veya yeterince nemli bir ortamda yaşamasına bağlı olarak, kök sisteminin, arid bir ortamda gelişen bitkilerden farklı olarak, fazla gelişmemesine baglıdır.

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